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Surgical Technique

Calipered Kinematically Aligned Medial Unicompartmental Knee Arthroplasty: A Surgical Technique

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ABSTRACT

This study presents a surgical technique for kinematically aligned medial unicompartmental knee arthroplasty with the MOTO (Medacta Corporate, Switzerland) partial knee implant. This technique aims to replicate the native medial femoral and tibial morphology by providing caliper-verified bone resections and kinematic alignment principles. The paper provides a comprehensive overview of the surgical steps and discusses the implications for implant longevity.

Introduction

Surgeons worldwide are exploring personalized approaches in total knee arthroplasty (TKA) to achieve optimal function, satisfaction, and "forgotten" knee sensation [1,2]. Among these approaches, the original kinematic alignment (KA) technique described by Howell aims to restore the precise alignment of the femoral and tibial components along the 3 axes and joint lines of the native knee without ligament releases and with caliper-verified checks of the osseous resections [3-6].

For patients with osteoarthritis limited to a single compartment, unicompartmental knee arthroplasty (UKA) is a valuable option, with survival rates between 88% and 98% at a 10-year follow-up period [7-9]. The alignment of the limb is a crucial factor linked to the need for UKA implant survivorship. Preoperative native varus alignment has been associated with an increased risk of implant loosening, while valgus alignment has been linked to the progression of osteoarthritis in the knee [7]. Recent studies have also found that a postoperative hip-knee-ankle angle outliers are exposed to higher risk of tibial implant failure by 5 times [10]. Therefore, performing a medial UKA in patients with a neutral lower limb axis and reproducing the native angles appears to enhance implant survivorship. In total knee arthroplasty surgery, the calipered KA technique has been consistently demonstrated to accurately replicate the native mechanical medial proximal tibial angle (mMPTA) and mechanical lateral distal femoral angle [11,12]. The current study presents a surgical technique for calipered kinematically aligned medial UKA using the MOTO partial knee implant (Medacta Corporate, Switzerland), where 3 cuts are made in the femur and allows the verification of distal and posterior cut using a caliper.

This technique features a fixed-bearing, round-on-flat design intended to replicate the native shape of the medial femur and tibia. Also, this implant offers a wide range of sizes for fine adaptation to bone resections according to the principles of KA.

Surgical technique

The sequence of performing medial KA-UKA with MOTO instrumentation is similar to the conventional mechanical alignment technique.

The stepwise approach for performing MOTO medial KA UKA is illustrated in Figure 1.

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The existing instrumentation for the UKA requires the initiation of the tibial cut, which is different from the approach used in the KA TKA. Since the mMPTA is often slightly varus or neutral in appropriate indications (inlier patients), to reproduce native mMPTA, the use of an extramedullary tibial guide requires a reference point for the center of the ankle joint. Anatomical investigations have shown that the tibialis anterior tendon (TA) is a reproducible landmark for the center of the tibiotarsal joint [13].

The patient is positioned supine with lateral support, and the TA is marked on the sterile stockinette (Fig. 2).

Once the tourniquet is inflated, a mini-medial parapatellar approach is performed [14].

The femoral chondral wear is assessed, and any remaining cartilage is removed (Fig. 3).

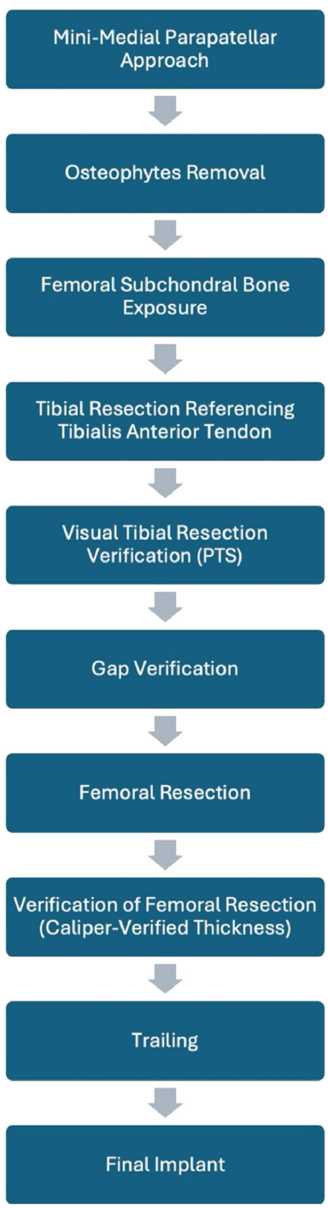

Figure 1. Stepwise approach to medial caliper-verified KA UKA using MOTO implant. PTS, posterior tibial slope.

