Introduction

- Recently, concerns arose over the increased medial tibial bone resorption of cobalt-chromium (CoCr) tibial prostheses after total knee arthroplasty (TKA).
- Greater medial tibial bone loss was reported with the CoCr implant compared to other implants with different materials.
- However, there was no consensus about the combined effect of the implant material and design on local mechanical environment in TKA.

Objective: we determined the effects of the implant materials and design on local biomechanical environment after TKA.

Methods

- Three-dimensional finite element model (Mimics, Materialise, Leuven, Belgium)
  - Normal proximal tibial bone with implants and cement (2 mm)
  - Biomechanical analysis was performed according to the depth at 5 locations and axial at 4 areas.

- Implants used: Original and modified (material) version
  - 4 types of implants with their original designs and materials:
    - 1) Attune (CoCr), 2) Vanguard (CoCr), 3) Legion (Ti), 4) Persona (Ti)
    - Homogenous & heterogenous models
  - 4 types of implants with materials changed (CoCr → Ti)
    - 1) Attune (Ti), 2) Vanguard (Ti), 3) Legion (CoCr), 4) Persona (CoCr)
    - Homogenous model only

- Classification according to depth at 5 locations
  - Zone 1: 0 - 2 mm, Zone 2: 2 - 5 mm, Zone 3: 5 - 30 mm
  - Zone 4: 30 - stem tip, Zone 5: step tip

- Classification of tibial bone, axial view
  - Anterior-Medial (AM), Anterior-Lateral (AL), Posterior-Medial (PM), Posterior-Lateral (PL)

- Strain energy density (SED)
  - Bone resorption = -0.75 > (SEDintact/SEDimplanted)-1
  - Normal range = -0.75 < (SEDintact/SEDimplanted)-1 < 0.75
  - Bone formation = (SEDintact/SEDimplanted) >0.75

- Normal walking condition

Results

- Homogenous model (original designs & materials)
  - Attune and Lesion showed increased bone resorption patterns in zone 1 and 2 (top - 5 mm from base plate).

- Heterogeneous model (original designs & materials)
  - The patterns were different from the homogenous model.
  - All 4 types of implants showed increased bone resorption pattern in posteromedial zone 1 and 2 (top - 5 mm from base plate).

- Analysis using implants with material changed
  - There was no substantial difference with Attune and Legion implants.
  - However, Vanguard and Persona implants were more affected by material changes even if the changes were in normal range.

Summary

- All 4 types of implants included in this study showed increased bone resorption in posteromedial area underneath tibial base plate (top- 5 mm) in heterogeneous 3-dimensional finite element analysis model.
- There was no substantial change of the biomechanical environments around the tibial component after changing the materials with the same implant design.