

# Estimated pre-osteoarthritic knee phenotypes in osteoarthritis patients shows an extensive distribution of femoral and tibial coronal alignment

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**Disclosures :** The authors have no competing interests to declare that are relevant to the content of this study

**Purpose :** Personalized arthroplasty is an emerging concept in total knee arthroplasty (TKA). One of the most crucial objective of personalized TKA is restoring joint line and alignment to the patient's pre-arthritis state. The purpose of this study was to investigate the distribution of knee phenotypes in patients undergoing mechanically aligned TKA (MATKA) due to knee osteoarthritis. In addition, we investigated proportion of patients that can be aligned to their original knee phenotypes when undergoing MATKA.

**Methods :** This study included 205 patients with osteoarthritis (OA) who were scheduled for TKA. 36 patients were excluded due to bone defects in the tibial or femoral condyle that caused changes in the joint line. After exclusion, total of 169 patients (249 knees) were eligible for analysis. We measured hip-knee-ankle angle (HKAA), femoral anatomical-mechanical angle (FAMA), femoral mechanical angle (FMA) and tibial mechanical angle (TMA) on a three-dimensional(3D) model of the lower limb. Each parameter with descriptive statistics such as means, ranges, and standard deviations (SD) were calculated. Each knee was categorized according to its measured FAMA, FMA and TMA. For FAMA each knee was classified into a category from  $4^{\circ} \pm 0.5^{\circ}$  to  $8^{\circ} \pm 0.5^{\circ}$  for every  $1^{\circ}$  amplitude. For FMA and TMA, each knee was classified into a category for every  $3^{\circ}$  amplitude from  $87^{\circ} \pm 1.5^{\circ}$  and  $81^{\circ} \pm 1.5^{\circ}$  respectively. Finally each knee's phenotype was identified using the formula FAMA X°- FMA Y°-TMA Z° (X,Y,Z accounting for its category regarding FAMA, FMA, TMA respectively).

**Results:** The mean HKAA was  $174.2^{\circ} \pm 3.4^{\circ}$  and ranged from  $164.5^{\circ}$  to  $184.5^{\circ}$ . The mean FAMA was  $6.3^{\circ} \pm 0.9^{\circ}$  and ranged from  $4.1^{\circ}$  to  $8.5^{\circ}$ . The mean FMA was  $91.7^{\circ} \pm 2.5^{\circ}$  and ranged from  $85.7^{\circ}$  (varus) to  $99.6^{\circ}$  (valgus). The mean TMA was  $85.7^{\circ} \pm 2.5^{\circ}$  and ranged from  $79.5^{\circ}$  (varus) to  $92.8^{\circ}$  (valgus). The most common femoral phenotype was FMA90° ( $88.5^{\circ} \leq \text{FMA} < 91.5^{\circ}$ , 38.4%) and the most common tibial phenotype was TMA87° ( $85.5^{\circ} \leq \text{TMA} < 88.5^{\circ}$ , 37.1%). The most common knee phenotypes were FAMA6°-FMA90°-TMA87° (6.5%). The knee phenotype representing a mechanical alignment target (FAMA6°-FMA90°-TMA90°) was found in only 1.7% of knees.

**Discussion:** Patients with osteoarthritis of knee showed extensive variability in knee phenotypes. Among 125 phenotypes in this new classification system, 249 knees that have been analyzed in this study were classified into 57 phenotypes in total. Considering that MATKA reconstructs patient's knee into a strict alignment boundary of TMA = 90°, FMA = 90° and FAMA = 6°, such alignment strategy could only align 1.7% of patients into their original knee phenotypes in this study. Such results clearly indicates that more personalized approach should be considered in TKA. This new classification system was designed based on the previous functional phenotypes of Hirschmann et al.[1]. However, this system puts FAMA in to consideration, which could provide additional information when planning for MATKA in osteoarthritic patients.

**Significance/Clinical relevance:** Phenotypes of knee in patients undergoing TKA for osteoarthritis showed extensive variability. Another important finding was that MATKA can only restore patient's original knee phenotype only in small number of cases (1.7%). We believe that this detailed knee phenotyping system will provide basic information when undergoing TKA for osteoarthritic patients.

## References

[1] Functional knee phenotypes: a novel classification for phenotyping the coronal lower limb alignment based on the native alignment in young non-osteoarthritic patients. Hirschmann et al. *Knee Surgery, Sports Traumatology, Arthroscopy* (2019) 27:1394–1402