Figure 2. Employing the tibialis anterior tendon as a reference for the center of the tibio-tarsal joint: the reference point at the tibialis anterior tendon is identified by palpation and marked while preparing the surgical field.

Tibial resection

The tibial resection is initially a preliminary cut, modifiable later. The extramedullary alignment guide is assembled with the goal of making the tibial cut as minimal as possible, considering the minimum total tibial thickness of the implant, which, for MOTO implant, is 8 mm. The strategy for a correct positioning of the tibial cutting guide is displayed in Figure 4.

The sagittal alignment has to be checked with an angel wing tool to replicate the native posterior tibial slope. The minimally invasive approach makes this phase more challenging than in TKA. However, it serves as a preliminary cut with the possibility of slope adjustment after visual evaluation of the resection. The coronal alignment references the TA. The guide is secured with 2 pins, and a spacer is used to confirm placement; ideally, upper medial aspect of the spacer should align with the superomedial part of the tibial plateau (Fig. 5).

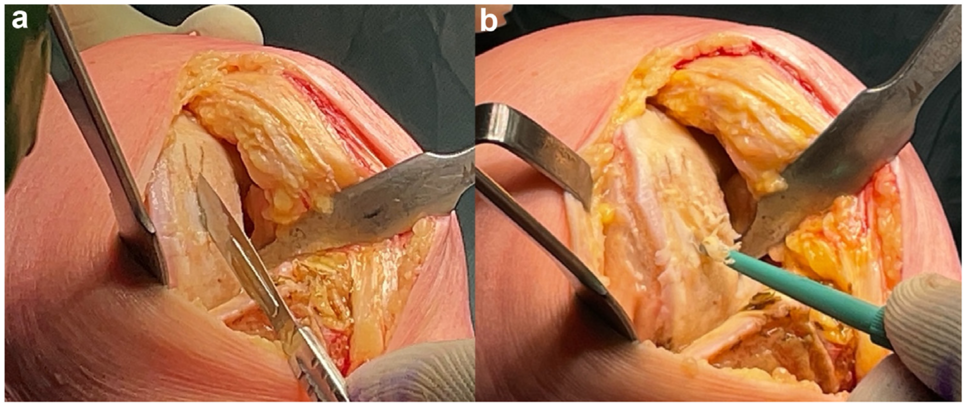

Figure 3. Assessment of femoral cartilage wear. (a) The thickness of the remaining cartilage is determined by inserting a scalpel; (b) Any residual cartilage is excised using a curette.

This evaluation uses the minimal gap spacer that is available (8 mm). The results of this verification can lead to a variety of scenarios, as shown in Figure 6.

This is conducted using the minimal gap spacer (8 mm). Ideally, upper medial aspect of the spacer should align with the superomedial part of the tibial plateau, which is used as a reference point.

The preliminary cut is followed by a verification of the tibial resection. This allows the size of the plateau to be determined as well as whether the posterior tibial slope (PTS) is correct (Figs. 7 and 8).

After achieving the desired PTS, the flexion gap is evaluated at 90° using the gap spacer sized 8 mm. The authors aim for a valgus opening of approximately 1 mm in flexion and adequate resistance to traction (Fig. 9).

The senior author employs an original technique—the “traction sign”—to evaluate the resistance. This involves inserting the gap spacer and assessing its fit with and without a manual distraction of the joint. If the spacer resists traction but yields when a distraction is applied, it indicates an appropriate size. Conversely, a lack of resistance without distraction of the knee implies the spacer is too thin, whereas persistent traction even with femur elevation suggests the spacer is excessively thick. This can be used for both flexion gap assessment with femoral elevation and extension gap assessment with leg traction (Fig. 10). In extension, the gap is tested with a 2 mm thicker spacer to account for cartilage wear. Also in extension, a slight valgus (approximatively 1 mm) and modest pulling resistance of the gap spacer to traction are sought.

Femoral resection

Since KA is a "resurfacing" of the knee joint, the femoral cut must match the thickness of the femoral implant, taking into account cartilage wear. Therefore, when using the MOTO Medacta implant, the distal cut should be 4 mm (3 mm thickness plus 1 mm saw blade), allowing for 2 mm of cartilage wear.

After completing the distal resection, this is verified with a caliper.

If the thickness is less than 4 mm (3 mm plus 1 mm for the saw blade), as may occur in severely sclerotic bone, recutting will be required. Then, the extension gap is tested with a space block corresponding to the total thickness of the femoral implant (which is 6 mm in this instance) and the thickness of the total tibial component. For this purpose, a 14-mm spacer is employed (Fig. 11).

The femoral component size is determined with traditional technique. However, following KA principles and allowing for negligible posterior wear, the posterior cut should always be 6 mm. To achieve this cut depth, the shim −2 in conjugation with the femoral cutting block of the chosen size must be used with this implant (Fig. 12).

