“Unrestricted Kinematic Alignment” Has No Kinematic Advantages During Gait Analysis when Compared to Robot-assisted “Restricted Kinematic” and Mechanical Alignments in Total Knee Arthroplasty

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INTRODUCTION: Despite multiple innovations in implant design, the normal kinematic of the knee, as shown by classical fluoroscopic and dynamic radiostereometric gait analysis studies, is not currently reproduced following total knee arthroplasty (TKA): this finding has been related with decreasing patient satisfaction. TKA surgeons, historically, during alignment of the lower extremity, used a mechanical alignment (MA) surgical technique: unfortunately, this approach routinely alters the constitutional limb alignment, the original joint line obliquity, the joint line distance from the femoral epicondyles, and, finally, the overall soft tissue tension. In searching for the perfect alternative, recently, several surgeons proposed the kinematic alignment (KA) as a technique able to maintain the patient’s knee individual anatomy. Different KA strategies have been recommended, many of them lacking two principles: simplification and reproducibility. To overcome these two major limitations, several robotic systems have been introduced to the market but there is still lack of evidence if the improvement in components placement according to the patient original limb alignment correlates with a closer-to-normal postoperative knee kinematic. The aim of the present randomized, observer-blinded, prospective study was to analyze full knee joint kinematics after robot-assisted, restricted (rKA, ±5° from the neutral Hip-Knee-Ankle axis) and standard unrestricted (uKA) KA TKA. Both a non-arthritic as well as a MA cohort served as references.

METHODS: 75 patients (25 standard medial pivot uKA, 25 medial pivot, robot-assisted rKA, 25 condylar-stabilized MA) and 5 healthy controls were included. All patients had to complete two 3D level walking gait analyses, the first was completed six weeks after surgery (as a control during their rehabilitative period) and the second, one year later (final data gathering), whereas controls needed to complete only a single analysis. The gait analysis was carried out utilizing a modern instrumented treadmill (WalkerView™–WV) equipped with an instrumented belt enriched with 8 load cells, a 48¨ wide LCD screen providing continuous virtual reality/biofeedback, a 3D camera for motion picture (Kinect v2) and a control, 15” touchscreen connected by PC. The WV integrated software utilized for the gait analysis evaluated, in real time, multiple spatiotemporal parameters (cadence, stance/swing times, step time and step length) and kinematic variables (spine, hips and knees ROM). The main spatiotemporal and kinematic parameters recorded were the following: 1) Contact time (sec); 2) Knee ROM during gait cycle; 3) Step length percentage respect to total gait (%) and pure step length (cm); 4) Center of gravity (CoG) variation during gait (cm and %). The Forgotten Joint Score (FJS) and the Knee Society Score (KSS) were collected. Statistical analyses included t-Test and One Way ANOVA in SPSS with post-hoc-analysis to compare joint kinematics.

RESULTS: At final FU, significant differences were noted during gait between TKA patients and controls. 1) Contact time: all TKA groups (uKA-rKA-MA) showed superior mean contact time on the surgical knee (uKA 1s; rKA 0.97s; MA 0.83s) respect to the control group (0.72s) (p=0.002) while no statistical differences were reported between them (p=0.11) (Fig. 1). 2) Knee ROM during gait cycle: all TKA groups showed a lower maximum ROM in the surgical knee (mean uKA 36º; mean rKA 49º; mean MA 43º) respect to the control group (mean 57º) (p<.05); a statistical difference was also found between the 3 TKA groups (p=0.003) (Fig.2). 3) Step length: all TKA groups showed an higher step lenght percentage respect to the total gait and a shorter step length on the surgical-side (uKA: mean 8.28% and mean step-length 35.5cm; rKA: mean 8.38% and mean step-length 34.6cm; MA: mean 9.37% and mean step-length 29.2cm) respect to the control group (mean 3.38%; mean step length 71.4cm) (p<.05) while no statistical differences (NS) were found between them. 4) Center of gravity (CoG) variation during gait (cm and %): all TKA groups (uKA-rKA-MA) showed inferior mean CoG variation during gait (uKA 1.19cm and 1.37%; rKA 1.23cm and 1.46%; MA 1.4cm and 1.23%) respect to the control group (3.08cm and 3.44%) (p=0.002) while no statistical differences were reported between them (NS). Clinically, patients with KA (uKA/rKA) had better final FJS and KSS compared to MA patients (KA: FJS 74, KSS 94; MA: FJS 67, KSS 90; p<.05)

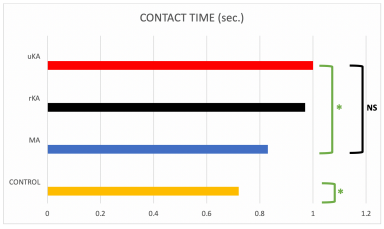

*Fig.1: Contact time (sec.) during gait analysis: the right lower extremity was considered in the control group while the surgical side was considered in each TKA group (unrestricted KA: red; restricted KA: black; MA: blue; control group: yellow). Green bars indicate significant different intervals during the gait cycle (*p=0.002). Black bars indicate NO significant different intervals (NS).*

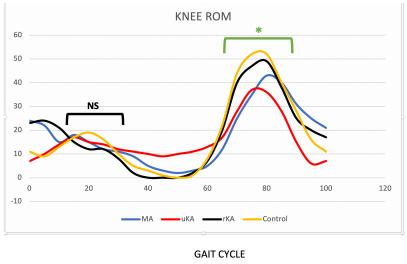

*Fig.2: Knee ROM during gait analysis: the right knee was considered in the control group while the surgical side was considered in each TKA group (unrestricted KA: red; restricted KA: black; MA: blue; control group: yellow). Green bars indicate significant different intervals during the gait cycle (*p=0.003). Black bars indicate NO significant different intervals (NS).*

DISCUSSION: This study compares few parameters of knee kinematics one year after uKA, rKA and MA TKA. All surgical techniques evaluated in this study failed, as shown by other studies, to reproduce a normal knee kinematics: the uKA knees showed an improved knee extension, closer to the controls, in the early stance phase, but failed to maintain it during late stance and showed the lowest maximum ROM during mid-to-late swing; the rKA knees showed the closest to normal ROM during the entire gait cycle; MA knees showed the closest-to-normal (trend, not statistically significant) contact time and CoG variation. Considering all results, in the pure kinematic comparison between uKA and rKA, rKA patients demonstrated better control of their knees in the sagittal plane during level walking, suggesting a more physiological gait pattern one year after TKA. In the clinical comparison between KA and MA, patients with KA were, in this study, more likely to forget about their knee in everyday life and to have a more satisfactory outcome.

SIGNIFICANCE/CLINICAL RELEVANCE: This study confirmed that current TKA surgical techniques and designs are still not able to reproduce a normal knee kinematics. On the other side, the lack of proved kinematic advantages for the uKA compared to the rKA and MA surgical techniques, suggests that the wide use of uKA, with often requires positioning of the implants outside the “safe zone” of ±5° from the traditional Hip-Knee-Ankle axis (historically related to a higher risk of early loosening of the components), should not be recommended.

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