Evaluation of the distribution of Coronal Plane Alignment of the Knee classification in Japan with arthritic and healthy knees

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INTRODUCTION: The Coronal Plane Alignment of the Knee (CPAK) classification has been proposed as a simple system for determining alignment strategies in knee replacement surgery [1]. This classification assesses two criteria: constitutional limb alignment and joint line obliquity (JLO). These factors enable the identification of suitable phenotypes for specific alignment strategies. While the validity and distribution of this classification system have been confirmed in patients from Australia and Belgium, geographic variations exist in the prevalence of CPAK types healthy individuals and those with arthritis [2]. Although the distribution of the CPAK classification has been documented in Japanese patients with osteoarthritis [3], its prevalence in healthy knees remains unclear. This study aims to clarify the distribution of the CPAK classification in Japanese patients with healthy knees, as well as in those with osteoarthritis.

METHODS: The study encompassed two distinct cohorts. The arthritic cohort comprised 150 knees from 125 patients who underwent primary total knee arthroplasty (TKA) at a single institution between January 2018 and March 2023. The healthy knee cohort included 150 knees from 150 patients who underwent either total hip arthroplasty or bipolar hip arthroplasty at the same institution between December 2014 and March 2023. Radiographic methods and measurements were conducted following the methodologies outlined by MacDessi et al. [1,4]. All patients underwent radiological assessments using long-leg radiographs and were classified into nine distinct phenotypes. Several angles were measured, including the lateral distal femoral angle (LDFA), medial proximal tibial angle (MPTA), mechanical and arithmetic hip-knee-ankle angles (mHKA and aHKA), and joint line obliquity (JLO). Two orthopedic surgeons independently performed the measurements, with each measurement being conducted twice. The intra- and inter-observer reliabilities were evaluated by intraclass correlation coefficients (ICCs) using IBM SPSS Statistics (version 29.0; IBM, LTD, Tokyo, Japan). The CPAK classification is predicated on two independent variables: aHKA (varus, neutral, and valgus) and JLO (apex distal, neutral, and apex proximal). Nine phenotypes were categorized from these subgroupings, as described by MacDessi et al. [1]. We investigated the distribution of CPAK classification phenotypes in a total of 300 knees, comprising 150 knees with arthritis and 150 healthy knees. This study was approved by the Institutional Review Board of the Mie University Hospital (H2018-083). Informed consent was obtained from all the patients for the use of their surgical data. All procedures were performed in accordance with the principles of the Declaration of Helsinki.

RESULTS SECTION: Intra- and interobserver reliability for all parameters was high, with ICCs > 0.95 ($p < 0.01$). The mean ages were 63.2 and 61.1 years for the arthritic and the healthy cohort, respectively. The mean LDFA values were 88.1 ° (SD, 2.9 °) and 86.9 ° (SD, 2.2 °) for the arthritic and healthy knee cohorts, respectively. The mean MPTA were 85.2 ° (SD, 4.0 °) and 86.6 ° (SD, 2.0 °) in the arthritic and healthy knee cohorts, respectively. The mean mHKA was -8.0 ° (SD, 10.1 °) and -1.2 ° (SD, 2.9 °) in the arthritic and healthy knee cohorts, respectively. The mean aHKA was -2.9 ° (SD, 5.9 °) and -0.3 ° (SD, 2.9 °) in the arthritic and healthy knee cohorts, respectively. The measurement results are listed in Table 1. In the arthritic knee cohort, most knees were classified as Type I (97 knees, 64.7%), followed by Type II (18 knees, 12.0%), Type III (14 knees, 9.3%), Type IV (10 knees, 6.7%), Type VI (9 knees, 6.0%), and Type V (2 knees, 1.3%) (Figure 3). In the healthy knee cohort, most knees were classified as type II (71 knees, 47.3%), followed by type I (34 knees, 22.7%), type III (26 knees, 17.3%), type V (9 knees, 6.0%), type IV (8 knees, 5.3%), and type VI (2 knees, 1.3%) (Fig.4). Types VII, VIII, and IX were not present in either cohort. CPAK classification is illustrated in Figures 1 and 2.