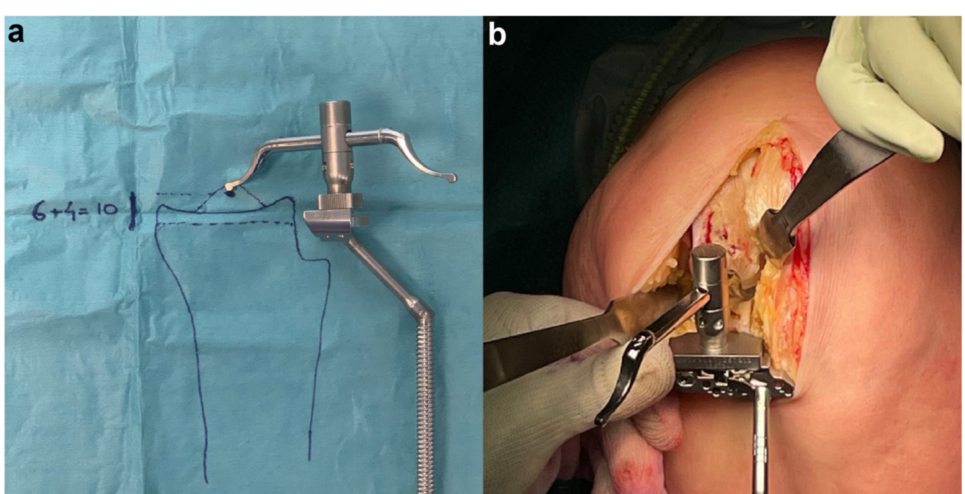

Figure 4. Illustration of the setting of tibial cutting guide. (a) Positioning a +4 mm stylus with a 6 mm base at the base of the medial tibial for placing the cutting guide at a 10 mm depth, allowing for a more adaptable configuration for subsequent adjustments; (b) intraoperative photograph depicting the positioning of the stylus.

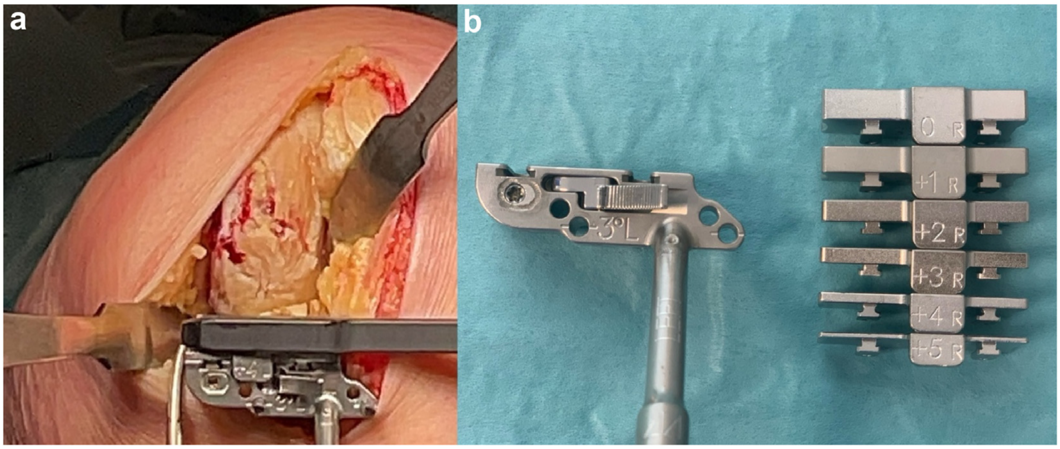

Figure 5. Cutting guide placement. (a) Use of a gap spacer to verify the adequacy of coronal bone resection; (b) use of the appropriate thickness of shims to proximalize the resection, or use of the 2 proximal pin holes of the cutting guide for a 2 mm distalization.

