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Case Report

Lateral Instability 13 Years After Kinematically Aligned Total Knee Arthroplasty

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ABSTRACT

To reduce unsatisfied patients following total knee arthroplasty (TKA), kinematic alignment has been introduced as an alternative to mechanical alignment. Studies have shown no significant differences in functional outcomes and early revision rates between alignment strategies. This case report presents a 64-year-old patient who developed progressive varus alignment and lateral instability 13 years after a kinematically aligned TKA. The case highlights the impact of varus alignment on the risk of medial plastic wear and lateral soft tissue attenuation. Both can contribute to lateral instability, a lateral thrust, and progressive varus deformity in unrestricted kinematic alignment TKA. This article suggests that excessive varus alignment should be avoided and restricted alignment targets should be considered when using kinematic, or functional alignment in TKA for varus osteoarthritis.

Introduction

For decades, mechanical alignment (MA) has been regarded as the gold standard in total knee arthroplasty (TKA). The primary objective of MA is to establish a hip–knee–ankle angle (HKA) within ±3° of a neutral mechanical axis (HKA = 0). This alignment strategy is associated with high long-term implant survival rates due to an even load distribution on the components [1-3]. Nevertheless, despite the continued advances of implant designs and materials and surgical techniques, a small percentage of patients remain unsatisfied following mechanically aligned TKA [4,5]. As MA ignores the patient's individual anatomical phenotype, alternative alignment strategies, like kinematic alignment (KA), aim at restoring the individual phenotype of the knee. KA aims at symmetric femoral cuts on the medial and lateral condyle and achieves soft tissue balance by adjusting the tibial cut to recreate a parallel extension and flexion space. The components are then placed to restore the native joint line, trying to minimize the need for a soft tissue release [6,7]. Due to technological improvements in the last years, such as robotic assistance and computer navigation, these highly individualized alignment strategies have become more achievable, as surgeons are able to place the components with greater accuracy [8]. In comparison to MA, KA does not aim for the biomechanically most sound implant alignment but rather preserves the patient's individual alignment. Consequently, some surgeons argue that it leads to better short-term functional and clinical outcomes [9,10], while other studies have been unable to find a significant difference [11-13]. Nevertheless, there has been an ongoing debate about the potential risk of early implant failure in kinematically aligned TKA, given that KA disregards the overall alignment of the lower limb. While short- and mid-term results indicate that KA has no impact on implant survival [14,15], this case report aims to highlight the risk of late implant failure in unrestricted kinematically aligned TKA.

Case history

A 64-year-old woman, with a body mass index of 26.8 kg/m^2, presented with pain and a feeling of instability in her left knee after bilateral TKA in 2011 for advanced osteoarthritis. A Sigma

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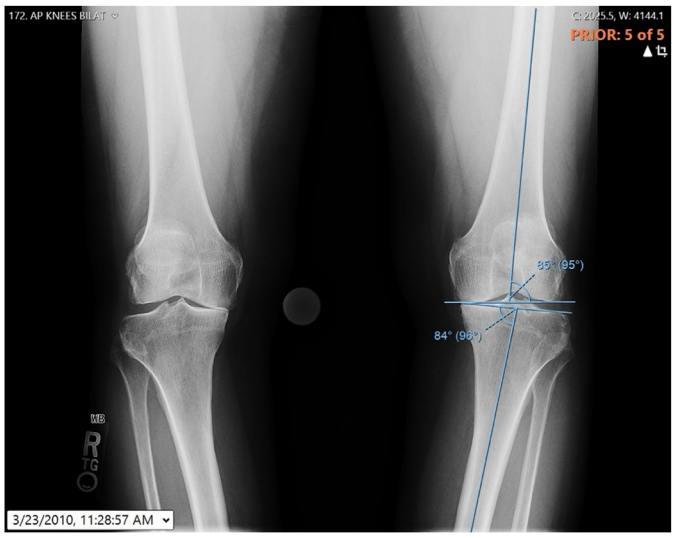

Figure 1. Preoperative anatomic lateral distal femur angle (aLDFA) and MPTA 2010.

