Original Article

Association between the inclination angle of the proximal tibiofibular joint surface and medial compartment knee osteoarthritis

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Background: Fibular support for the lateral tibial plateau through the proximal tibiofibular joint (PTFJ) results in nonuniform settlement of the tibial plateau in middle-aged and elderly persons and may lead to medial compartment knee osteoarthritis. However, the inclination angle of the PTFJ surface varies widely and may affect nonuniform settlement. The purpose of this case-control study was to assess the association between the inclination angle of the PTFJ surface and medial compartment knee osteoarthritis.

Methods: The fibular inclination angle (FIA) and tibial inclination angle (TIA) of the PTFJ surface were measured using radiographs. Differences of FIA and TIA among groups were assessed with t tests and the odds ratios (ORs) for risk factors of medial compartment knee osteoarthritis were calculated with binary logistic regression analysis.

Results: Forty patients and 40 control participants were included in this case-control study. Patients had both a lower FIA (P=0.005) and TIA (P=0.000) than the controls, and logistic regression analysis showed that FIA (OR =7.000) and TIA (OR =17.000) were risk factors for medial compartment knee osteoarthritis.

Conclusions: A lower inclination angle of the PTFJ surface is associated with a risk of medial compartment knee osteoarthritis. Clinically, early prevention of medial compartment knee osteoarthritis should be considered for middle-aged and elderly persons with low PTFJ inclination angles.

Keywords: Proximal tibiofibular joint (PTFJ); inclination; knee osteoarthritis; medial compartment; fibula

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Introduction

Knee varus and medial compartment knee osteoarthritis are common in middle-aged and elderly patients, and always develop together (1,2). Knee varus and medial compartment knee osteoarthritis are affected by various factors, including biomechanical, genetic, and biological factors (3-5). Recent studies have shown the development of the two is related to the fibular support of the tibial plateau and bone settlement (6,7). The fibula is located in the posterolateral region of the knee, bolsters the lateral tibial plateau, and bears approximately one-sixth of the tibial plateau load (8) and the load distribution at the tibial plateau changes after the lateral bolster of the fibula on the tibial plateau is removed by fibulectomy (9-11). In the aging process, bone density and bone mechanical strength decrease gradually, and varying extents of bone settlement appear in weight-bearing bones, including the tibia and fibula (7), although the decreases are less severe in the latter. In the proximal tibia, fibular lateral support for the lateral tibial plateau results in nonuniform bone settlement of the tibial plateau, while bone settlement of the lateral tibial plateau is less severe than that of the medial tibial plateau. Nonuniform settlement leads to knee varus, increased external knee adduction moment and load increases in the medial compartment of the knee; knee varus, increased external knee adduction moment and load increases in the medial compartment of the knee, in turn, exacerbate nonuniform settlement and consequently create a negative cycle, which can provoke and aggravate medial compartment knee osteoarthritis (3,6,7).

Fibular support of the lateral tibial plateau is achieved through the proximal tibiofibular joint (PTFJ), which is formed by the proximal fibular head and posterolateral surface of the proximal tibia. However, the inclination angle of the PTFJ surface in different individuals varies widely from 0–10 degrees to 76 degrees (12). From the perspective of force transmission, a lower inclination angle can lead to greater fibular support for the lateral tibial plateau and when settlement of the tibial plateau takes place in these individuals, it is more susceptible to nonuniform settlement, making the medial compartment more susceptible to osteoarthritis. Therefore, the inclination of the PTFJ surface may be a risk factor for medial compartment knee osteoarthritis.

The objective of this case-control study was to research the association between the inclination angle of the PTFJ surface and medial compartment knee osteoarthritis using radiographs. It was hypothesized that individuals with low inclination angles of the PTFJ surface would have an increased risk of suffering medial compartment osteoarthritis compared with those with high inclination angles.

We present the following article in accordance with the STROBE reporting checklist (available at https://dx.doi.org/10.21037/apm-21-1348).

Methods

This case-control study (Level III Evidence) was performed in line with the principles of the Declaration of Helsinki (as revised in 2013). After institutional ethical review committee approval (No.113 Hospital of People's Liberation Army, ERC No. 113YY-LUNLI-2017005), the study was registered in ClinicalTrials.gov (ID: NCT03147495). Written informed consent was obtained from all participants.

Study design and patient selection

The study was performed to compare the inclination angle of the PTFJ surface in participants with and without medial compartment knee osteoarthritis. A sample size power analysis conducted before the study revealed a minimum of 39 subjects per group were required to achieve statistical significance with two-sided α=0.05 and 1–β=0.80 and an assumed mean difference between two groups =65% of the standard deviation. Participants were enrolled at the outpatient clinic of our hospital with patients with medial compartment knee osteoarthritis enrolled as a patient group. Participants in the control group were then enrolled (control group) and matched for sex and age (within 5 years) to patients. The control-to-patient ratio was 1:1.