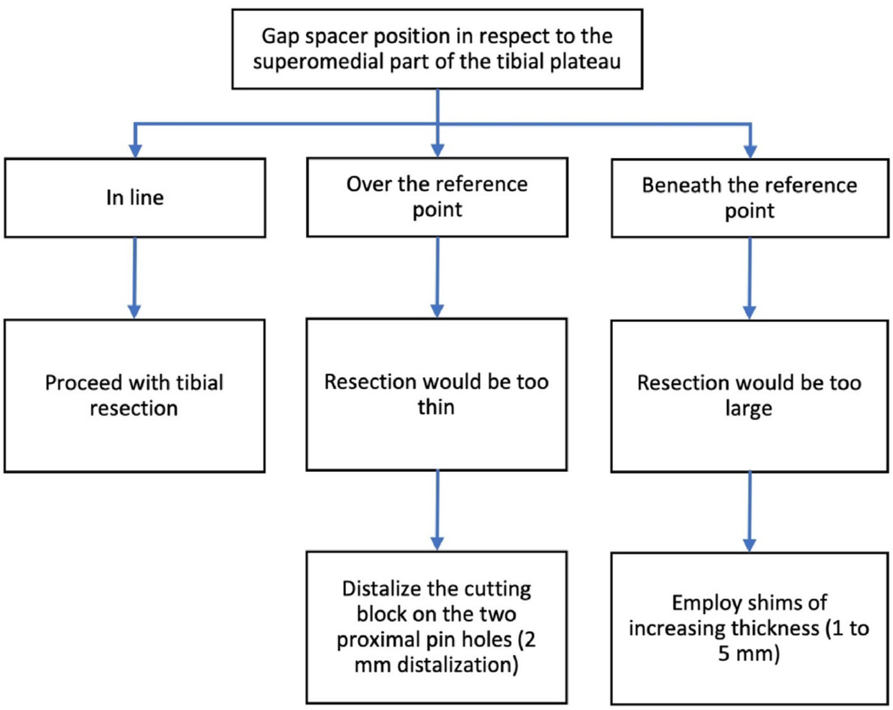

Figure 6. Flow diagram verification prior to tibial resection and subsequent decision-making steps.

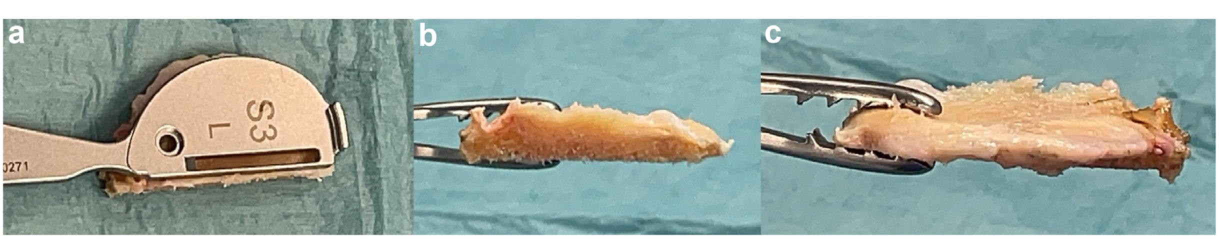

Figure 7. Examination of the tibial resection. (a) Assessment of the tibial size using the specific template; (b and c) confirmation of the posterior tibial slope (PTS).

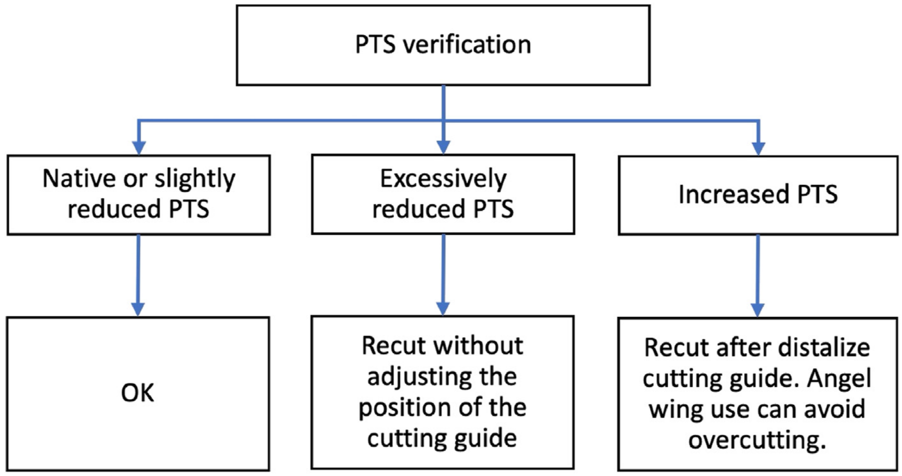

Figure 8. Flow diagram of the posterior tibial slope (PTS) verification process after tibial resection and subsequent decision-making steps.