cruciate-retaining uncemented total knee system (DePuy Synthes, Warsaw, IN) with a rotating platform was used for both knees (femoral size: 3, tibial size: 3, insert: curved rotation platform 10 mm, patella: 38 mm). The initial surgery was performed at the author's institution. Given the alignment of the right knee and the preferences at the author's institution at the time of surgery, it appears that the surgeon aimed for MA targets at the time of surgery, which resulted in 0° of MA on the right side but 5° of varus alignment on the left side. Measurements confirmed that both the lateral distal femur angles (LDFAs) and medial proximal medial tibia angles remained unchanged, suggesting a kinematically aligned knee. The components were well fixed at the time of revision surgery. The patient initially reported that she experienced no residual pain or functional limitations following the surgery in 2011. She perceived both of her legs as straight early after surgery. In 2022, 11 years after the surgery, she began to experience discomfort after walking long distances and observed a change in the alignment of her left lower extremity, as the knee began to bow out. Over the following 2 years, the patient's symptoms progressively worsened, leading to other people mentioning the increasing bow leg deformity of her left leg. The patient reported that her pain was predominantly localized to the lateral aspect of her knee and was exacerbated by activities such as ascending and descending stairs and walking distances exceeding 3 miles. Furthermore, she began to experience a sensation of instability and reported that, on occasion, her knee would lock during certain bending motions. While she was still able to function in her daily life, she ceased all of her usual sporting activities due to the discomfort and instability. Beside a history of a right total hip replacement in 2011, the patient had no other significant medical history. A clinical examination revealed that the patient had good range of motion in both knees (120°), without any deficit in extension. In comparison to the right knee, the left knee showed severe laxity of the lateral soft tissues. The patient demonstrated a severe varus thrust during walking.

A review of the patient's preoperative radiographs (Fig. 1) revealed a varus deformity of approximately 13° with a medial proximal tibial angle (MPTA) of 84° and a mechanical LDFA (mLDFA) of 92°. Given the absence of full weight-bearing standing hip-to-ankle radiographs, the mLDFA was calculated by adding the anatomical LDFA to the femoral mechanical–anatomical axis angle, which was measured to be 7° on a full weight-bearing standing hip-to-ankle radiograph from 2024. The HKA was calculated using the MPTA, mLDFA, and the joint line congruency angle, which was 5°, resulting in an HKA of approximately 167°. Upon examination of the postoperative radiographs from 2011 (Fig. 2), it was observed that the joint was restored by the surgeon with an almost identical LDFA and MPTA.

The HKA was calculated in the same manner as previously described, revealing that the patient exhibited a varus deformity of approximately 5.5° postoperatively in 2011. Over the subsequent 11-year period, the patient developed a progressive

