Collaborative Engineering

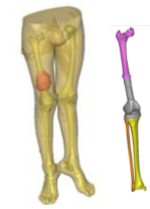
Problem Definition – TKP System

- Patient Requirement
- Surgeon Requirement
- Requirements & Constraints
- Problem Statement

OrthoCAD Lab, I.I.T. Bombay

Requirement Study – TKP system

- **Example: Tumour Knee Prosthesis System**
  - **Who**: for young patients diagnosed with knee Osteo-sarcoma
  - **What**: Artificial knee to replace tumour
  - **Why**: For standing (load bearing), walking (motion)
  - **When**: Daily activities
  - **Where**: In patients body
  - **Wish**: Minimal invasive surgery
- **Affecting two users**
  - Patients
  - Surgeons



Patient Requirement

- Basic Features
  - Reconstruct tumour affected area
  - Load bearing like natural knee
  - Motion like natural knee
  - High Quality
- Performance features
  - Affordable
  - Minimal Surgery
  - Longevity
- Unexpected features
  - Expandable, Bio-integral

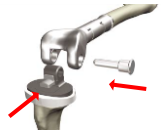
Surgeon Requirement

- Basic Features
  - Anatomical Conformity
  - Ease of assembly-dissembly
  - Intra-operative modularity
  - Minimal Surgery – avoid infection
- Performance features
  - Bio-integral
  - Longevity – less revision surgeries
- Unexpected features
  - Expandable
  - Immediate Post-operative recovery

Limitations of Current Systems

- Imported Joints
  - Prohibitively expensive (Rs 5-15 lacs)
  - Not designed for the Indian anatomy
  - Assembly needs 2 directional freedom
  - Uncontrolled Second DOF

Overhang



2 Directional Assm.

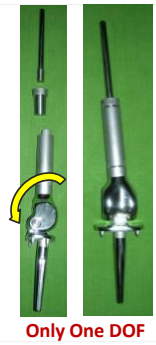
2nd DOF Uncontrolled

Limitations of Current Systems

- Indian Joints
  - Structural breakages, Stainless steel
  - Anatomical Conformity
  - Only one DOF

Breakages

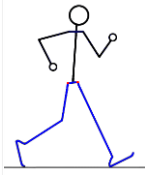
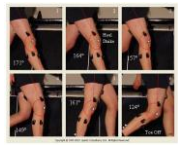
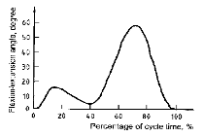
Patella Matching



Only One DOF

Requirement Analysis

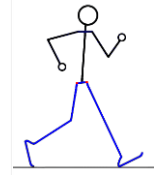
- Functional Requirements – Essential Features:
  - Function: Motion
    - At least 2 DOF during walking
    - Higher Flexion angle (Squatting)
    - 0-120° Flexion angle, 5° rotaion

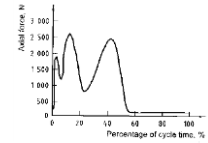




Kinematic Studies ISO Standards

Requirement Analysis

- Functional Requirements – Essential Features:
  - Function: Load, Strength
    - 4-5 times BW during walking
    - Cyclic Loading
    - AP force 110 N, Moment 6 Nm

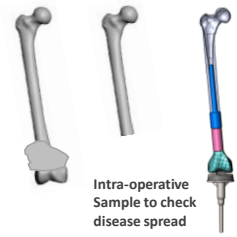




Kinetic Studies ISO Standards

Requirement Analysis

- Functional Requirements – Essential Features:
  - Function: Demographic
    - Anatomical Difference
  - Intra-operative
    - Modularity (frozen section)

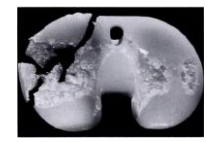



Intra-operative Sample to check disease spread

Requirement Analysis

- Functional Requirements – Essential Features:
  - Function: Motion, Load, Strength, Demographic & intra-operative variance,
  - Usability: bio-compatible, safety, life
  - Efficiency: Assembly/ disassembly effort, invasiveness



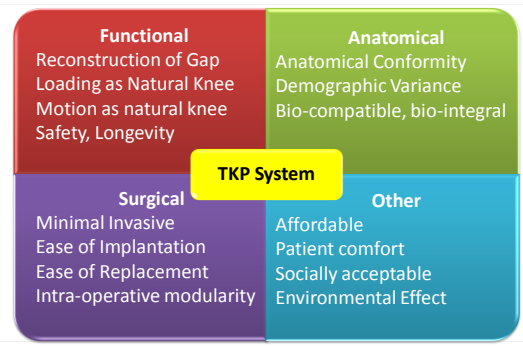


Safety, Longevity

Requirement Analysis

- Constraints – Desirable Features or Limits:
  - Physical: natural replacement (size, weight, noise)
  - Cost: Affordable, revision surgery


Requirement Analysis



Problem Definition – OrthoCAD Project

- OrthoCAD Network Centre for Endo-Prosthetic Skeletal Reconstruction Systems (Mega Medical Implants)

- **Goal:** Total Knee Prosthesis system for saving the limbs of patients affected by osteosarcoma by reconstructing gaps in bone after tumour resection.

  - ✓ Modular rotating hinge joint design suitable for local population
  - ✓ Manufacture using bio-compatible materials; quality with economy
  - ✓ Testing the knee prosthesis for fatigue and wear using knee simulator
  - ✓ Surgical armamentarium for measurements, resection, implantation
  - ✓ Virtual surgery software to select suitable parts, plan correct position.