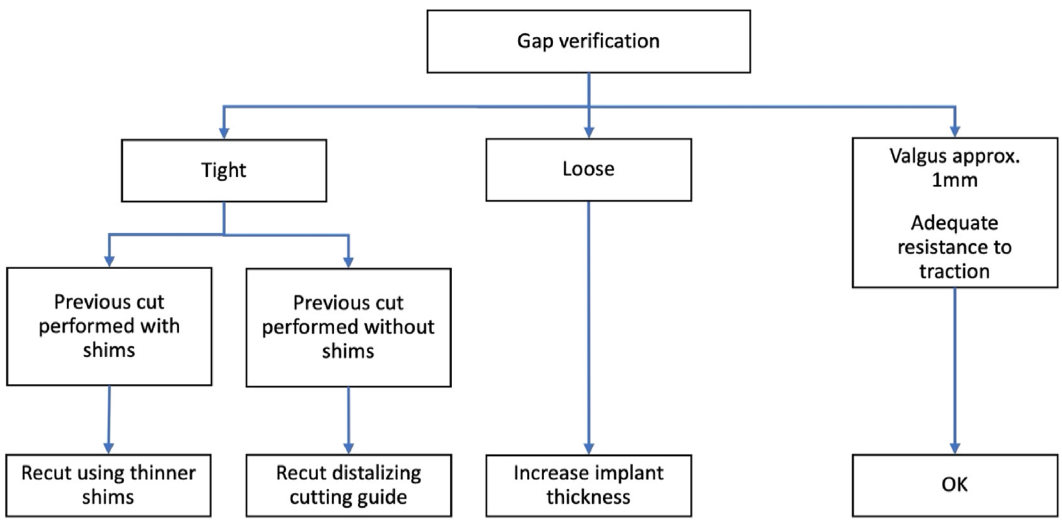

Figure 9. Flow diagram of the gap verification process after tibial resection and subsequent decision-making steps.

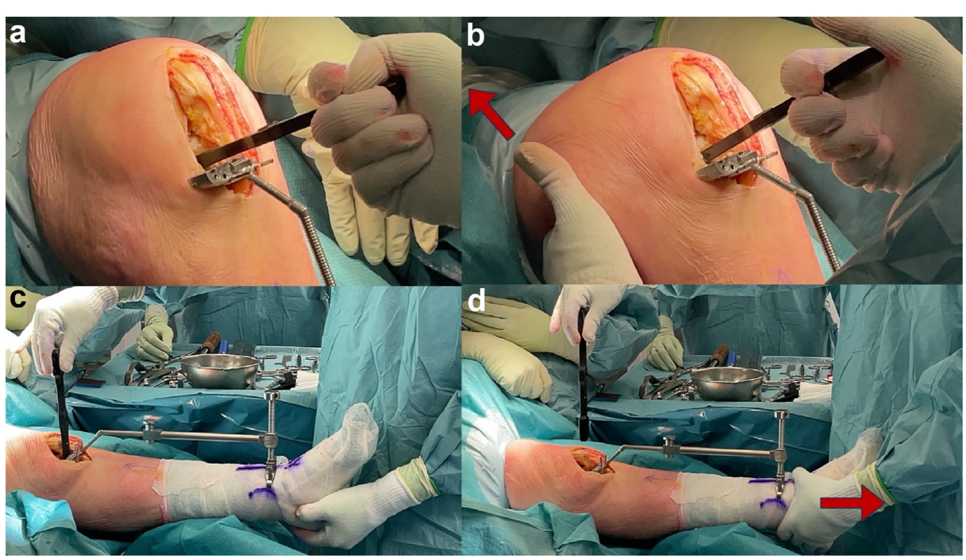

Figure 10. Illustration of the "traction sign." (a) In flexion, the gap sizer is subjected to traction, and resistance to this traction is observed; (b) while in flexion, the femur is elevated, leading to the gap spacer disengaging effortlessly; (c) in extension, traction is applied to the gap sizer, again noting resistance to the traction; (d) when in extension, the tibia is distracted, resulting in the gap spacer being removed without resistance. The red arrow indicates the direction of the traction.

