

キネマティックアライメントによる人工膝関節全置換術において股関節から踵を結ぶ軸 (hip-to-calcaneus axis) を中立に設定することで、歩行周期の初期接地時の後足部冠状面の圧バランスが均等化される

Achieving a neutral hip-to-calcaneus axis in kinematically aligned total knee arthroplasty equalizes coronal hindfoot pressure balance at initial ground contact in the gait cycle

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Aims:

Evaluating plantar pressure distribution and coronal lower limb alignment, including the hindfoot, using the hip-to-calcaneus axis, known as the ground mechanical axis (GA), is valuable in total knee arthroplasty (TKA). This study aimed to compare postoperative changes in plantar pressure distribution and lower limb alignment between mechanically aligned TKA (MA-TKA) and ground kinematically aligned TKA (gKA-TKA), targeting neutral GA.

Methods:

After 1:1 propensity score matching, 35 pairs of patients with end-stage osteoarthritis of the knee, who underwent gKA-TKA and MA-TKA with similar preoperative disability between September 2019 and March 2022, were compared. Plantar pressure distribution during walking and unipedal stance was measured preoperatively and one year postoperatively using a pressure plate. The hip-knee-calcaneus angle (HKC) (positive values = valgus) and the percentage of the GA passing position at the knee joint (%GA; medial edge, 0%; lateral edge, 100%) were assessed on long-leg radiographs in unipedal stance.

Results:

MA-TKA showed a medial loading pattern in the hindfoot. gKA-TKA exhibited a nearly equal pressure distribution in the coronal plane of the hindfoot. Postoperative centre-of-pressure path length during unipedal stance was significantly better for gKA-TKA than MA-TKA ($p = 0.043$). Furthermore, mean HKC angle and mean %GA of the MA-TKA were 2.0° (SD 2.4°) and 54.2% (SD 9.0%), respectively; those of the gKA-TKA were -0.2° (SD 1.0°) and 49.6% (SD 5.0%), respectively. Significant correlations were observed between the HKC angle ($r = 0.391$ (95% CI 0.172 to 0.573)) or %GA ($r = 0.343$ (95% CI 0.117 to 0.535)) and the hindfoot plantar pressure pattern in the coronal plane, indicating that postoperative lower limb valgus deformity in the hip-to-calcaneus axis results in a medial loading pattern.

Conclusion:

gKA-TKA can provide more neutral weightbearing in the GA, more equal coronal hindfoot pressure during walking, and improved stability in unipedal stance compared with MA-TKA.

目的:

人工膝関節全置換術 (TKA) において、ground mechanical axis (GA) として知られる hip-to-calcaneus axis を用いて後足部を含めた足底圧分布および下肢冠状面アライメントを評価することには価値がある。この研究の目的は、中立的な GA を目標とした mechanically aligned TKA (MA-TKA) と ground kinematically aligned TKA (gKA-TKA) における、術後の足底圧分布と下肢アライメントの変化を比較することである。

方法:

2019 年 9 月～2022 年 3 月に gKA-TKA または MA-TKA が行われ、術前に同程度の障害が認められていた末期変形性膝関節症患者のうち、傾向スコアにより 1:1 の割合でマッチさせた 35 組を比較した。術前および術後 1 年の時点で、圧プレートを用いて歩行時および片脚立位時の足底圧分布を測定した。hip-knee-calcaneus (HKC) 角 (正の値は外反を示す) と膝関節での GA 通過位置 (%GA, 内側縁および外側縁をそれぞれ 0% および 100% として示す) を片脚立位全下肢 X 線写真で評価した。

結果:

MA-TKA では後足部の内側荷重パターンが示された。gKA-TKA では後足部冠状面においてほぼ均等な圧分布が示された。片脚立位時の術後の足圧中心の軌跡長は gKA-TKA のほうが MA-TKA よりも有意に短く、良好なバランスを呈していた ($p = 0.043$) [反復測定分散分析]。また、平均 HKC 角と平均 %GA は、MA-TKA ではそれぞれ 2.0° (標準偏差 [SD] 2.4°) と 54.2% (SD 9.0%)、gKA-TKA ではそれぞれ -0.2° (SD 1.0°) と 49.6% (SD 5.0%) であった。HKC 角 ($r = 0.391$ [95% 信頼区間 [CI] 0.172～0.573]) または %GA ($r = 0.343$ [95% CI 0.117～0.535]) と後足部冠状面の足底圧パターンのあいだには有意な相関が認められたことから [Pearson 相関分析]、hip-to-calcaneus axis における術後の下肢外反は内側荷重パターンをもたらすことが示された。[ロジスティック回帰分析による傾向スコアマッチング、対応のある t 検定、 χ^2 検定]