DISCUSSION: The CPAK classification reported by MacDessi et al [1]. is currently being adopted and used in studies across the globe. There exists considerable geographical variability in the prevalence of CPAK types among healthy and arthritic patients [2]. In this study, over 50% of the knee osteoarthritis were type I (64.7%), similar to the report by Toyooka et al. [3], which illustrated that the distribution of the CPAK classification for knee osteoarthritis in Japan significantly differed from that observed in Australia. MacDessi et al. reported that CPAK phenotypes are similarly distributed in arthritic and healthy cohorts [1]. However, the distribution patterns within the arthritic and healthy knee groups differed in this study. In Belgium, 39.2% of were type II and 15.4% were type V; whereas in this study, 47.3% were type II and 6.0% were type V, with slightly more type II with apex distal JLO and fewer type V with neutral JLO. Previous research has indicated that the LDFA and MPTA values for healthy Japanese knees tend to be smaller compared to those reported in other countries [5]. In this study, the mean LDFA and MPTA values for healthy knees were 86.9° and 86.6°, respectively. These were lower than the mean LDFA and MPTA values of 87.9° and 87.0° in Belgium [6]. These result indicate that the distribution of Type V is small while that of Type II is large in healthy Japanese knees. Our study had several limitations. First, we used full-leg standing radiographs for our measurements, and the flexion contracture and rotational position of the lower extremities may have influenced the measurement outcomes. Second, the effects of hip degeneration could not be excluded. Third, the sample size was small, making further investigations necessary. However, the mean ages of the osteoarthritic and healthy cohorts were similar, and we consider this study meaningful.

SIGNIFICANCE/CLINICAL RELEVANCE: This study clarified the CPAK classification distribution in healthy knees of Japanese individuals, revealing a constitutional difference between arthritic and healthy knees in the study population, which provides valuable information for considering alignment strategies for total knee arthroplasty in the target population.

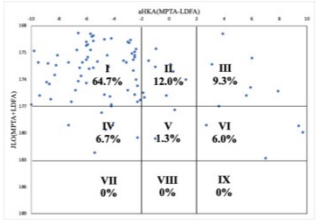
REFERENCES: [1] MacDessi SJ et al, Bone Joint J. 2021. [2] Pagan CA et al, J Arthroplasty. 2023. [3] Toyooka S et al, J Knee Surg. 2023. [4] MacDessi SJ et al, Bone Jt Open. 2020. [5] Wanezaki Y et al, J Orthop Sci. 2023. [6] Griffiths-Jones W et al, Bone Jt Open. 2021.

Table. 1 Measurement results

	arthritic knees	healthy knees
mHKA(°)	-8.0±10.1	-1.2±2.9
Mean LDFA(°)	88.1±2.9	86.9±2.2
Mean MPTA(°)	85.2±4.0	86.6±2.0
aHKA(°)	-2.9±5.9	-0.3±2.9
JLO(°)	173.2±3.6	173.4±3.0

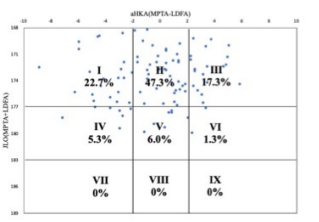
mHKA, mechanical hip-knee-ankle angle; LDFA, lateral distal femoral angle; MPTA, medial proximal tibial angle; aHKA, arithmetic hip-knee-ankle angle; JLO, joint line obliquity

Fig. 1 The distribution of the Coronal Plane Alignment of the Knee (CPAK) classification in cohorts of arthritic knees



aHKA, arithmetic hip- knee-ankle angle; JLO, joint line obliquity; LDFA, lateral distal femoral angle; MPTA, medial proximal tibial angle.

Fig. 2 The distribution of the Coronal Plane Alignment of the Knee (CPAK) classification in the healthy knee cohorts



aHKA, arithmetic hip-knee-ankle angle; JLO, joint line obliquity; LDFA, lateral distal femoral angle; MPTA, medial proximal tibial angle.