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RESEARCH

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# Research on the biomechanical characteristics of the tibiofemoral joint before and after kinematic alignment unicompartmental knee arthroplasty

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## Abstract

**Background** Kinematic alignment (KA) unicompartmental knee arthroplasty (UKA), which has not been widely adopted in clinical practice, aims to implant a more personalized and physiologically compatible mobile-bearing UKA prosthesis for the treatment of advanced single compartment knee osteoarthritis. KA UKA is anticipated to enhance patient satisfaction and decrease the revision rate following UKA. However, its quantified biomechanical indicators remain unclear. The purpose of this study is to reveal the biomechanical characteristics of the tibiofemoral joint in normal and KA UKA knees, and to evaluate the biomechanical effect.

**Methods** In this study, six cadaveric knee joint specimens were utilized for biomechanical testing before (normal cadaveric knee joint specimen ) and after KA UKA. The knee joint specimens were subjected to an axial load of 1000 N, and the biomechanical parameters were assessed at flexion angles ranging from 0° to 120° in 10° increments.

**Results** The root mean square (RMS) values of the tibiofemoral contact area, mean contact pressure, and peak contact pressure during knee flexion were 529 $mm^2$, 1.8 MPa, and 4.5 MPa in normal knees, respectively. After KA UKA, these values changed to 449 $mm^2$, 2.0 MPa, and 9.8 MPa, respectively. Additionally, the RMS value of the external rotation of the femur relative to the tibia in the tibiofemoral joint was 9.9° in normal knees, while the posterior translations of the center of the femoral condyle, the medial femoral condyle, and the lateral femoral condyle were 18.4 mm, 11.5 mm, and 25.4 mm respectively. After KA UKA, these values changed to 8.6°, 19.3 mm, 12.9 mm, and 25.9 mm respectively.

**Conclusion** At the same flexion angle, the increase in peak contact pressure in the medial compartment after KA UKA is the most significant compared with the normal knees. However, the kinematic characteristics do not change significantly after KA UKA. These findings are beneficial for understanding the possible postoperative complications and good functional effects of KA UKA.

**Keywords** Unicompartmental knee arthroplasty, Kinematic alignment, Tibiofemoral joint, Biomechanical testing, Cadaveric knee specimen

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## Introduction

Knee osteoarthritis (KOA) affects approximately 654 million individuals globally and is the most prevalent diagnosis for knee pain in patients aged 45 years and older, with a worldwide incidence of about 8.15% [1]. Among the various compartments, the medial compartment is the most frequently involved in KOA, accounting for approximately 30–50% of cases [2, 3]. The surgical treatments for end-stage KOA include total knee arthroplasty (TKA), unicompartmental knee arthroplasty (UKA), and high tibial osteotomy (HTO). In recent years, with the gradual expansion of the indications for UKA, UKA has become more popular among patients compared to before [4]. Some studies have indicated that the outcomes of UKA in people over 50 years old is better than that of HTO [5]. While UKA offers several advantages over TKA, such as reduced intraoperative injury, greater postoperative range of motion, and faster recovery, its low long-term survivorship remains a critical issue that requires urgent attention [6–8]. The reasons for UKA failure include aseptic loosening, progression of OA, polyethylene wear and residual knee pain, etc [9, 10]. Furthermore, the incidence of these postoperative complications is predominantly associated with biomechanical factors [11]. Numerous factors influence knee biomechanics, with alignment technology being one of the most critical. Currently, the predominant alignment technique for UKA is mechanical alignment (MA), valued for its simplicity and reproducibility. This method refers to the mechanical axes of the tibia and femur, utilizing auxiliary guides to perform osteotomy and prosthesis implantation either perpendicular to or parallel with the respective mechanical axes [12, 13].

In recent years, the successful implementation of Kinematic Alignment (KA) technology in TKA has prompted Philippe Cartier et al. to adopt KA in UKA. This method involves vertical or parallel osteotomy and prosthesis implantation based on two axes of motion, rather than mechanical axes, with the aim of restoring the biomechanical environment of the patient's knee. The primary objectives include re-establishing the orientation of the natural joint line, ensuring physiological bone loading, and preserving the integrity of the physiological soft tissues [14–17]. Currently, research on KA UKA is primarily based on computer simulation experiments. Nevertheless, there is still a dearth of sufficient biomechanical basis to fully demonstrate its biomechanical characteristics, particularly biomechanical quantitative indicators.

Since the mobile-bearing UKA has at least a postoperative effect that is no worse than that of the fixed-bearing UKA [18], we therefore selected the mobile-bearing UKA prosthesis to start this specimen study. The aim is to reveal the contact mechanics and kinematic characteristics of the tibiofemoral joint before and after KA UKA and to evaluate its biomechanical impact. We speculate the contact mechanical characteristics after KA UKA will mainly change in the medial compartment. However, the changes in its kinematic characteristics are not obvious.

## Methods

### Specimen preparation

The study utilized knee specimens from six embalmed corpses (mean age: 55.5 years; age range: 48–61 years), including four males and two females. Prior to testing, X-ray, CT, and MRI examinations were completed on these knee joint specimens to ensure that the knee joint specimens had little degenerative changes, no meniscus or ligament injuries, and had similar sizes. Retain about 20 cm above and below the knee joint line of the specimen, and sequentially cut off the skin, subcutaneous tissue and muscles until the required shape was obtained. The distal ends of the tibia and fibula, along with the proximal ends of the femur, were secured in a cylindrical mold according to their anatomical positions using denture base resin.

### Experimental setup

The computerized servo material testing machine (Dongguan Lixian Instrument Technology Co., Ltd. Guangdong, China) was employed to apply the axial load required for this experiment.

