

Effect of Design and Fixation Technique in TKA Performance

Mattia Sisella, Liang Zhou, Lorenzo Allegri, Bernardo Innocenti

INTRODUCTION:

Total Knee Arthroplasty (TKA) is one of the most performed orthopedic surgical procedures and its incidence is increasing exponentially year by year. The most used prosthetic designs for primary TKA are the Cruciate Retaining (CR) and Posterior Stabilized (PS) designs for both Press Fit (PF) and cemented implants - whether conventional (CEM) or hybrid (HY). Data indicates that fully cemented implants remain the most widely adopted choice by surgeons for TKA. Furthermore, Fixed Bearing (FB) designs are still preferred over Mobile Bearing (MB). It should be emphasized that a cemented implant (whether fully cemented or hybrid) can feature various cement thicknesses and literature rarely examines their effects on TKA performance. The goal of this finite element study is to examine how cement thickness, prosthetic design and alignment choice influence stress distribution in the bone and in the PMMA layer.

METHODS:

Finite element models were developed considering the geometry of a left, fourth generation composite tibia, medium size (# 3401, Sawbones, Pacific Research Laboratories Inc., Malmö, Sweden) with a 3° varus alignment. A total of 42 models were analysed and compared. The materials and interactions were defined in accordance with literature. Four regions of interest (two proximal and two distal) were identified on the cortical bone, along with two regions on the cement layer. A load of 2 kN was applied along the mechanical axis of the lower limb. Concerning implant alignments, mechanical and kinematic alignment were considered. Regarding fixation techniques involving the use of PMMA, three thicknesses were considered: 2mm, a conventional one of 3.5mm, and 5mm.

RESULTS:

Distal regions appear to be significantly less affected by the prosthesis design and the cement thickness. In contrast, the proximal regions, particularly in the CEM configurations, show greater variability induced by differences in cement thickness. The M/L ratio was calculated for each configuration to analyse the effect of load distribution of the different alignment adopted. The results on PMMA show that hybrid configurations exhibit higher compressive stresses, while in cemented configurations, the mean stresses are higher and more significantly influenced by shear stresses.

DISCUSSION AND CONCLUSION:

No significant differences were observed between mechanical and kinematic alignment. Thickness of PMMA influences stress distribution, particularly in CEM configurations. In FB configurations, excessive use of PMMA can lead to higher stress on the cortical bone, associated with an increase in shear forces. In general, configurations with conventional thickness appear to provide the best results and ensure the greatest margin for error.

