Observational Study

Medicine

OPEN

Coronal tibiofemoral subluxation in patients with osteoarthritis was corrected after total knee arthroplasty

Ruibo Li, MD[a,*], Peng Fu, BA[b]

Abstract

The objective of this study was to investigate the effect of preoperative coronal tibiofemoral subluxation (CTFS) on postoperative mechanical alignment in patients undergoing total knee arthroplasty (TKA) for primary knee osteoarthritis (OA) and to investigate whether TKA can correct preoperative CTFS. We hypothesized that TKA would correct CTFS in patients with knee OA. A retrospective analysis of 102 patients with knee OA who underwent TKA was performed. The preoperative and postoperative CTFS and mechanical alignment were measured and compared. At the same time, the baseline values of CTFS and mechanical alignment in "normal" patients were measured and compared with those in the operation group. Eighty patients were eventually enrolled in the study. Mechanical alignment was corrected from 7.3 ± 5.2°, preoperatively, to 1.6 ± 2.3° postoperatively, while the tibiofemoral subluxation was corrected from 5.3 ± 2.6 mm, preoperatively, to 2.3 ± 2.7 mm postoperatively. There was no significant correlation between preoperative CTFS and gender (r = 0.03), BMI (r = −0.09), age (r = 0.05), or preoperative mechanical alignment (r = 0.09). In addition, there was no correlation between the degree of correction of CTFS and the degree of correction of overall mechanical alignment (r = 0.14). The difference between the value for CTFS in the "normal" patients and the preoperative value for arthritis cohorts were statistically significant (P = .004). However, no significant difference was appreciated between the value for CTFS in the "normal" patients and the postoperative value for TKA cohorts (P = .25). Preoperative CTFS does not affect postoperative mechanical alignment. Excellent TKA can correct preoperative CTFS in OA patients to reduce prosthesis wear and improve postoperative patient satisfaction.

Abbreviations: BMI = body mass index, AP = anteroposterior, CTFS = coronal tibiofemoral subluxation, OA = osteoarthritis, TKA = total knee arthroplasty, UKA = unicompartmental knee arthroplasty.

Keywords: femorotibial joint, mechanical alignment, subluxation, total knee arthroplasty.

Introduction

Total knee arthroplasty (TKA) is one of the most cost-effective and successful procedures in orthopedic surgery, which can effectively relieve knee pain, restore knee function and improve the quality of life of patients.[1,2] Although the 10-year survival rate of TKA prosthesis is more than 90%, there are still up to 30% of patients who are not satisfied with the postoperative results or have pain symptoms.[3] Poor patient satisfaction and decreased prosthesis survival rate after TKA are not only related to females, higher body mass index (BMI), previous knee surgery, depression, diabetes, and other patient-related factors, but also related to poor prosthesis position and poor mechanical alignment.[4]

Subluxation of the tibia relative to the femur in the coronal plane has been reported as a common radiological finding in knee osteoarthritis (OA).[5] At the same time, some studies have confirmed that coronal tibiofemoral subluxation (CTFS) can lead to knee pain and poor knee function.[6]

Although studies have evaluated the effect of CTFS on high tibial osteotomy and unicompartmental knee arthroplasty (UKA),[7,8] and the effect of CTFS on polyethylene thickness and knee pain after TKA,[9] there is no study to describe whether the existence of CTFS will affect the postoperative mechanical alignment and whether the TKA can correct CTFS.

This is the first study to evaluate the effect of preoperative CTFS on postoperative mechanical alignment in patients with

This study was supported by the Science and Technology Planning Project of Deyang City, China (2021SZZ061, 2019SZ040). The funders had no role in the design or conduct of the study; the collection, management, analysis, or interpretation of the data; the preparation, writing, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

The authors have no conflicts of interest to disclose.

The authors declare that they have no competing interests.