結論:

gKA-TKA は MA-TKA と比較して、GA においてより中立的な荷重が得られ、歩行時の後足部冠状面の圧がより均等になり、片脚立位時の安定性が改善する。

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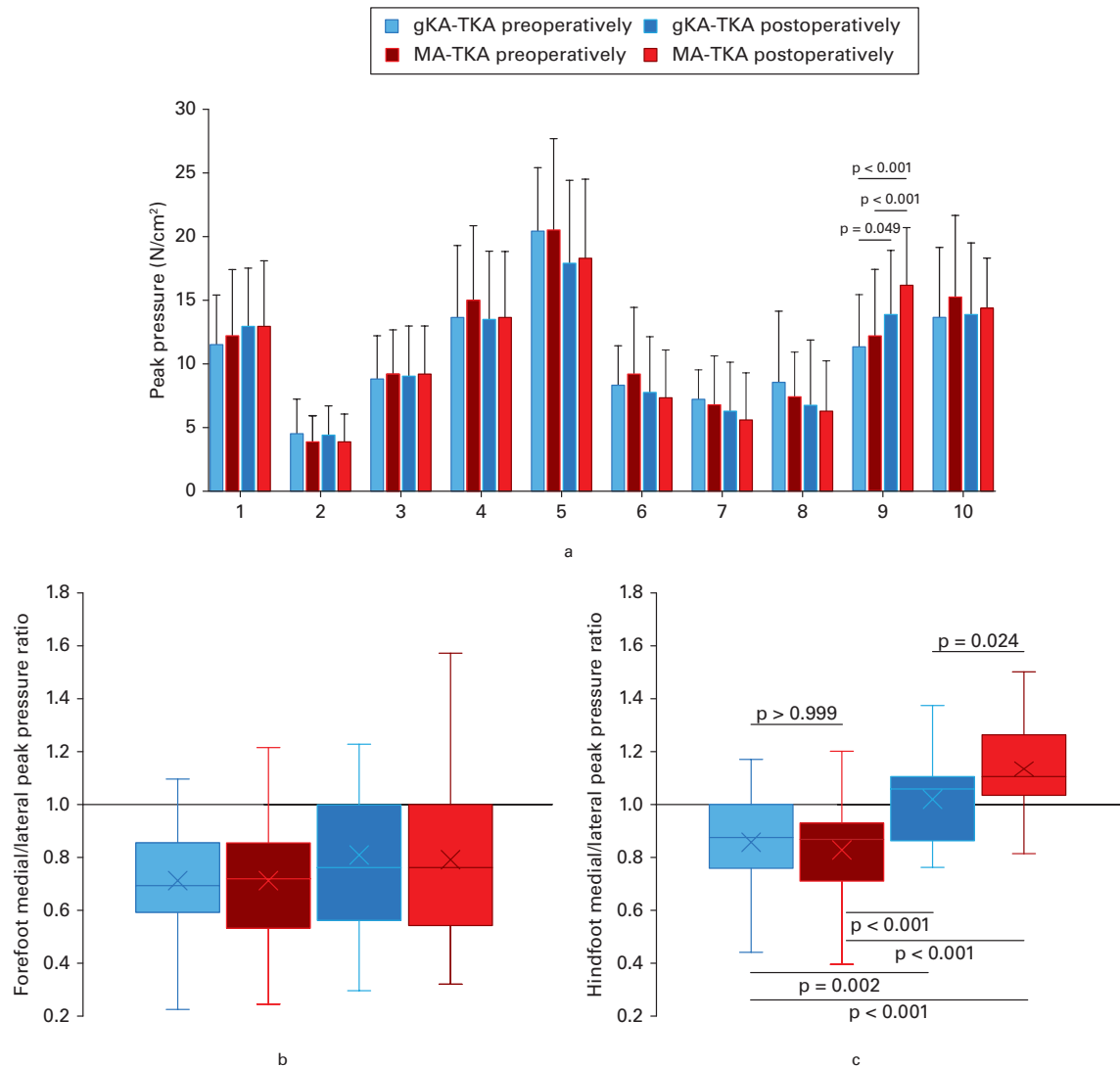


Fig. 5

a) Graph showing the mean peak pressure during walking for all foot regions (1 to 10) in ground kinematically aligned total knee arthroplasty (gKA-TKA) and mechanically aligned total knee arthroplasty (MA-TKA) groups, preoperatively and postoperatively. The anatomical areas corresponding to 1 to 10 are: 1, hallux; 2, second to the fifth toes; 3 to 7, first to the fifth metatarsal; 8, midfoot; 9, medial hindfoot; and 10, lateral hindfoot. b) Graph comparing the forefoot medial/lateral peak pressure ratios during walking in gKA-TKA and MA-TKA groups, preoperatively and postoperatively. c) Graph comparing the hindfoot medial/lateral peak pressure ratios during walking in gKA-TKA and MA-TKA groups, preoperatively and postoperatively. In the box-and-whisker plots, the boxes represent the IQR and the horizontal line inside the box indicates the median. The whiskers extend to the most extreme data points within 1.5 times the IQR from the quartiles. The cross indicates the mean value. Statistical analysis was performed by repeated-measures analysis of variance.