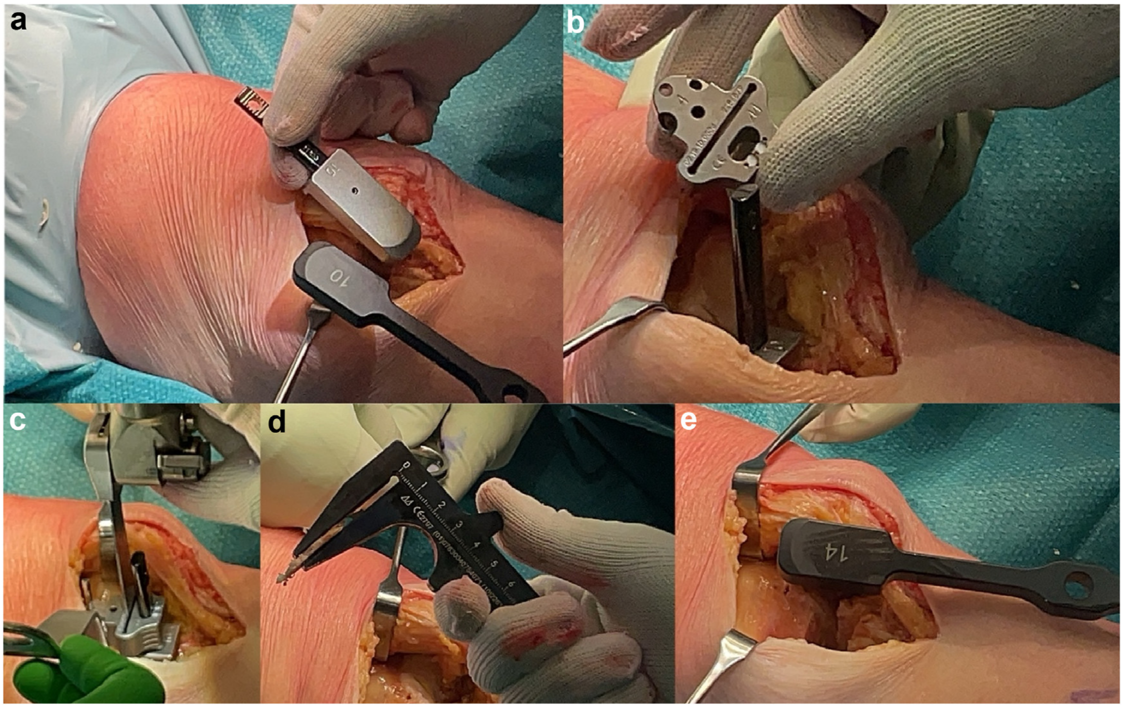

Figure 11. Execution of the distal femoral cut. (a) Selection of a distal spacer block matching the gap spacer size; (b) securing the spacer block to a 4mm distal cut guide using a connector rod; (c) performing the distal femoral cut with an oscillating blade; (d) measurement of the distal femoral resection thickness utilizing a caliper; (e) choice of a gap spacer size corresponding to the total of the distal femoral cut and the total tibial thickness.

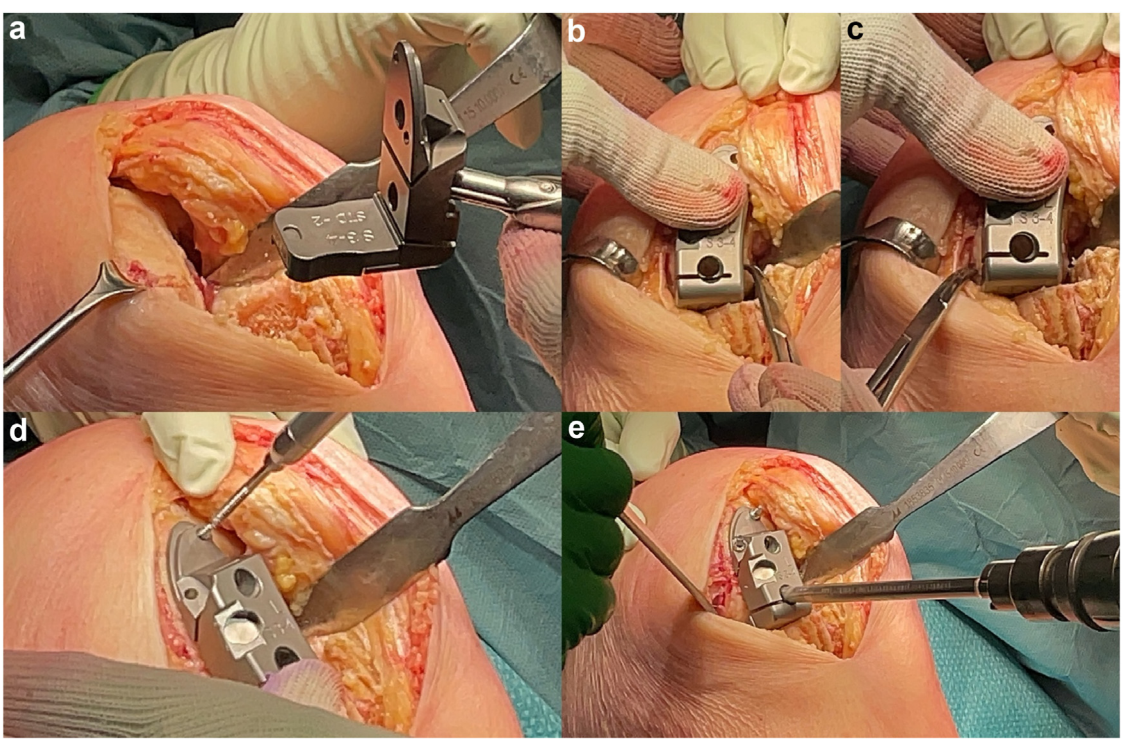

Figure 12. Femoral cutting block placement. (a) The cutting block is coupled with a shim (−2) leading to a line-to-line cut; (b and c) check of the cutting block contour, both in the medio-lateral and antero-posterior directions; (d) once the optimal coverage has been obtained, pins are placed in the upper and lower fixation holes; (e) finally, the peg holes are drilled through the dedicated holes.