Inclusion criteria for the patient group were: (I) minimum age of 50 years, (II) symptomatic knee osteoarthritis according to the American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the knee joint (13), (III) predominance of self-reported pain over the medial aspect of the knee, (IV) radiographic evidence of medial compartment knee osteoarthritis with an Ahlbäck score of grade I or greater (14), and (V) radiographic evidence of lateral compartment osteoarthritis with Ahlbäck classification grade 0. We excluded participants with any previous surgery, severe trauma, inflammatory joint disease, or tumors in the affected limb.

The control group consisted of participants aged 50 years or older, without knee osteoarthritis according to the American

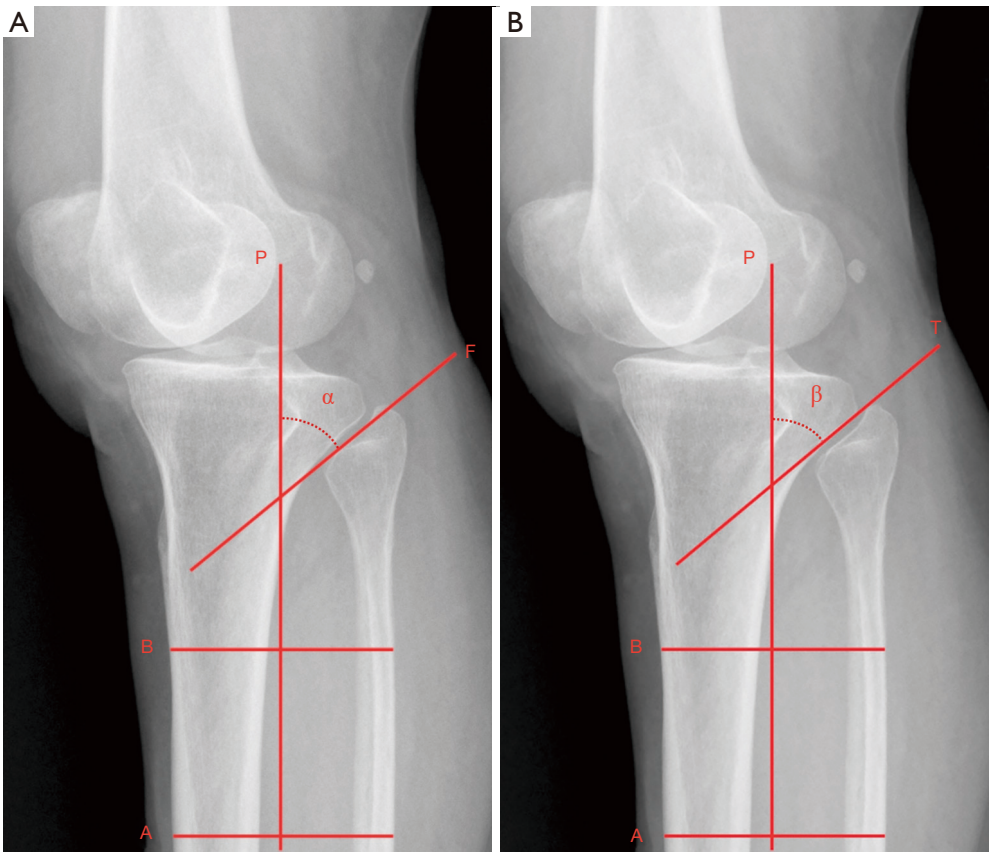

Figure 1 Measurements of the fibular inclination angle and tibial inclination angle of the PTFJ surface on radiographs. (A) The longitudinal axis (line P) of both fibula and tibia was determined by connecting the mid-points of two lines (line A and line B) drawn along the medial-to-lateral width of the diaphysis of the fibula and tibia. Line F was drawn along the fibular surface of the PTFJ. The fibular inclination angle was defined as 90° minus the acute angle (α) subtended by line P and line F. (B) A similar approach was used to determine the tibial inclination angle. The tibial inclination angle was defined as 90° minus the acute angle (β) subtended by line P and line T. PTFJ, proximal tibiofibular joint.

College of Rheumatology criteria for the classification and reporting of osteoarthritis of the knee joint, and with radiographic evidence of the knee with Ahlbäck classification grade 0. Exclusion criteria were a history of previous surgery, severe trauma, inflammatory joint disease, or tumors in the affected limb.

