Total Knee Replacement

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Introduction

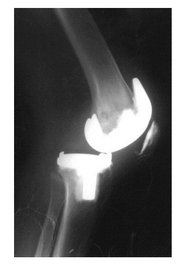
- Thousands of people suffer from knee joint discomfort which may be corrected surgically by a total knee replacement (TKR).
- Over 700,000 knee replacements were reported in the US in 2010.
- Knee replacements are generally known to be successful.
- The Food and Drug Administration (FDA) has reported the recall of several knee implants due to labeling errors, durability issues and compatibility. These issues may require expensive revision surgery.

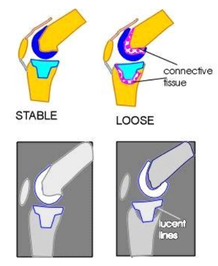
Total Knee Replacement

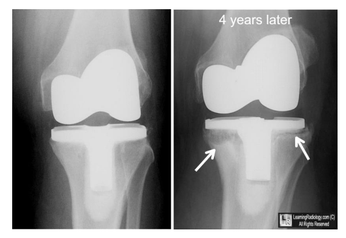
- The purpose of a TKR is to:
  - reduce pain
  - restore mobility.
- X-rays, physical examination and patient condition are used to determine if surgery is a viable treatment option.
- Surgery performed by orthopedic surgeon and team. The faces of the bones involved in the knee joint are removed and replaced with a prosthetic knee joint.

Repercussions of Failures

- Joint pain
- Inflammation
  - loss in range of motion
- Dislocation
- Fatigue fracture



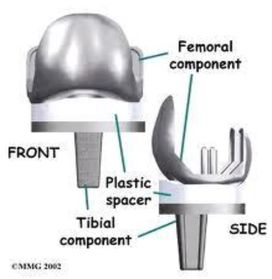




Objective

- The objective of the undergraduate research project is to:
  - study the problems with the present knee implants
  - make recommendations for
    - improving the lifespan of the knee implants.
    - reducing the number of complications associated with knee replacement implants.

Knee Implant Components



- Tibial Component
  - Metal tray coated with ultra-high molecular weight polyethylene (UHMWPE), plastic spacer.
- Femoral Component
  - Metal coated with UHMWPE.
- Patellar Component
  - UHMWPE.
  - or combination of metal and plastic.
- Cement
  - Acrylic polymer.
  - Polymethylmethacrylate (PMMA).

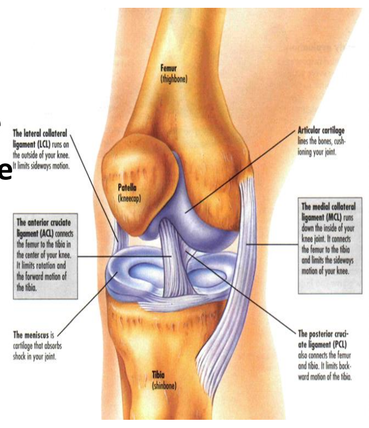
Implant Recalls

- Stryker Eius Unicompartmental Knee system
  - experienced a higher than normal revision rate, forcing it to be recalled in August, 2011.

- Smith & Nephew Oxinium Genesis II and Profix II
  - voluntarily recalled based on a higher than expected number of revision surgeries due to loosening.
- Vanguard by Biomet, Inc.
  - knee implants were labeled as left but right knee implants were enclosed in the packages.

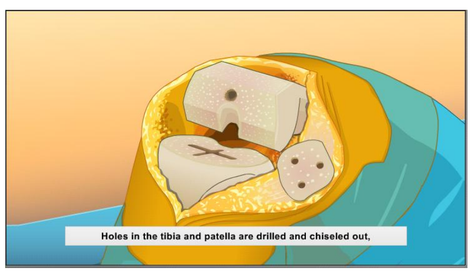
Knee Anatomy

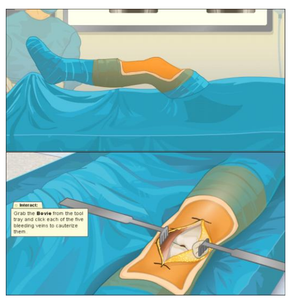
- The knee joint is composed of:
  - femur, patella, tibia.
- Articular cartilage lines the face of the bones on the inside of the joint.
- Ligaments provide stability.
  - LCL & MCL prevent sideways motion.
  - ACL & PCL prevent forward and backward motion.