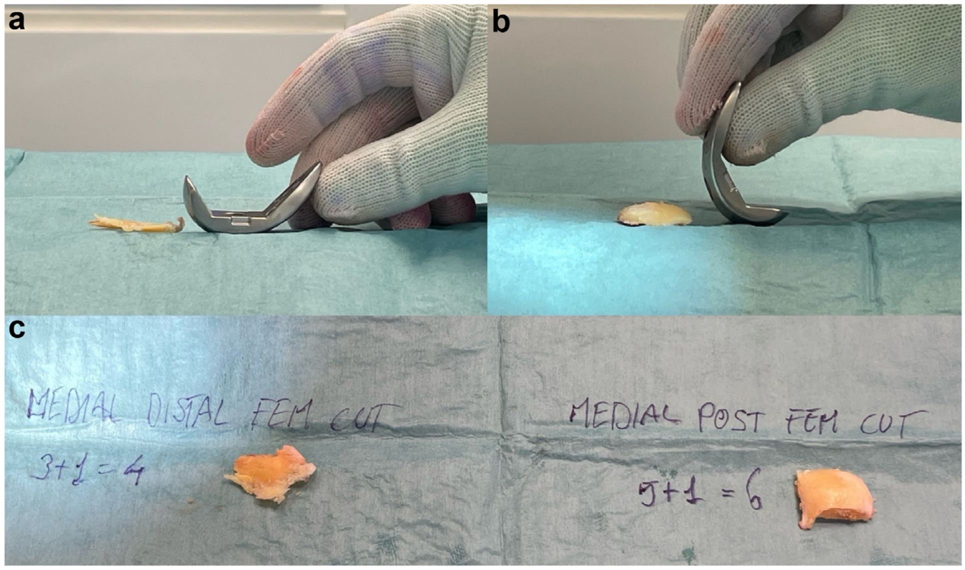

Figure 13. Inspection of distal and posterior cuts. (a) Distal femoral cut; (b) posterior femoral cut; (c) overview of both cuts (measurements provided in millimeters).

To maintain the stability of the cutting block, after ensuring it with 2 pins, the sequence of cuts should be as follows: 1) drilling for pegs; 2) making the chamfer cut; and 3) executing the posterior cuts. After confirming the proper depth of the posterior femoral cut (Fig. 13), the remaining steps, which include completion of the tibial preparation, trial fitting, and final implant placement, are consistent with and do not differ from the standard MOTO UKA mechanical alignment technique. The radiographic appearance of a KA UKA is reported in Figure 14.