The knee joint specimens were installed in the customized testing jig, which could allow or control the six degrees of freedom of knee joint motion, consistent with previous studies [19]. The free rotation and translation of the tibia avoided excessive constraints on the tibia during the axial loading process, thus ensuring the realization of physiological loading in each test.

The pressure-sensitive transducer (Tekscan model 4000, South Boston, Massachusetts, USA) was composed of two force measuring areas and a "Y"-shaped sensor (Fig. 1A). Each force measuring area was composed of $26 \times 22$ transducers. These sensors were utilized to test the contact area, mean contact pressure, and peak contact pressure of the medial and lateral compartments of the tibiofemoral joint respectively. These sensors were calibrated according to the manufacturer's guidelines, and each sensor was only used for one specimen test. Small incisions were made on the joint capsule, and then the sensors were inserted into the medial and lateral compartments of the tibiofemoral joint and fixed to the posterior aspect of the tibia by suture anchors.

A three-dimensional motion analysis system (Simi Motion, Simi Reality Motion Systems GmbH, Germany) along with three digital cameras was utilized to collect kinematic data of the tibiofemoral joint, achieving an

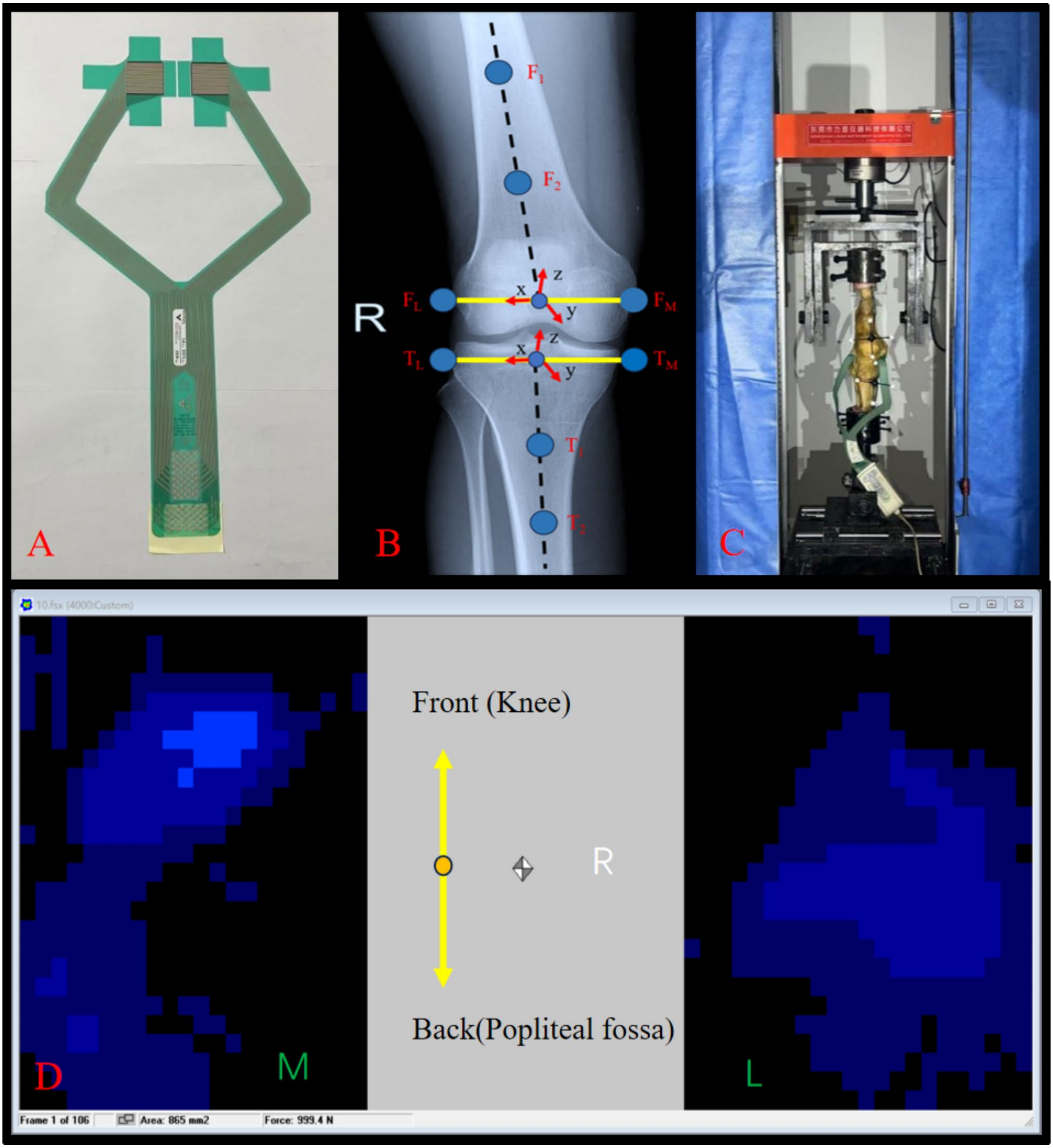


**Fig. 1** The experimental process and setup for biomechanical testing. **A** The Tekscan pressure-sensitive transducer; **B** Anatomical landmarks of the knee joint and local coordinate systems of the femur and tibia; **C** Biomechanical testing; **D** The real-time feedback of the contact pressure map in the Tekscan software

accuracy of up to 0.1 mm. Eight knee anatomical markers were used to create the local coordinate systems of the femur and tibia segments. Two reference marker frames were firmly fixed to the femur and tibia to record their motions. The kinematics of the tibiofemoral joint was analyzed by using custom Matlab programs and adopting the Z- Y- X Euler angle transformation.