TKR Procedure

- Surgical drapes & sterile environment are necessary to prevent an infection.
- An incision is made to expose the bones of the knee joint.
- A bone saw is used to shape the femur, tibia & patella. Alignment tools are necessary.





Computer-Assisted Robotics in TKR

The use of computer assisted robotics provides:

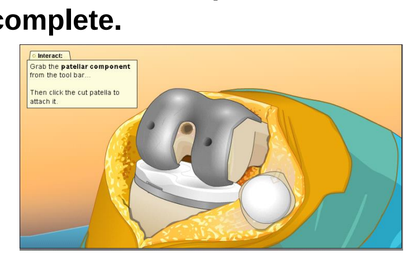
- Better alignment.
- Lower risk of infection.
- Reduced early failure rate.

Arthritis

- Osteoarthritis – wear and tear on the knee. The cartilage softens & deteriorates.
- Rheumatoid arthritis – synovial membrane becomes inflamed & thickened.
- Post-traumatic arthritis – fractures to the surrounding bones or tears to the ligaments can damage the cartilage.

TKR Procedure (contd.)

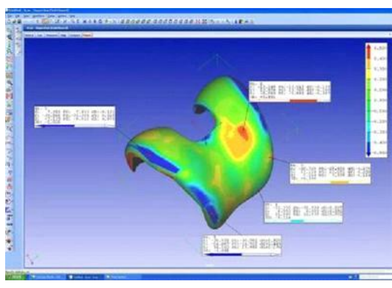
- The replacement knee components are then fitted onto and into the reshaped bone.
- Range of motion and alignment are verified, and the replacement knee components are then cemented into place.
- The surrounding soft tissue is sutured and stapled shut once the internal operation is complete.



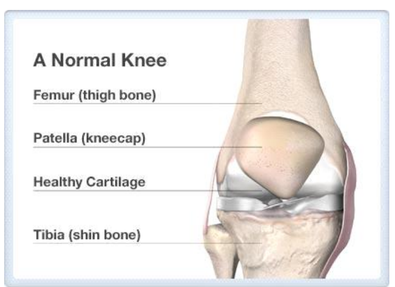
Custom fitting TKR using CT and MRI

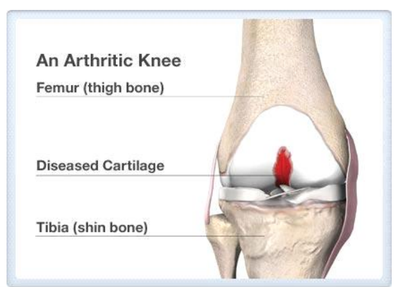
Rather than using predetermined knee implant sizes, surgeons can use CT and MRI images to custom fit implants by transforming them into 3D computer models via computer aided design (CAD).

- Bone removal is reduced.
- Shorter surgery time.
- Quicker recovery time.
- Less pain postoperative.



Normal Knee v. Arthritic Knee





Modes of Failure of TKR

- Loosening - at interface between the bone & prosthetic.
- Mechanical wear - Cyclic stress causes the materials of the prosthetic to degrade
- Infection - always a risk with surgeries, complicated with metallic implants.
- Misalignment - implant is not placed in correct alignment
- Dislocation - can cause bones to fracture

Recommendations

- Simulating with pressure sensors may:
  - give insight on problems with various materials and different combinations of those materials
  - provide information on stress distribution which may lead to improved contours of the prosthesis.
- Effectiveness of TKR can be improved by:
  - biologically compatible, non-corrosive materials
  - lubricants that provide for:
    - a greater range of motion
    - lifespan
  - cement
    - prevents loosening with time.