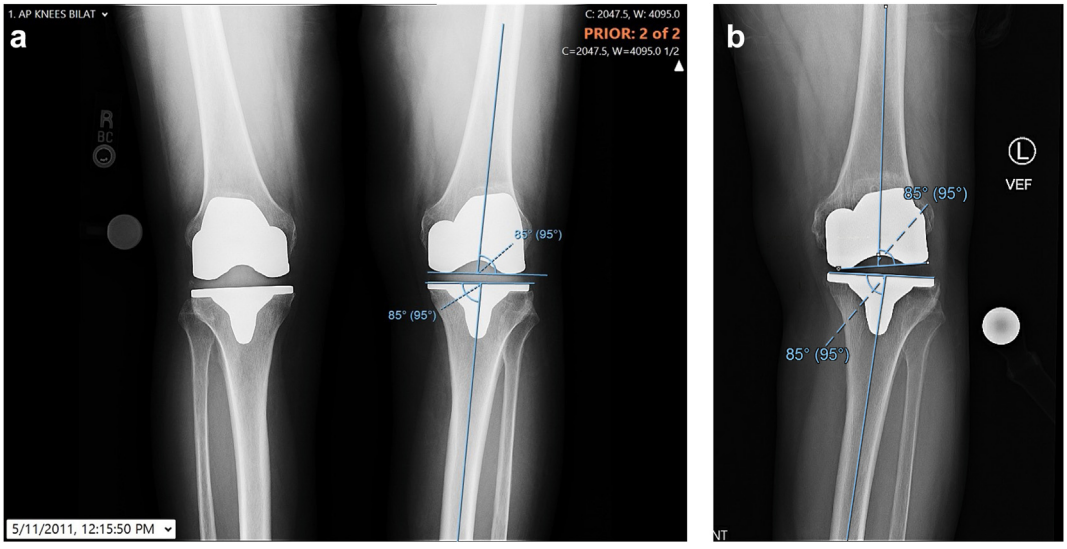

Figure 2. (a) Postoperative anatomic lateral distal femur angle (aLDFA) and MPTA 2011 resembling the preoperative alignment of the knee. (b) There is no change in implant alignment in the images from 2024.

Figure 3. Postoperative radiographs in 2024, showing increasing lateral opening and varus deformity.

varus deformity of 11° (Figs. 3-5). The increasing deformity resulted in an increasing moment arm of the ground reaction force (GRF) (Fig. 6) accompanied by increasing instability of the knee displayed by the increase in the joint line congruency angle to 5° and evidence of an increase in the lateral space between femoral component and tibial tray. After the surgery, there was a symmetric space of 6 mm medial and 6 mm lateral that changed to 4 mm medial and 9 mm lateral at the 13-year follow-up. The patient underwent surgery including both component revision. At the time of surgery, both the medial plastic wear (Fig. 7) and excessive lateral laxity (Fig. 8 and Video) were documented. During surgery, the stretched-out lateral soft tissue envelope was reconstructed by using 5-mm distal femoral augments medial and laterally and also using medial and lateral 5-mm tibial augments (Fig. 9).

Discussion

In a recently published meta-analysis including 26 studies from 2014 to 2024, Van Essen et al. [16] examined the discrepancy between mechanically and kinematically aligned TKA with respect to clinical outcome and complications. A comparison of different patient-reported outcome measures indicated that KA tended to achieve better or similar scores within the first 2 years of follow-up. However, all statistically significant differences were minimal and not clinically relevant. This finding is supported by other recent studies [11-13], which collectively suggest that there is no significant difference between KA and MA in terms of the clinical outcome for the patient. No statistically significant difference was identified in major complications between MA and KA. However, the majority of the included studies presented results for a relatively short- to mid-term follow-up period, with a mean follow-up ranging from 12 to 96 months.

At a mean follow-up of 6.3 years, Howell et al. [15] found that varus alignment of the tibial component, as well as the lower limb, did not affect implant survival. The HKAs of the included patients ranged from −10° valgus to 8.5° varus. Implant survivorship was 97.5% after a 6-year follow-up period. However, there is a lack of consensus in the literature regarding the elevated risk of early implant failure in kinematically aligned TKA [17,18]. Therefore,