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Our research complied with the guidelines for human studies and was conducted ethically per the principles enshrined in the World Medical Association Declaration of Helsinki. The study was approved by the Bioethics Committee of the People's Hospital of Deyang City (No. LWH-OP-006-A04-V2.0). Written informed consents were obtained from all individual participants included in the study.

[a] *Department of Orthopaedics, Deyang Peoples' Hospital, Deyang, Sichuan Province, China,* [b] *Department of Rehabilitation, Deyang Peoples' Hospital, , Deyang, Sichuan Province, China.*

**Correspondence: Ruibo Li, Department of Orthopaedics, Deyang Peoples' Hospital, No. 173, section 3, North Taishan Road, Deyang 618000, Sichuan Province, China (e-mail: lirb09@163.com).*

How to cite this article: Li R, Fu P. Coronal tibiofemoral subluxation in patients with osteoarthritis was corrected after total knee arthroplasty. Medicine 2022;101:37(e30641).

Received: 29 August 2021 / Received in final form: 17 August 2022 / Accepted: 18 August 2022

http://dx.doi.org/10.1097/MD.0000000000030641

TKA. The objective of this study was to investigate the effect of preoperative CTFS on postoperative mechanical alignment in patients undergoing TKA for primary knee OA and to investigate whether TKA can correct preoperative CTFS. We hypothesized that TKA would correct CTFS in patients with knee OA.

Materials and Methods

This study is a retrospective review of an institutional review board-approved database of a single surgeon. From January 2018 to January 2020, 88 patients underwent a TKA for severe osteoarthritis. Inclusion criteria for this study were patients who received a TKA and received both preoperative and postoperative standing, anteroposterior (AP) hip-to-ankle radiographs. Exclusion criteria were the presence of inflammatory arthropathy, traumatic bone defect and insufficiency of ligaments around the knee joint. The presence of CTFS was not an exclusion criterion for this study. Gender, BMI, and age at surgery were recorded for all patients who met our inclusion criteria. All operations were performed by two experienced joint surgeons. The operation was performed through a midline skin incision and a parapatellar medial arthrotomy. All surgeries were performed with posterior stability prosthesis.

Standing, AP hip-to-ankle radiographs were taken at our institution both preoperatively and first week postoperatively. Be careful to ensure that each patient stood with their patellae facing forward to reduce rotation changes in the radiographs. Mechanical alignment of the lower limbs was measured preoperatively and postoperatively. The method for performing this measurement is demonstrated in Figure 1. The line connecting the center of femoral head and the center of distal femoral joint line formed the femoral mechanical axis. Similarly, the line connecting the center of proximal tibial plateau and the center of talar dome formed the tibial mechanical axis. The angle formed between the femoral and tibial mechanical axes was recorded as the overall lower extremity mechanical alignment (Fig. 1A).[10] For the measurement after TKA, the straight line from the center of the femoral head to the center of the distal component of the femur was defined as the mechanical alignment of the femur, and the straight line from the center of the talar dome to the center of the tibial platform component was defined as the mechanical alignment of the tibia[11] (Fig. 1B). For convention, all (+) values corresponded with a varus alignment, and all (–) values corresponded with a valgus alignment.

On standing knee AP radiographs, the amount of CTFS was measured as the distance (mm) between the line tangential to the most lateral border of the femoral lateral condyle and the line tangential to the most lateral border of the tibial lateral condyle with 0.1 mm accuracy (Fig. 2). In addition, CTFS was measured in 30 patients without joint space stenosis or arthritic disease who had standing, hip-ankle films and were diagnosed with a simple meniscus injury or patellofemoral pain. These measurements are intended to provide baseline values for CTFS in patients without OA.