Calculations were made of the posterior femoral translation of the lateral and medial condyle as well as the femoral rotation relative to the tibial coordinate system during knee flexion [19]. The initial reference position was defined as the location of knee extension (flexion of 0°).

### KA UKA procedure

All surgeries on knee joint specimens were performed using the Oxford III Mobile-Bearing UKA prosthesis and were completed by the same senior surgeon. The surgical procedures closely followed those described by Philippe Cartier et al. [17]. Prior to surgery, knee specimens of comparable size were selected for this experiment, ensuring that the models of the prosthesis and polyethylene liner were uniform during KA UKA; specifically, the femoral components was designated as size M, the tibia components as size B, and the polyethylene liner as 3 mm.

### Biomechanical testing

Prior to the commencement of the test, the Motion Analysis three-dimensional motion capture system was employed to record all the spatial coordinates of the marker rod. The marker rod, made up of 20 markers which had been previously divided into three layers, was placed in front of the testing jig. Subsequently, the Simi Reality Motion system was utilized to capture the 20 markers on the marker rod, aiming for accurate spatial positioning.

Two marker frames, each containing 4 markers, were firmly affixed on both sides of the joint line of the knee joint specimen respectively. After that, the knee joint specimen was carefully placed into the testing jig. Next, 8 anatomical markers were attached to the knee joint specimens (Fig. 1B). Utilizing the Simi motion system, the spatial coordinates of these 16 markers could be meticulously recorded and calculated. At that particular moment, these coordinates denoted the initial position coordinates of the knee joint specimen. Subsequently, the 8 anatomical marker points were removed, leaving only the 2 marker frames, and then the formal biomechanical test was initiated.

The computerized servo material testing machine was operated to apply axial pressure (Fig. 1C). Once the pressure reached 1,000 N and achieved relative stability, the Simi Motion system was used to collect the kinematic data of the tibiofemoral joint. Through the Simi motion system, the spatial positions of the eight markers when the knee joint specimens were flexed at 0°could be computed. Additionally, the contact mechanical data of the knee joint specimens when flexed at 0°could be obtained via the I - Scan software.

The loading was then stopped, and the material testing machine was operated to return to its original position. The knee joint specimen was manually adjusted to a flexion of 10°, and then the loading process was resumed. When the pressure reached 1000 N and stabilized, the kinematic data was tested and recorded. The aforementioned operations were repeated, with the flexion angle being incremented by 10°each time. The kinematic and contact mechanical data were tested and recorded for a total of 13 angles, spanning from 0°to 120°.

During each biomechanical test loading process, it was of utmost importance to ensure that the center of force continuously output by the I-scan software was located at the center (Fig. 1D). It should be noted that the knee specimens were not fixed in any specific position, no additional forces or moments were imposed, and no obvious damage occurred during the repeated experiments. This type of loading method has been adopted in numerous specimen studies [19–21].

### Data analysis

The contact mechanics data included the calculation of the contact area, mean contact pressure, and peak contact pressure in the medial and lateral compartments of the tibiofemoral joint both before and after KA UKA. This data could be directly obtained after being processed by the I-scan software.

The kinematics data included the rotation of the femur relative to the tibia, along with the translations of the center of femoral condyle, medial femoral condyles and lateral femoral condyles. A local coordinate system of the femur was established (Fig. 1B). Four anatomical landmarks of the femur, which were the medial femoral epicondyle, the lateral femoral epicondyle, and two points parallel to the anatomical axis of the femur, were named $F_M$, $F_L$, $F_1$, and $F_2$ respectively. The line connecting $F_M$ and $F_L$ was defined as the medial-lateral axis, denoted as $X_f$, with the direction pointing laterally being considered positive. The midpoint of this line was defined as the origin, denoted as $O_f$. The vector cross product of the line connecting $F_1$ and $F_2$ and the $X_f$ axis was defined as the anterior-posterior axis, denoted as $Y_f$, with the direction pointing anteriorly being regarded as positive. The vector cross product of the $X_f$ axis and the $Y_f$ axis was defined as the superior-inferior axis, denoted as $Z_f$, and the direction pointing superiorly was stipulated as positive. Similarly, a local coordinate system of the tibia was established based on the four anatomical landmark points of the tibia. These points were the medial epicondyle of the tibia, the lateral epicondyle of the tibia, and two points that were parallel to the anatomical axis of the tibia. The calculation of translation required the use of the "direction cosine" method.

The calculation of displacement needed to use the "direction cosine" method. First, the local coordinate system of the femur was transformed into the local coordinate system of the tibia, and then finally it was transformed into the global coordinate system. The calculation of rotation needed to use the "Z-Y-X intrinsic rotation Euler angle" method. Finally, the spatial coordinates of the basic position of the knee joint specimen and the spatial coordinates of each flexion angle of the knee joint specimen were imported into Matlab 2016b, and the program edited according to the above principles was run to calculate all the data of the knee joint specimen kinematics.

## Results

### Contact mechanics results

At the same flexion angle, compared with the normal knee, smaller contact area and larger mean and peak contact pressure were found in the joints after KA UKA. Among them, the increase in peak contact pressure in the medial compartment is the most obvious. The root mean square (RMS) values of the tibiofemoral contact area, mean contact pressure, and peak contact pressure during knee flexion were 529 $mm^2$, 1.8 MPa, and 4.5 MPa in normal knees, respectively. After KA UKA, these values changed to 449 $mm^2$, 2.0 MPa, and 9.8 MPa, respectively. In normal knees, the RMS value of the peak contact pressures in the medial compartment was 4.2 MPa, and that in the lateral compartment was 3.8 MPa. In KA UKA knees, the RMS value of the peak contact pressures in the medial compartment was 9.6 MPa, and that in the lateral compartment was 5.6 MPa.