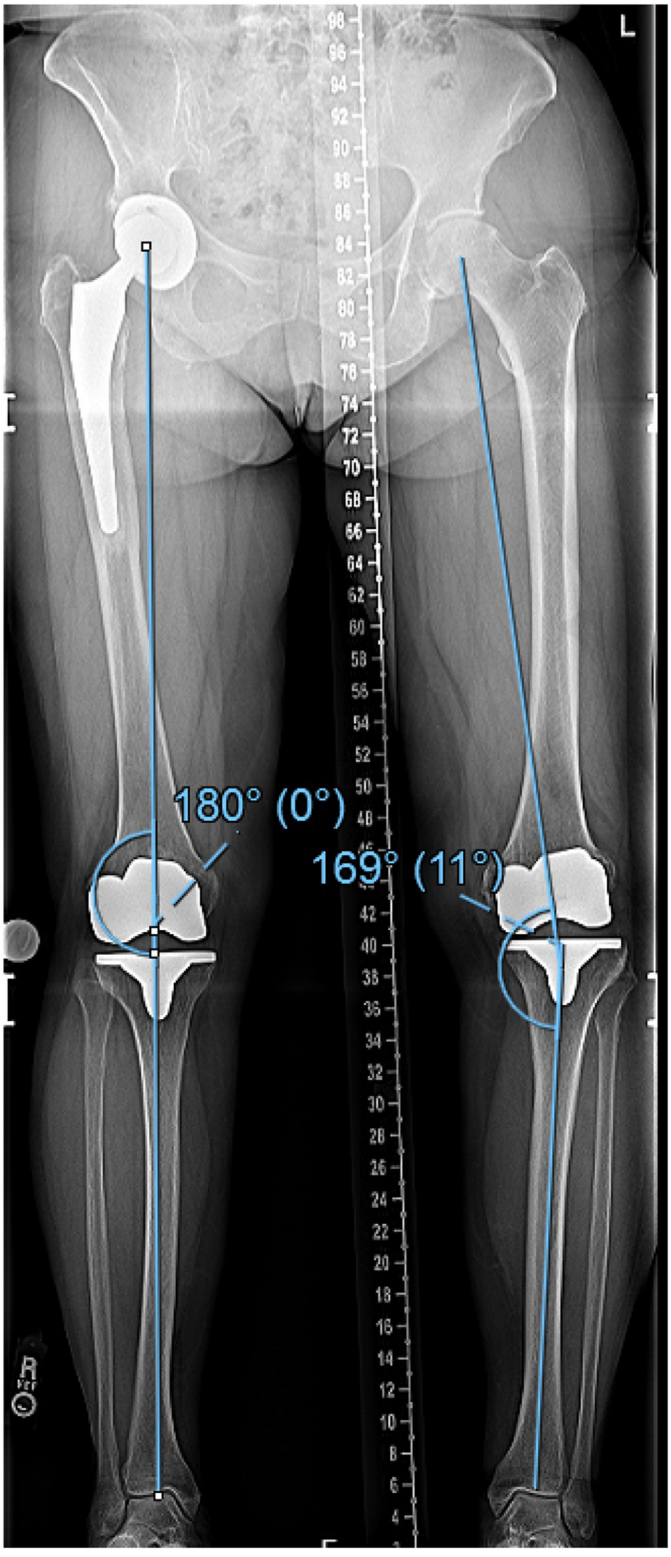

Figure 4. Postoperative hip-to-ankle radiographs showing 11° of varus deformity of the left knee compared to 0° of the right knee at the time of the last follow-up in 2024.

further research is needed to better understand the long-term risks of unrestricted alignment targets.

Despite the absence of long-term results, a review of the literature on biomechanics indicates that knees with severe varus alignment, when kinematically aligned, are more susceptible to

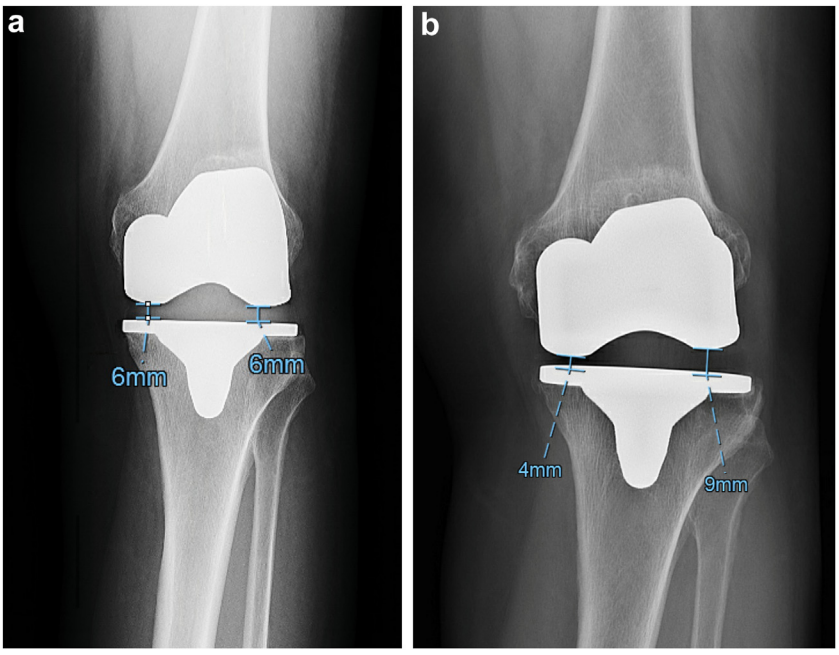

Figure 5. Comparison of preoperative distances between femoral and tibial component on (a) preoperative and (b) postoperative images.

