Kinematic alignment achieves a more balanced total knee arthroplasty than mechanical alignment prior to soft tissue releases among CPAK type I patients

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INTRODUCTION: In recent decades, the mechanical alignment (MA) method has been the gold standard for TKA alignment. However, this method ignores the natural alignment of patients to place implants uniformly in all patients. Howell et al. introduced the conceptual framework of kinematic alignment, which aims to reproduce the innate "constitutional alignment" of the knee to address the individual differences in knee joint morphology. Currently, there are many reports showing that KA provides better outcomes than MA.

The CPAK classification has become an essential part of the KA method, as it can be used to estimate constitutional alignment even in patients with knee osteoarthritis. Varus aHKA with a medially tilted articular surface is classified as CPAK Type I, and the phenotype has been reported to be the most common in Asia. Although reports have generally suggested that KA leads to a more balanced knee than MA, there are no reports indicating whether KA is superior to MA in Type I patients, which is a phenotypical characteristic that is particular to specific regional populations in terms of balance. Therefore, the purpose of this study was to determine whether KA or MA can achieve balance in CPAK Type I patients, which is the most common in Asia.

METHODS: Data for 127 knees of 88 consecutive patients with knee osteoarthritis who underwent primary TKA were analyzed prospectively. Only those with CPAK Type I were included in this study. Type I patients with an alignment of at least 2° varus aHKA and apex distal JLO of less than 177° medially were selected according to a method described by MacDessi et al. using MPTA and LDFA measurements from preoperative standing whole-leg radiographs.

CT scans were used to develop three-dimensional models of the knees of the patients. During the TKA procedure, the balance of implant placement was simulated using the Mako planning software (Stryker, Fort Lauderdale, FL, USA) prior to the actual osteotomy. The Mako software provided bone resection plans for the preferred implant positioning. To achieve the appropriate balance, the MA and KA plans were applied to the same knee of the patient, the balance after im-plant placement was evaluated, and the difference in balance obtained by fine-tuning the implant position. Each plan was subsequently compared in a simulation.

This study assessed the extension balance (difference between medial and lateral gaps at extension), medial balance (difference between medial extension and medial flex-ion gaps), and overall balance of the knee. Extension balance was defined in the simulation software (Stryker Mako, Fort Lauderdale, FL, USA) as the difference between the lateral component gap under varus stress and the medial component gap under valgus stress in the extended position. Measurements were taken in 10 degree flexion, because the fully extended position is affected by the posterior capsule. In addition, medial balance was defined as the difference between the medial extension gap and the medial flexion gap under manual valgus stress. Although equal gaps were the preferential target, the ex-tension balance and medial balance were considered balanced when the assessed gaps were within 2 mm of each other. The overall balance was considered balanced when both extension balance and medial balance were obtained. The extension, medial, and overall balance of the knees were compared between the KA and MA groups.

RESULTS: One hundred twenty-seven knees of 88 consecutive patients were included in this study.

Extension balance, medial balance, and overall balance with KA and MA are shown in Table 3. In terms of medial balance, 100% of the MA knees and 94% of the KA knees achieved balance, and both groups had a high rate of achievement ($P = 0.01$). An extension balance was achieved in 83% of the KA knees and only 38% of the MA knees ($P < 0.001$). Overall balance was also observed in 75% of the KA knees compared to only 38% of the MA knees ($P < 0.001$). This balance was maintained after prosthesis im-plantation with no significant difference in balance.

DISCUSSION AND CONCLUSION: The most important finding of this study is that in CPAK Type I knees, KA requires less knee soft tissue alteration than MA and can provide a more balanced TKA. If an im-balance of more than 2 mm is observed in this phenotype, which is common in Asian populations, the knee requires soft tissue release to achieve proper balancing of the TKA.

A medial balance was obtained in all patients with MA and 94% with KA. In the present study, simulation software was used to adjust the osteotomy volume to achieve as good a gap as possible. By using this procedure, the difference between the medial extension and flexion gaps might be minimized, and medial balance could have been achieved at high rates in both groups. In actual clinical practice without simulation software, a me-dial balance can be obtained for both the MA and KA by adjusting the remaining osteotomy after creating an extension or flexion gap. The MA technique uses the most prominent joint surface (primarily the medial femoral condyle and lateral tibial plateau) as a reference for resection thickness when making the extension gap, and the technique tends to reduce the extension of the medial gap in varus knees and the lateral gap in valgus knees. With the extension gap, however, a significant balance was obtained in KA at 83% com-pared with MA at 38%. If the MA alignment is maintained, it would be difficult to achieve balance no

matter how implant is adjusted. In varus knees, a perpendicular cut to the mechanical axis results in a gap that is inevitably more open on the lateral side in the coronal plane since the original varus alignment is not maintained.
Among CPAK Type I osteoarthritis, KA achieved a balanced knee, especially in extension, without soft tissue release in a greater percentage of patients than MA.