In normal knees, as the flexion angle of the knee joint specimen (ranging from 0° to 120°) increases, the contact area of the tibiofemoral joint gradually diminishes, while the mean contact pressures of the tibiofemoral joint gradually rise, with ranges of 792 $mm^2$ – 263 $mm^2$, 1.2 MPa – 2.2 MPa, respectiFig. (Figure 2A and C). The change trend of peak contact pressures is relatively stable,

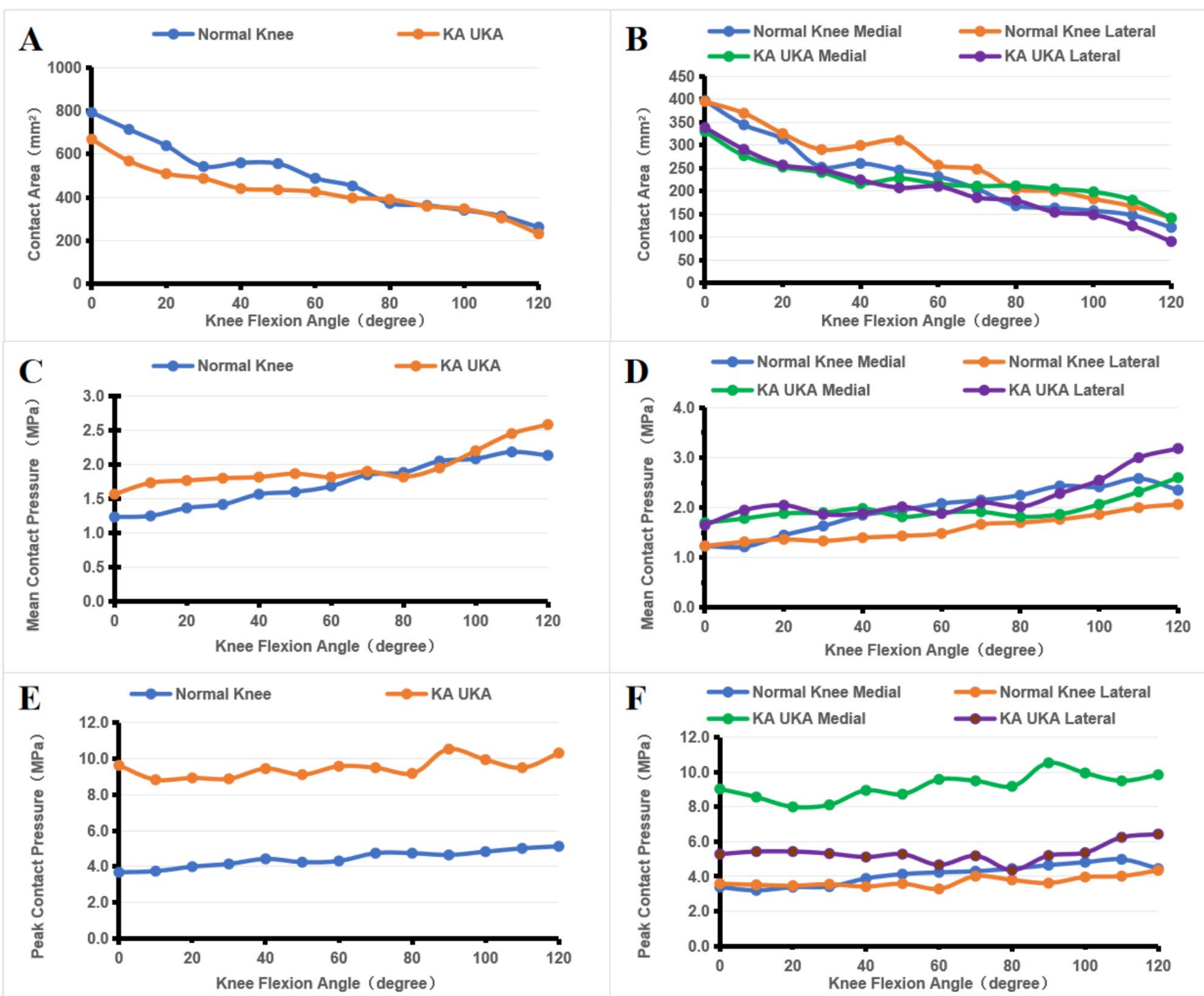


**Fig. 2** The contact mechanics characteristics of the tibiofemoral joint in normal and KA UKA knees during knee flexion. **A** The contact area of total tibiofemoral compartment; **B** The contact area of medial and lateral tibiofemoral compartment; **C** The mean contact pressure of total tibiofemoral compartment; **D** The mean contact pressure of medial and lateral tibiofemoral compartment; **E** The total peak contact pressure of tibiofemoral compartment; **F**: The peak contact pressure of medial and lateral tibiofemoral compartment

with values ranging from 3.7 MPa – 5.1Fig. (Fig. 2E). The contact area trends of the medial and lateral compartments are both on the decline, with ranges of 397 mm² – 121 mm² and 395 mm² – 142 mm² respectiFig. (Figures 2B and 3). The mean contact pressures trends of the medial and lateral compartments are also increasing, with ranges of 1.2 MPa – 2.6 MPa and 1.2 MPa to 2.1 MPa respectiFig. (Fig. 2D). The change trends of peak contact pressures in the medial and lateral compartments are relatively stable, with ranges of 3.4 MPa – 5.0 MPa and 3.6 MPa – 4.4 MPa respectiFig. (Fig. 2F).