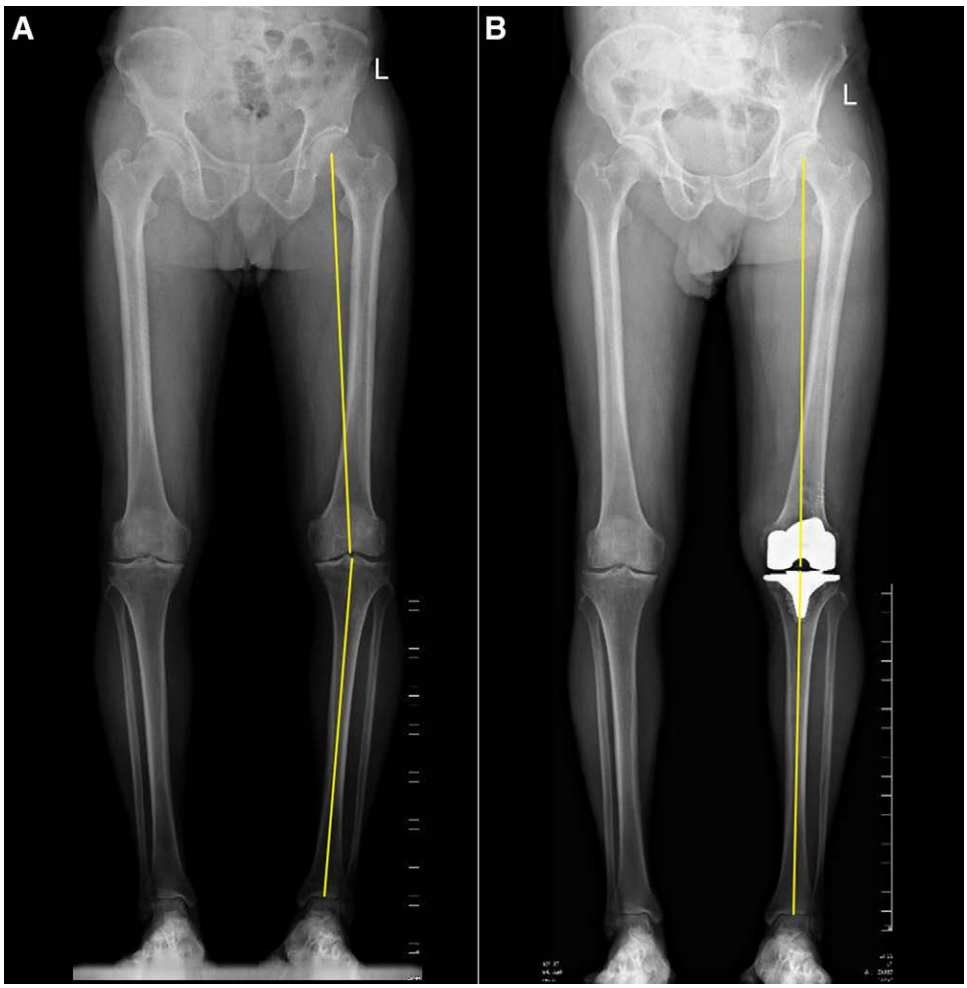

Figure 1. Radiographs demonstrating measurement of the overall lower extremity mechanical alignment both preoperatively (A), and after total knee arthroplasty (B). In this patient, the preoperative alignment was 8.3°, which was corrected to 0.6° postoperatively.