developing secondary instability than those with MA. The knee adduction moment (KAM) is mostly determined by the GRF, which acts medial to the knee joint center and the distance between the GRF vector and the center of the knee joint. Accordingly, KAM can be modified by an increase in patient weight or a longer moment arm between the GRF and the center of the knee joint, as observed in a leg with varus deformity [19,20]. Indeed, previous research has demonstrated a positive correlation between KAM and the contact force between the medial femur and tibia [21]. As KAM is a force that internally rotates the tibia, it is considered to be related to the pathogenesis of lateral soft tissue laxity and the development of varus thrust in osteoarthritic varus knees [22,23]. As the GRF is the same for both legs in our patient, the only difference in KAM between both knees is the length of the moment arm, which is determined by the HKA of each leg. When standing on the left leg, the patient's GRF was distributed more medially compared to when standing on the right leg. This is likely the result of a change in her right HKA following her

Figure 6. GRF as vector and its moment arm.

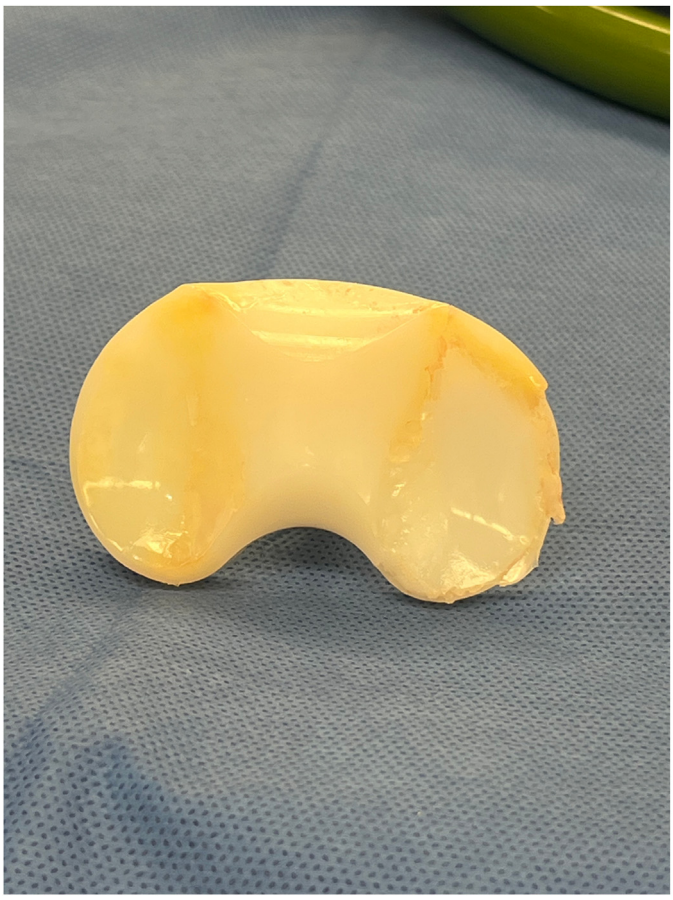

Figure 7. Medial plastic wear at the time of revision surgery.