In KA UKA knees, as the flexion angle of the knee joint specimen (ranging from 0° to 120°) increases, the contact area of the tibiofemoral joint gradually diminishes, while the mean contact pressures of the tibiofemoral joint gradually rise, with ranges of 669 mm² – 233 mm²,1.6 MPa – 2.6 MPa respectiFig. (Figure 2A and C). The change trend of peak contact pressures is relatively stable, with values ranging from 8.8 MPa – 10.5Fig. (Fig. 2E). The contact area trends of the medial and lateral compartments are both on the decline, with ranges of 330 mm²-142 mm² and 339 mm² – 91 mm²(Figs. 2B and 3). The mean contact pressures trends of the medial and lateral compartments are also increasing, with ranges of 1.7 MPa – 2.6 MPa, 1.7 MPa – 3.2 MPa respectiFig. (Fig. 2D). The change trends of peak contact pressures in the medial and lateral compartments are relatively stable, with ranges of 8.0 MPa – 10.5 MPa, 4.4 MPa – 6.4 MPa respectiFig. (Fig. 2F).

### Kinematic results

As the flexion angle of the knee joint specimen increases, compared with the normal knee, smaller external rotation of the femur relative to the tibia were found after KA UKA ($P = 0.255 > 0.05$). The changes in the posterior translation of the femoral condyle center, medial and lateral femoral condyle are not obvious ($P = 0.761 > 0.05$; $P = 0.496 > 0.05$; $P = 0.923 > 0.05$). The RMS value of the external rotation of the femur relative to the tibia in the tibiofemoral joint was 9.9°in normal knees, while the posterior translations of the center of the femoral condyle, the medial femoral condyle, and the lateral femoral condyle were 18.4 mm, 11.5 mm, and 25.4 mm respectively. After KA UKA, these values changed to 8.6°, 19.3 mm, 12.9 mm, and 25.9 mm respectively.

In normal knees, as the flexion angle of the knee joint specimen (ranging from 0° to 120°) increases, the external rotation degree of the femur relative to the tibia gradually increases, with a range of 0.2° to 17.3° (Fig. 4A). The posterior translation of the femoral condyle center, medial and lateral femoral condyle gradually increase, with a range of 1.1 mm to 36.0 mm,1.1 mm to 23.2 mm, 1.2 mm to 48.7 mm, respectively (Fig. 4B–D).