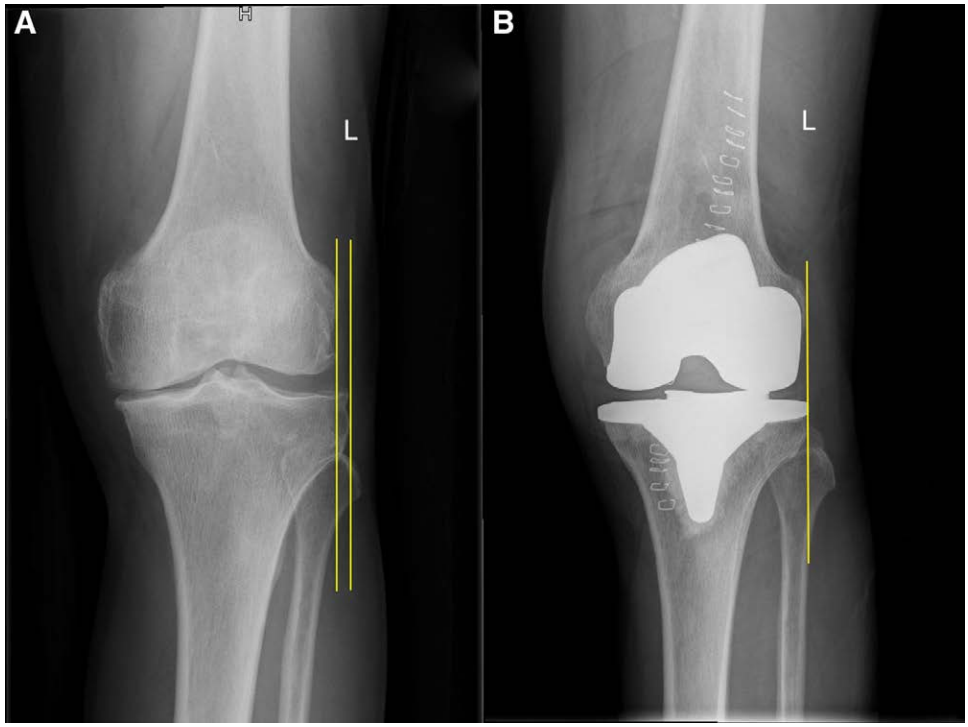

Figure 2. The preoperative (A) coronal tibiofemoral subluxation distance was 4.6 mm. Postoperatively (B) the femur shifted laterally and the coronal tibiofemoral subluxation was corrected.

All radiographic measurements were independently measured by two observers, and the results were assessed for interobserver reliability.

Statistical methods

Continuous variables are presented as mean value and standard deviation. Paired-sample *T* test was used to compare the changes in mechanical alignment and the degree of CTFS before and after surgery, and independent sample *T* test was used to compare the baseline values with the surgical group. A *t* test sample size estimation yielded a group size of 34 patients (alpha, 0.05; power, 0.8; effect size 0.5). A 2-sided *P* value of .05 was considered statistically significant. Interclass correlation coefficients for radiographic measurements were graded using semi-quantitative criteria: excellent for $0.9 \le r \le 1.0$, good for $0.7 \le r \le 0.89$, fair/moderate for $0.5 \le r \le 0.69$, low for $0.25 \le r \le 0.49$, and poor for $0.0 \le r \le 0.24$. In addition, correlation coefficients between the values for CTFS, patient demographics, and mechanical alignment were calculated.

Results

A total of 80 patients were included in the study, including 32 males and 48 females, with a mean age of 67.2 ± 6.4 years and a mean BMI of 24.2 ± 2.1. Four patients were excluded from the study because of inflammatory joint disease, 2 because of bone defects, and 2 because of ligament defects. The mean preoperative mechanical alignment was 7.3°±5.2°, while the mean postoperative alignment was 1.6°±2.3°, a difference that was statistically significant ($P < .001$). This corresponded with a mean mechanical alignment correction of 6.1°±3.8°. The mean preoperative CTFS was 5.3 ± 2.6 mm, while the mean postoperative subluxation was 2.1 ± 1.0 mm, a difference that was statistically significant ($P < .001$). This corresponded with a mean CTFS correction of 3.4 ± 2.7 mm. There was no significant correlation between preoperative CTFS and gender ($r = 0.03$), BMI ($r = -0.09$), age ($r = 0.05$), or preoperative mechanical alignment of lower limbs ($r = 0.09$). In addition, there was no correlation between the degree of correction of CTFS and the degree of correction of overall mechanical alignment ($r = 0.14$).