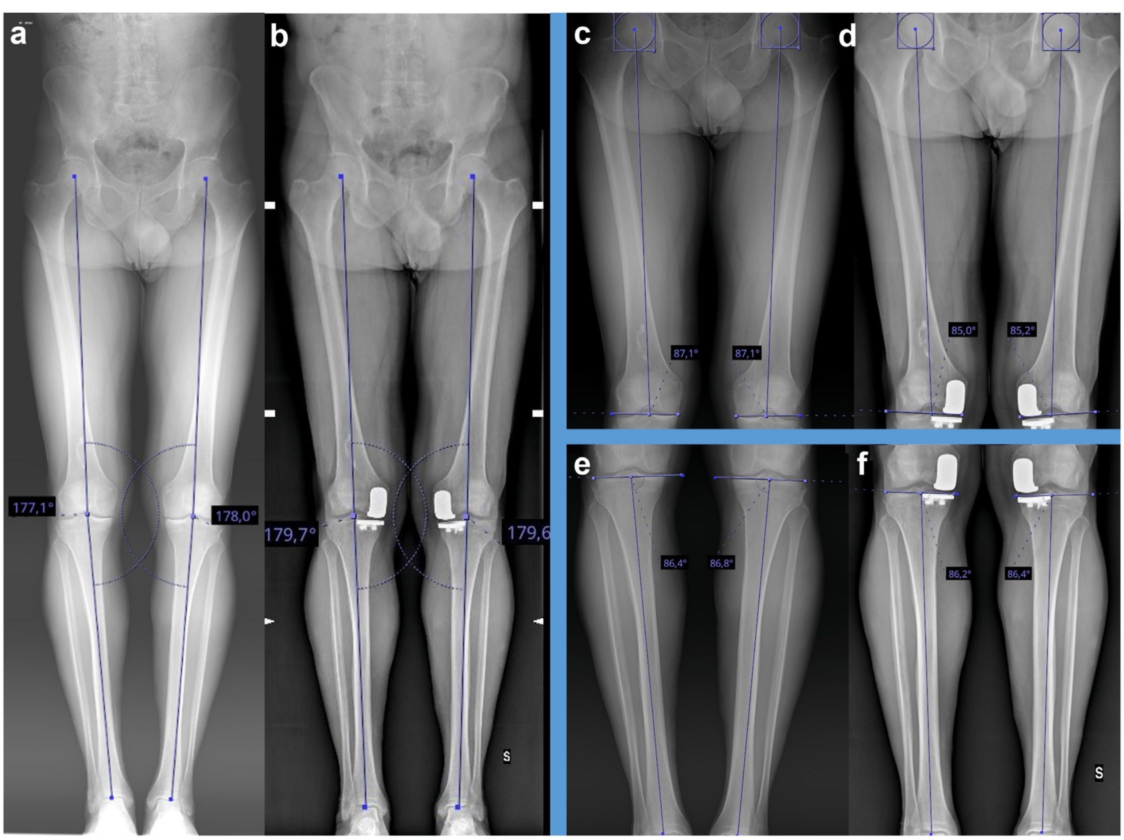

Figure 14. Preoperative and postoperative radiographs after a bilateral simultaneous KA UKA. (a) Preoperative hip-knee-ankle angle (HKA); (b) postoperative HKA; (c) preoperative lateral distal femoral angle (LDFA); (d) postoperative LDFA; (e) preoperative medial proximal tibial angle (MPTA); and (f) postoperative MPTA. Postoperative radiographic evaluation shows restoration of the lower extremity angles compared to the preoperative status. The slight difference in HKA and LDFA with respect to the implant replacing both bony and cartilaginous tissue, resulting in a discrepancy in measurements compared to the native knee, which is based solely on bony structures without consideration of cartilage depth.

Discussion

The current study presents a surgical technique for calipered kinematically aligned medial UKA. This implant, in contrast to other KA UKA techniques with different implants, permits the verification of every femoral cut with caliper, according to unrestricted caliper-verified KA principles.

The measurements of the femoral resection cuts are essential, as the femur serves as the reference point. The femur has to be the reference for accurately co-aligning the femoral and tibial components with the 3 axes and joint lines of the native knee without ligament releases, similar to in KA TKAs [3]. Given that femoral wear is exclusively chondral and predictable, it is primarily accounted for the distal femoral level while being considered negligible posteriorly [15]. The negligible nature of posterior wear permits to start the cuts for UKA with the tibial cut, diverging from the typical approach in KA TKA, and allows you to define the final thickness of the polyethylene insert. The tibial cut follows the Cartier axis and is executed with a depth equivalent to the minimum thickness of the implant in flexion, maintaining the native PTS.

In extension, the distal femur has a predictable wear; typically, 2 mm of cartilage is considered [15,16]. Based on this KA principle, the gap spacer has to correspond to implant thickness used in flexion increased by 2 mm. Therefore, it is crucial to select an implant designed for measurable femoral cuts using a caliper. Rivière et al. recently detailed a calipered KA technique for implanting a Medial Oxford UKA, reporting encouraging short-term results [17]. However, in our opinion, with this type of implant, it is not possible to verify the distal femoral cut with the caliper. In respect to the tibial resection, unlike the technique described by Rivière et al., caliper measurement is not performed because of its lack of reproducibility due to the concave nature of the tibial plateau and the absence of the meniscus.

Further studies are necessary to evaluate whether, following KA principles for UKA, this technique accurately replicates the patient's native angles, including assessing whether the tibial cut corresponds with the Cartier axis.

Summary

Unrestricted, caliper-verified KA principles can also be applied to medial UKA. The described technique aims to accurately restore the native anatomy and alignment of the knee. However, further investigations are needed to better define the reproducibility and clinical impact of this surgical technique.

Conflicts of interest

M. Malavolta is a consultant for Medacta. A. Carrozzo is an editorial board member of the BMC Musculoskeletal Disorders journal. All other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2024.101470.

CRediT authorship contribution statement

Michele Malavolta: Writing – review & editing, Methodology, Data curation, Conceptualization. **Alessandro Carrozzo:** Writing – review & editing, Writing – original draft, Conceptualization. **Silvio Mezzari:** Writing – review & editing, Methodology. **Gianpietro Lista:** Writing – review & editing, Data curation, Conceptualization. **Alberto Residori:** Writing – review & editing, Conceptualization.

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