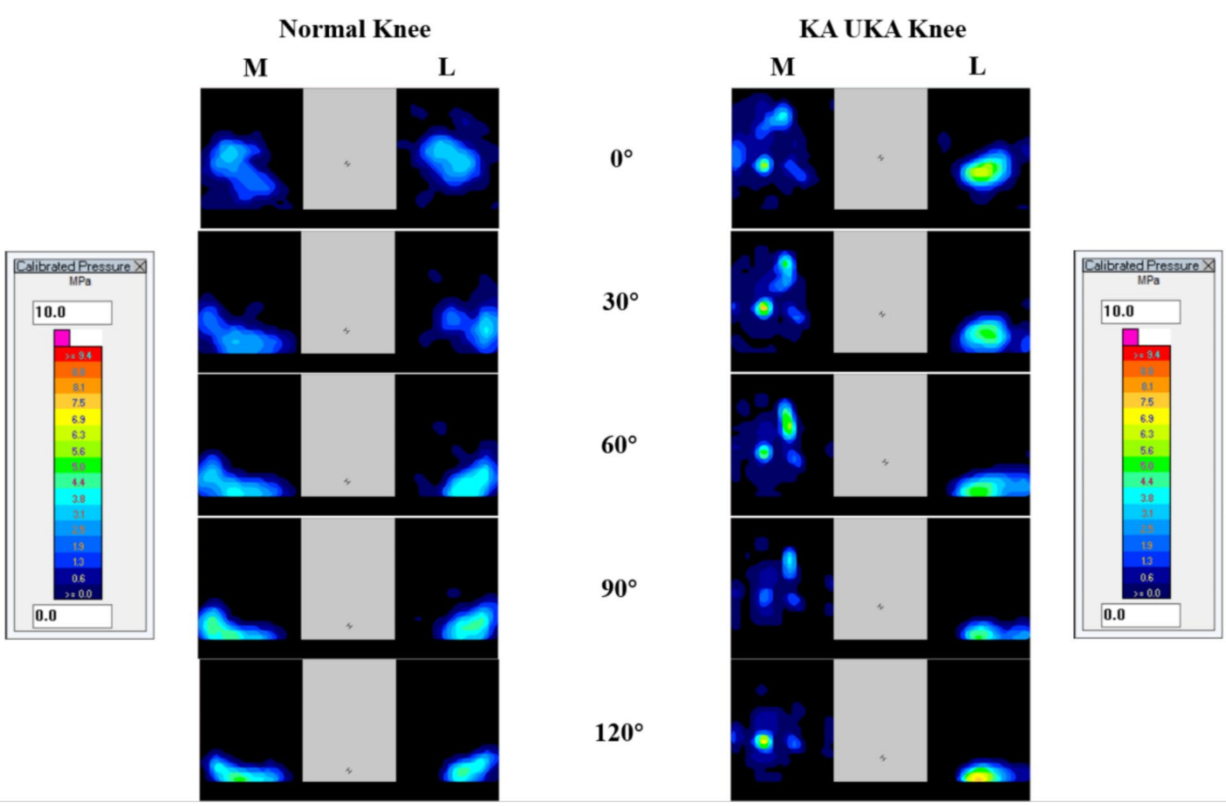


**Fig. 3** The tibiofemoral joint contact pressure map in normal and KA UKA knees during knee flexion

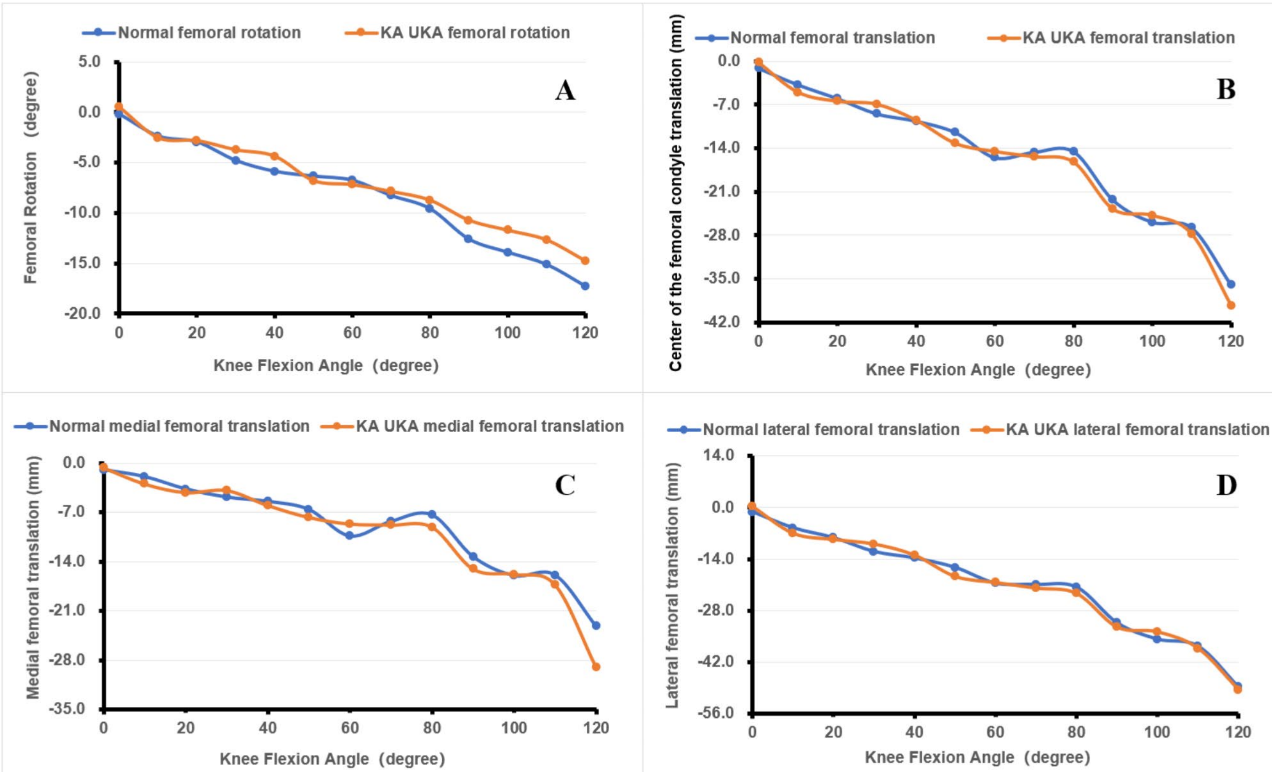


**Fig. 4** The kinematic characteristics of the tibiofemoral joint in normal and KA UKA knees during knee flexion. **A** Rotation of the femur relative to tibia; **B** Translation of the center of femoral condyle; **C** Translation of the medial femoral condyle; **D** Translation of the lateral femoral condyle. Internal rotation of the femur is considered positive, while external rotation is regarded as negative; forward translations are defined as positive, and backward translations are defined as negative

In KA UKA knees, as the flexion angle of the knee joint specimen (ranging from 0° to 120°) increases, the external rotation degree of the femur relative to the tibia gradually increases, with a range of -0.5° to 14.7° (Fig. 4A). The posterior translation of the femoral condyle center, medial and lateral femoral condyle gradually increase, with a range of 0.2 mm to 39.3 mm, 0.7 mm to 29.0 mm, -0.2 mm to 49.5 mm, respectively (Fig. 4B–D).

## Discussion

In general, as the flexion angle of the knee joint specimen increases, compared with the normal knee, smaller contact area and larger mean and peak contact pressure were found in the joints after KA UKA. Among them, the increase in peak contact pressure in the medial compartment is the most obvious. Smaller external rotation of the femur relative to the tibia were found after KA UKA. The changes in the posterior translation of the femoral condyle center, medial femoral condyle, and lateral femoral condyle are not obvious.

The results of this experiment show that in KA UKA knees, the RMS value of the peak contact pressures in the medial compartment is approximately 2.3 times that in normal knees, while RMS value of the peak contact pressures in the lateral compartment is approximately 1.5 times that in normal knees. The above values are significantly smaller than the yield stress (22 MPa) of the polyethylene liner [22]. Nevertheless, this could still be the cause of knee pain following KA UKA. Due to the different elastic moduli of the femoral prosthesis and the polyethylene liner [23, 24], when a load is applied, the softer material (polyethylene liner) is more likely to undergo local deformation when in contact with the force, which makes the pressure distribution in the contact area uneven and finally leads to the formation of the peak contact pressure. Excessive pressure in the medial compartment may lead to the destruction of trabecular bone, and then stimulate nerve endings and cause pain [25]. Moreover, it may also result in the wear or extrusion of the polyethylene liner. Subsequently, the deviation of the motion trajectory may occur and affect the soft tissues of the knee joint, thus leading to knee pain [26, 27].