We also measured CTFS and mechanical alignment in 30 patients (mean age 37.6 ± 10.6 years) who had no radiographic manifestations of knee OA. These patients were diagnosed with a simple meniscus injury and presented to our hospital. The mean value for CTFS in this cohort was 2.3 ± 1.2 mm, while the mean lower extremity mechanical alignment was 1.8°±2.1°. The difference between the value for CTFS in the "normal" patients and the preoperative value for arthritis cohorts were statistically significant ($P = .004$). However, no significant difference was appreciated between the value for CTFS in the "normal" patients and the postoperative value for TKA cohorts ($P = .25$).

Finally, the interobserver correlation coefficients for mechanical alignment and CTFS were good, with 0.81 and 0.79, respectively.

Discussion

There are 2 main findings from this study. First, the degree of CTFS in patients with knee OA does not affect the alignment of the lower extremity after TKA. Second, TKA can properly correct CTFS in patients with knee osteoarthritis, and the degree of correction has no significant correlation with postoperative mechanical alignment. This is the first study to investigate the relationship between CTFS in the coronal plane and postoperative mechanical alignment after TKA.

The lateral displacement of femur after TKA has a great relationship with the operation technique. For knee implants, maximum bone coverage is generally required without any overhang. If the femoral implant is positioned more medially in relation to the tibia, the femoral bone relatively shifts laterally. In addition, the femoral implant size is not always equal to the tibial implant size. In TKA, manufacturers usually recommend combinations of equal femoral and tibial implant sizes as well as one size smaller and larger. As a consequence, combinations

of equal tibial and femoral component sizes or tibial one size larger cause the femoral bone to shift laterally.[4] In addition, the medial and lateral structures of the proximal tibia are asymmetric. According to the theory of Maderbacher G,[4] proximal tibial anatomy differs between the medial and lateral cortex; the medial cortex is medially oblique, while the lateral cortex is straight, and sometimes it even leans inward. In the case of proximal tibial resection, due to the oblique anatomy of the medial border, the medial border relatively shifts laterally while the lateral border does not change or even shifts laterally too; therefore, the tibial prosthesis will shift laterally relative to the tibia, the femur can also shift laterally.

Up to 20% of TKA patients are dissatisfied after surgery[12] and most of these patients present with pain in the front of the knee[13] CTFS after TKA may change the patellar kinematics to some extent, and whether this change will relieve anterior knee pain or cause persistent pain in front of knee after surgery is still unclear, and further studies are needed in the future.

Prosthesis wear after TKA is directly related to mechanical alignment.[14,15] Interestingly, the amount of CTFS correction did not correlate with the amount of overall, mechanical alignment correction. In addition, the amount of preoperative subluxation demonstrated little to no correlation with the patient's sex, age, BMI, or degree of preoperative deformity. This indicates that CTFS is an independent imaging parameter of the knee joint, which is consistent with the results of Nam D.[7] Scott RD et al.[16] believed that CTFS after UKA would accelerate polyethylene wear. Unfortunately, our study did not investigate the relationship between CTFS and polyethylene wear in a long-term follow-up, so it is not clear whether CTFS accelerates polyethylene wear after TKA.

To date, the match between the femoral and tibial components of all knee prostheses has been constant, regardless of the degree of preoperative tibiofemoral subluxation. However, the relative displacement of the tibia and femur in the coronal plane after TKA may alter the tension of the ligaments and soft tissues around the knee, leading to knee dysfunction or persistent pain in the knee. Therefore, further studies are needed in the future to find the most appropriate tibiofemoral coronal plane matching position. At least, the authors of this study believe that the extent of the coronal subluxation of the tibiofemoral joint should be taken into account when the operator makes preoperative planning, not only the correction of the mechanical alignment of the lower limbs.

The present study has several limitations. The study included only a small number of knees, which might have influenced our presented findings. In the present study, only 1 implant was used. The described effect might be implant-related and not transferable to other implants. While the same protocol was used for obtaining each patient's preoperative and postoperative AP, standing, and hip-to-ankle radiographs, these studies are still subject to rotational variations that may affect our measurements. In addition, we did not evaluate the postoperative knee joint score, nor did we have a longer clinical follow-up for these patients, so we could not evaluate the difference in long-term knee joint function.