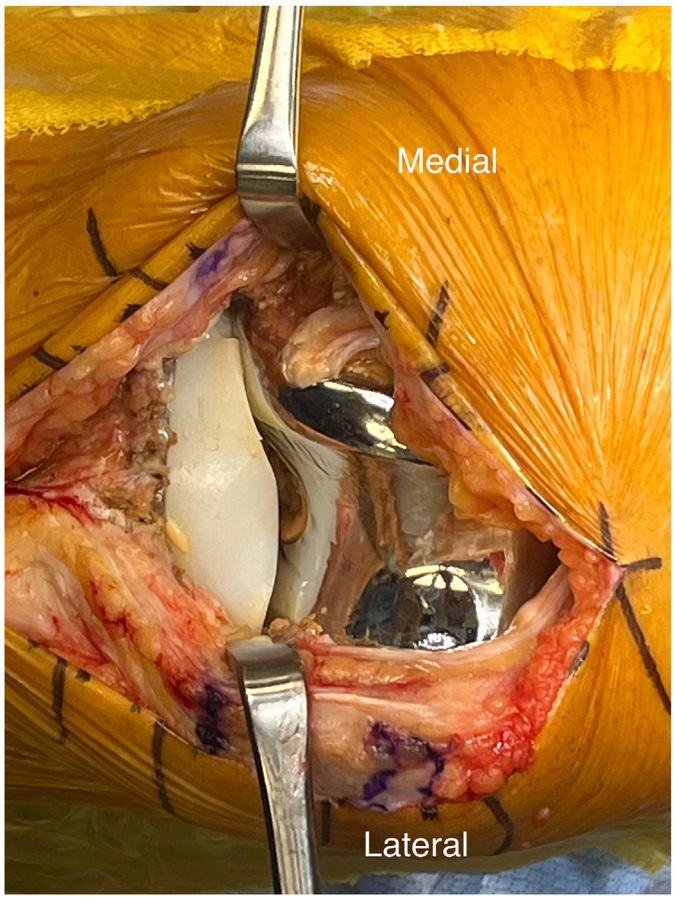

Figure 8. Lateral laxity at the time of revision surgery.

right hip replacement in 2011 which reduced the offset of the hip and positively influenced the alignment on the right side. Therefore, the moment arm for the GRF was smaller on the right side, resulting in a lower KAM and less stress on the lateral soft tissues [24]. The increased KAM is likely the source of medial plastic wear and increasing instability in the left knee (Fig. 6). Given the widespread use of KA and many surgeons advocating unrestrictive KA targets of more than 5° varus, the current case raises considerable concern about the long-term viability of this alignment concept. While varus alignment might not necessarily result in loosening the increasing lateral soft tissue laxity, medial plastic wear and progressive varus alignment put some of these patients at the risk of revision down the road.

Summary

This case report details the case of a 64-year-old woman who developed severe secondary varus instability and lateral knee pain 11 years after undergoing bilateral knee surgery due to advanced osteoarthritis. The patient underwent KA and reported an initial favorable postoperative outcome. While the mechanically aligned right knee remained unchanged, the kinematically aligned left knee subsequently developed plastic wear and lateral instability (Fig. 2a and b, Figs. 7 and 8). The cases suggests that unrestricted alignment targets resulting in more than 5° of varus, while providing favorable early outcomes, might ultimately result in increased plastic wear and lateral soft tissue laxity.

Conflicts of interest

Dr. F. Boettner receives royalties from Ortho Development Inc.; is a paid consultant for Ortho Development Inc. and J&J Depuy; and receives stock or stock options in AccuPredict Inc; all other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2025.101674

Informed patient consent

The authors confirm that written informed consent has been obtained from the involved patient or if appropriate from the parent, guardian, power of attorney of the involved patients; and, they have given approval for this information to be published in this case report (series).

CRediT authorship contribution statement

Oliver Haider: Writing – original draft, Visualization, Formal analysis, Data curation, Conceptualization. **Tobias Scheidl:** Writing – original draft, Visualization, Formal analysis, Data curation, Conceptualization. **Christian Manuel Sterneder:** Writing – review & editing, Resources, Investigation, Formal analysis, Data curation. **Friedrich Boettner:** Writing – review & editing, Supervision, Conceptualization.

Figure 9. Anterior-posterior radiograph at the time of the 4-week follow up after revision TKA.

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