Aseptic loosening, progression of lateral compartment osteoarthritis, polyethylene wear, and unexplained pain are the main reasons that necessitate surgical revision of UKA [9, 10]. The causes of these revisions are directly or indirectly related to the stress within the joint. Studies have shown that squatting or increasing the knee flexion angle elevates pressure in the joint, potentially resulting in knee pain [28–30]. As the flexion angle of the knee joint specimen increases, the contact area gradually decreases. This phenomenon is attributed to the sagittal radius of the femoral posterior condyle connected to the tibia is gradually decreasing [31]. As can be seen from contact pressure map (Fig. 3), in KA UKA knees, the contact area has a high correlation with the contact area of the polyethylene liner and the femoral prosthesis. Appropriate increase of this contact area can reduce the pressure on the medial compartment.

When compared with the normal knee, the kinematic characteristics do not change significantly after KA UKA. This may be attributed to the surgical technique of KA UKA, which minimizes the physiological anatomy of the patient's medial compartment, maintains a more natural and physiological orientation of the joint line, involves less bone resection, and avoids opening the femoral marrow cavity [14–17]. This is also the reason why KA UKA may be superior to MA UKA in terms of functional effects. We speculate that since the kinematic parameters change relatively minimally, the postoperative satisfaction will be relatively high. This was primarily because pain was markedly reduced, and there was no need to adapt to a new limb movement patterns [32, 33]. It can be further speculated that good postoperative kinematic performance is related to the preoperative kinematic function of the knee joint. Specifically, if there is severe varus or valgus deformity of the knee joint prior to KA UKA, the postoperative kinematic performance may be limited. Further studies are needed to clarify the specific indications for knee deformities to ensure that KA UKA achieves optimal postoperative outcomes. The posterior translations of the femoral condyle in this study was larger than that reported in previous studies, while the degree of external rotation was similar [19, 34]. The main reason is that the specimen has been soaked in formalin for a long time, and the elasticity of its ligament tissue is relatively poor.

There are several limitations to this experiment. First, the use of formalin-soaked embalmed specimens, as opposed to freshly frozen cadaveric specimens, may impact the parameters obtained from biomechanical tests. Second, the loading method employed in this experiment is limited to axial loading. While this approach has been utilized in several studies, it does not account for the influence of forces and moments in other directions on biomechanical parameters. Third, during the processing of knee joint specimens, to ensure that they fit well into the fixture of the biomechanical testing platform and allow for better flexion and extension movement, a significant amount of muscle tissue is removed. This may affect the biomechanical parameters of the tibiofemoral joint.

## Conclusion

At the same flexion angle, the increase in peak contact pressure in the medial compartment after KA UKA is the most significant compared with that before surgery. However, when compared with the normal knee, the kinematic characteristics do not change significantly after KA UKA. These findings are beneficial for understanding the possible postoperative complications and good functional effects of KA UKA.

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**Author contributions**
CL: data acquisition, data analysis, writing manuscript. MYC: data acquisition, data analysis, reviewing manuscript. XYW: data analysis, reviewing manuscript. SHY: protocol, reviewing manuscript. JZZ: protocol, surgery, reviewing manuscript. KZ: protocol, reviewing manuscript.

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**Data availability**
No datasets were generated or analysed during the current study.

## Declarations

**Ethics approval and consent to participate**
This research has been approved(Medical Ethics Committee of Beijing Luhe Hospital affiliated to Capital Medical University)(2024-LHKY-019-02).

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

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## References

1. Duong V, Oo WM, Ding C, Culvenor AG, Hunter DJ. Evaluation and treatment of knee pain: A review. JAMA. 2023;16:1568–80.
2. Neubauer M, Reinberger EM, Dammerer D, Moser LB, Neugebauer J, Gottsauner-Wolf F, et al. Unicompartmental knee arthroplasty provides superior clinical and radiological outcomes compared to high tibial osteotomy at a Follow-Up of 5–8 years. J Clin Med. 2023;16:5387.
3. Schraknepper J, Dimitriou D, Helmy N, Hasler J, Radzanowski S, Flury A. Influence of patient selection, component positioning and Surgeon's caseload on the outcome of unicompartmental knee arthroplasty. Arch Orthop Trauma Surg. 2020;6:807–13.