Conclusion

Preoperative CTFS does not affect postoperative mechanical alignment. Excellent TKA can correct preoperative CTFS in OA patients to reduce prosthesis wear and improve postoperative patient satisfaction.

Author contributions

Conceptualization: RBL
Data curation: PF
Formal analysis: RBL，PF
Investigation: RBL, PF
Writing—original draft: RBL.
Writing—review & editing: RBL

References

[1] Clement ND, Bardgett M, Weir D, Holland J, Gerrand C, Deehan DJ. The rate and predictors of patient satisfaction after total knee arthroplasty are influenced by the focus of the question: a standard satisfaction question is required. Bone Joint J. 2018;100-B:740–8.

[2] Murphy BPD, Dowsey MM, Spelman T, Choong PFM. The impact of older age on patient outcomes following primary total knee arthroplasty. Bone Joint J. 2018;100-B:1463–70.

[3] Ueyama H, Kanemoto N, Minoda Y, Yamamoto N, Taniguchi Y, Nakamura H. Long-term clinical outcomes of medial pivot total knee arthroplasty for Asian patients: a mean 10-year follow-up study. Knee. 2020;27:1778–86.

[4] Maderbacher G, Keshmiri A, Springorum HR, Greimel F, Grifka J, Baier C. Are we subluxating knees in total knee arthroplasty? A cadaveric investigation. J Arthroplasty. 2017;32:263–9.

[5] Khamaisy S, Zuiderbaan HA, Thein R, Gladnick BP, Pearle AD. Coronal tibiofemoral subluxation in knee osteoarthritis. Skeletal Radiol. 2016;45:57–61.

[6] Chang CB, Koh IJ, Seo ES, Kang YG, Seong SC, Kim TK. The radiographic predictors of symptom severity in advanced knee osteoarthritis with varus deformity. Knee. 2011;18:456–60.

[7] Nam D, Khamaisy S, Gladnick BP, Paul S, Pearle AD. Is tibiofemoral subluxation correctable in unicompartmental knee arthroplasty? J Arthroplasty. 2013;28:1575–9.

[8] Ogawa H, Matsumoto K, Akiyama H. Coronal tibiofemoral subluxation is correlated to correction angle in medial opening wedge high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc. 2018;26:3482–90.

[9] Buyukkuscu MA, Misir A, Kirat A, et al. Tibiofemoral subluxation in the coronal plane does not affect WOMAC and KOOS after total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2021;29:914–20.

[10] Lording T, Lustig S, Neyret P. Coronal alignment after total knee arthroplasty. EFORT Open Rev. 2017;1:12–7.

[11] Ueyama H, Minoda Y, Sugama R, et al. Two-dimensional measurement misidentifies alignment outliers in total knee arthroplasty: a comparison of two- and three-dimensional measurements. Knee Surg Sports Traumatol Arthrosc. 2019;27:1497–503.

[12] Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KDJ. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? Clin Orthop Relat Res. 2010;468:57–63.

[13] Planckaert C, Larose G, Ranger P, Lacelle M, Fuentes A, Hagemeister NA-O. Total knee arthroplasty with unexplained pain: new insights from kinematics. Arch Orthop Trauma Surg. 2018;138:553–61.

[14] Bhimani R, Bhimani F, Singh P. Difference between mechanical alignment in navigation and scanogram during total knee arthroplasty. Adv Orthop. 2019;2019:4096306.

[15] Dexel J, Kirschner S, Günther K-P, Lützner J. Agreement between radiological and computer navigation measurement of lower limb alignment. Knee Surg Sports Traumatol Arthrosc. 2014;22:2721–7.

[16] Scott RD, Santore RF. Unicondylar unicompartmental replacement for osteoarthritis of the knee. J Bone Joint Surg Am. 1981;63:536–44.