

Kinematic profile of normal knees

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Introduction: During past decade a lot of emphasis has been placed on alignment and balancing in total knee replacement (TKR) especially in wake of computer navigation. Traditionally the goal of total knee surgery has been to create a neutral mechanical femoro tibial mechanical axis angle (FTMA). Computer navigation has carried on this traditional concept. It has also emphasised to provide patient specific alignment, yet the goal of alignment remains neutral for that specific patient. No studies yet provide the idea of what alignment is best for a specific knee. We conducted a study to look at what normal alignment of FTMA is. We also looked at its postural variations and collateral ligamentous strength in relation to sex.

Methods: We conducted this multicentre study on normal knees. It was decided to make it multicentre to include subjects from a wide geographical region. Six centres across a country were included. Power calculations showed we required 100 subjects in each group to show a difference of up to 1 degree (based on previous work in the institution). Persons aged between 18 and 35 were included. Those with any history of pain in knee, leg, alignment problems in legs, developmental dysplasias, previous injuries, fractures were excluded. Those with previous history of developmental or alignment problems in the family were also excluded. A computerised infrared based navigation system was used for measurement of the FTMA. The trackers were attached extra cutaneous with elastic fabric straps. These have been validated in a previous study presented at CAOS International 2011 (Clarke JV et al).

The centre of hip and knee were calculated kinematically. The centre of ankle was registered anatomically with most prominent medial and lateral malleoli as is done in routine total knee replacement surgery. FTMA was measured in supine position without any stress applied in 0 degree extension and 15 degree flexion. These were also measured with 10 Newton Meter moment arm stress in valgus and varus directions. The force applied was measured with digital scale. A total range of movement from full extension to full flexion was also noted. The subject was then asked to stand in bipedal and monopodal stance and FTMA and extension was measured in these two postures.

Results: A total of 314 knees were tested. 25 knees were excluded because hip centre could not be acquired, 22 were excluded because of age and history of trauma. After exclusion 267 knees were included of which 155 were from male and 112 were female subjects. These belonged to 135 persons of whom 132 recorded bilateral knees. 134 knees were right side and 133 were left.

Mean age was 26.2(SD4.4), 100 knees were from northern part of the country and 167 from southern part of the country.

Mean FTMA was a varus of 1.2 degrees (SD 4.0) in full extension and 1.2 varus (SD 4.4) in 15 degree flexion. On varus stress of 10NM these changed by a mean of 3.1 varus (SD 2.0) and 6.9 varus (SD 2.6) respectively. On valgus stress of 10 NM these changed by valgus of 4.6 (SD 2.2) and 7.9 (SD 3.4) respectively. The supine FTMA changed by a mean of varus 2.2 (SD 3.6) in bipedal stance and 3.4 varus (SD 3.8) in monopodal stance.

The mean range of movement was 146.4 (SD 10.4). On standing, the knee extension increased by 5.6 degrees (SD 6.8) in bipedal stance and by 5.5(SD 7.7) in monopodal stance.

There were variations seen in males and females. The mean male FTMA in extension was 1.7 varus (SD 4) while in females it was 0.4 varus (SD 3.9). The detailed analysis and results will be shown in the presentation.

Discussion: Though the aim in TKR surgery at present is to restore the FTMA to neutral axis, it may not be the best axis for each individual due to large variations that our study has shown. These differ in

males and females. The ligamentous envelop also differs. Thus more needs to be done in order to individualise the alignment for a specific individual. Our study also raises a question on achieving alignment in supine non wt bearing position in TKR surgery as it changes when one stands up. All these questions need to be answered with more studies. There are limitations of our study. The study subjects may be normal but were from one country, so results may not be applicable globally although we had a fairly wide sample of that country. Genetic variations may be present. Our study was based on extra cutaneous attachment of trackers which may not be as accurate as the bony attachment, though these have been validated in a previous study.

Conclusion: The neutral alignment may not be the best for each individual. It also changes with posture as one stands from a non weight bearing supine position. Different alignment goals may be needed in males and females. Our study has laid foundation for future studies needed to clarify the issue of alignment in individuals.