4. Giordano L, Maffulli N, Morenghi E, Quaglia A, Prospero E, Rosa F, et al. A BMI above 30 results in satisfying outcomes in patients undergoing fixed-bearing lateral unicompartmental knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2023;31:1106–12.
5. Migliorini F, Driessen A, Oliva F, Maffulli GD, Tingart M, Maffulli N. Better outcomes and reduced failures for arthroplasty over osteotomy for advanced compartmental knee osteoarthritis in patients older than 50 years. J Orthop Surg Res. 2020;19:15:545.
6. Janssen SJ, van Oost I, Breugem SJM, van Geenen RCI. A structured evaluation of the symptomatic medial Oxford unicompartmental knee arthroplasty (UKA). EFORT Open Rev. 2021;10:850–60.
7. Justin S, Chang FSH. Long-term survivorship of hip and knee arthroplasty. Bone Joint J. 2020;4:401–2.
8. Ellis RT, Nettrour JF, Keeney JA. TKA is more durable than UKA for morbidly obese patients: A Two-Year minimum Follow-Up study. J Arthroplasty. 2021;36:1933–41.
9. van der List JP, Zuiderbaan HA, Pearle AD. Why do medial unicompartmental knee arthroplasties fail today?? J Arthroplasty. 2016;31:1016–21.
10. Montilla FJ, Payo-Ollero J, Serrano-Toledano D, Del Río-Arteaga M, Ribera J, Muela R. Unicompartmental knee arthroplasties: does the type of tibial component selected influence implant survival? Arch Orthop Trauma Surg. 2024;144:347–55.
11. Chang TW, Yang CT, Liu YL, Chen WC, Lin KJ, Lai YS, et al. Biomechanical evaluation of proximal tibial behavior following unicondylar knee arthroplasty: modified resected surface with corresponding surgical technique. Med Eng Phys. 2011;33:1175–82.
12. Emerson RH Jr, Higgins LL. Unicompartmental knee arthroplasty with the Oxford prosthesis in patients with medial compartment arthritis. J Bone Joint Surg Am. 2008;90:118–22.
13. Walker T, Heinemann P, Bruckner T, Streit MR, Kinkel S, Gotterbarm T. The influence of different sets of surgical instrumentation in Oxford UKA on bearing size and component position. Arch Orthop Trauma Surg. 2017;137:895–902.
14. Rivière C, Sivaloganathan S, Villet L, Cartier P, Lustig S, Vendittoli PA, et al. Kinematic alignment of medial UKA is safe: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2022;30:1082–94.
15. Preston B, Harris S, Villet L, Mattathil C, Cobb J, Rivière C. The medial condylar wall is a reliable landmark to kinematically align the femoral component in medial UKA: an in-silico study. Knee Surg Sports Traumatol Arthrosc. 2022;30:3220–7.
16. Rivière C, Harman C, Leong A, Cobb J, Maillot C. Kinematic alignment technique for medial OXFORD UKA: an in-silico study. Orthop Traumatol Surg Res. 2019;105:63–70.
17. Rivière C, Logishetty K, Villet L, Maillot C. Calipered kinematic alignment technique for implanting a medial Oxford®: A technical note. Orthop Traumatol Surg Res. 2021;107:102859.
18. Migliorini F, Maffulli N, Cuozzo F, Elsner K, Hildebrand F, Eschweiler J, et al. Mobile bearing versus fixed bearing for unicompartmental arthroplasty in monocompartmental osteoarthritis of the knee: A Meta-Analysis. J Clin Med. 2022;17:11:2837.
19. Wang Y, Yan S, Zeng J, Zhang K. The Biomechanical effect of different posterior tibial slopes on the tibiofemoral joint after posterior-stabilized total knee arthroplasty. J Orthop Surg Res. 2020;15:320.
20. Koh JL, Yi SJ, Ren Y, Zimmerman TA, Zhang LQ. Tibiofemoral contact mechanics with horizontal cleavage tear and resection of the medial Meniscus in the human knee. J Bone Joint Surg Am. 2016;98:1829–36.
21. Padalecki JR, Jansson KS, Smith SD, Dornan GJ, Pierce CM, Wijdicks CA, et al. Biomechanical consequences of a complete radial tear adjacent to the medial meniscus posterior root attachment site: in situ pull-out repair restores derangement of joint mechanics. Am J Sports Med. 2014;42:699–707.
22. Watanabe T, Koga H, Horie M, Katagiri H, Sekiya I, Muneta T. Post-Cam design and contact stress on tibial posts in Posterior-Stabilized total knee prostheses: comparison between a rounded and a squared design. J Arthroplasty. 2017;32:3757–62.
23. Zhu GD, Guo WS, Zhang QD, Liu ZH, Cheng LM. Finite element analysis of Mobile-bearing unicompartmental knee arthroplasty: the influence of tibial component coronal alignment. Chin Med J (Engl). 2015;128:2873–8.
24. Villa T, Migliavacca F, Gastaldi D, Colombo M, Pietrabissa R. Contact stresses and fatigue life in a knee prosthesis: comparison between in vitro measurements and computational simulations. J Biomech. 2004;37:45–53.
25. Thoreau L, Morcillo Marfil D, Thienpont E. Periprosthetic fractures after medial unicompartmental knee arthroplasty: a narrative review. Arch Orthop Trauma Surg. 2022;142:2039–48.
26. Wen P, Zhang Q, Sun X, Zhang B, Ma T, Zhang Y. Exploring the relationship between bearing extrusion and postoperative persistent pain in Oxford unicompartmental knee arthroplasty: A trajectory measurement study. Front Bioeng Biotechnol. 2022;29:10:965009.
27. Lunebourg A, Parratte S, Galland A, Lecuire F, Ollivier M, Argenson JN. Is isolated insert exchange a valuable choice for polyethylene wear in metal-backed unicompartmental knee arthroplasty? Knee Surg Sports Traumatol Arthrosc. 2016;24:3280–6.
28. Kothurkar R, Lekurwale R, Gad M, Rathod CM. Finite element analysis of a healthy knee joint at deep squatting for the study of tibiofemoral and patellofemoral contact. J Orthop. 2023;40:7–16.
29. Liu H, Gong H, Chen P, Zhang L, Cen H, Fan Y. Biomechanical effects of typical lower limb movements of Chen-style Tai Chi on knee joint. Med Biol Eng Comput. 2023;61:3087–101.
30. Rabe KG, Stockman TJ, Kern AM, Wirth W, Eckstein F, Sharma L, et al. Longitudinal relationship between tibiofemoral contact stress at baseline and worsening of knee pain over 84 months in the multicenter osteoarthritis study. Am J Phys Med Rehabil. 2022;101:726–32.
31. D'Lima DD, Chen PC, Colwell CW Jr. Polyethylene contact stresses, articular congruity, and knee alignment. Clin Orthop Relat Res. 2001;392:232–8.
32. Celestino ML, van Emmerik R, Barela JA, Bacca O, Barela AMF. Effects of limited knee flexion movement in intra-limb gait coordination. J Biomech. 2021;128:110712.
33. Buchman-Pearle JM, Kingston DC, Acker SM. Lower limb movement pattern differences between males and females in squatting and kneeling. J Appl Biomech. 2021;37:204–14.
34. Heyse TJ, El-Zayat BF, De Corte R, Chevalier Y, Scheys L, Innocenti B, et al. UKA closely preserves natural knee kinematics in vitro. Knee Surg Sports Traumatol Arthrosc. 2014;22:1902–10.

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