All participants gave signed informed consent before enrolment.

Radiographic examination

Standing anteroposterior knee radiographs and special PTFJ radiographs were taken for the participants in both groups. The standing anteroposterior knee radiographs were obtained with the knee extended and the participants standing on both legs. The PTFJ radiographs were acquired with the knee of participants in approximately 45 degrees to 60 degrees of internal rotation as the PTFJ articulation is clearly visible in this projection (15,16).

Radiographic evaluations and measurements

Knee osteoarthritis was evaluated in the standing radiographs by using the Ahlbäck grading scale (14), and the femorotibial angle (FTA) was measured (17). For the PTFJ radiographs, degenerative joint disease of the PTFJ was staged with the Kellgren-Lawrence staging system (18), and the fibular inclination angle (FIA) and the tibial inclination angle (TIA) of the PTFJ surface to the longitudinal axis of both fibula and tibia were measured separately (*Figure 1*) (12). As shown in

Table 1 Demographics of participants[a]

Demographics	All (n=80)	Patients (n=40)	Controls (n=40)	P value
Mean age, y	62.59±7.34	64.08±6.84	61.10±7.60	0.070
Sex				1.000
Female	40 (50.00)	20 (50.00)	20 (50.00)	
Male	40 (50.00)	20 (50.00)	20 (50.00)	
BMI, kg/m^2	25.55±3.34	26.26±3.72	24.84±2.78	0.057
Laterality				0.369
Right knee	44 (55.00)	24 (60.00)	20 (50.00)	
Left knee	36 (45.00)	16 (40.00)	20 (50.00)	

[a], data are presented as mean ± standard deviation or the number of participants (%). BMI, body mass index.

Figure 1, the longitudinal axis (line P) of both fibula and tibia was determined by connecting the mid-points of two lines (line A and line B) drawn along the medial-to-lateral width of the diaphysis of the fibula and tibia. Line F was drawn along the fibular surface of the PTFJ. The FIA was defined as 90degrees minus the acute angle (α) subtended by line P and line F. A similar approach was used to determine the TIA. The TIA was defined as 90 degrees minus the acute angle (β) subtended by line P and line T.

Radiograph annotations were deleted, each participant was assigned a random and unique number, and participants of the two groups were mixed. All radiographic evaluations and measurements were carried out in a blinded, independent, and random fashion by a radiologist with 17 years of radiograph experience and who did not know the study hypothesis. The digitized picture archiving communication system (PACS, RAD info Technologies Co., Ltd., Hangzhou, China) was used for radiographic analysis. Additionally, 20 participants per group were randomly selected and the FIA and TIA of these 40 participants were measured again 1 month later by the same radiologist and an orthopedic surgeon who had 7 years of radiograph experience and did not know the study hypothesis. The intraobserver reliability and interobserver reliability in the FIA and TIA measurement were assessed by using an intraclass correlation coefficient (ICC).

Statistical analysis

Statistical analysis was performed with SPSS (v25.0; IBM Corp) and P<0.05 was considered significant. Demographics and FTA were compared between the patient group and control group using two-sample *t* test or χ^2 test, and paired-samples *t* test was used to compare the difference between the FIA and TIA of all participants.

Any differences of the FIA and TIA between the patient group and control group were assessed with the two-sample *t* test, and the odds ratios (ORs) for risk factors of medial compartment knee osteoarthritis were calculated using binary logistic regression analysis.

The PTFJ osteoarthritis grades were compared between the two groups by using the Mann-Whitney *U* test.

Results

From July 2017 to September 2020, a total of 40 patients with medial compartment knee osteoarthritis and 46 controls were enrolled. In the control group, one participant was excluded because of osteochondroma at the tibia, another because of inflammatory joint disease, and four others because of radiographic evidence of the knee with Ahlbäck classification grade I resulting in forty patients and 40 control participants ultimately included. Demographics are presented in *Table 1* which shows there were no significant differences between the two groups. In the patient group, 21 (52.5%), 6 (15%), 10 (25%), 2 (5%), and 1 (2.5%) cases had tibiofemoral joint osteoarthritis grades I, grade II, grade III, grade IV, and grade V according to Ahlbäck grading scale, respectively. The mean FTA in the patient group was 179.34±3.60 degrees compared with 174.37±2.65 degrees in the control group (P=0.000). As expected, the knees of the patient group showed more varus than those of the control group.

The ICCs for intraobserver reliability were 0.97 for

Table 2 Comparison of the FIA and TIA between the patient group and control group[a]

Inclination angle	Patient group (n=40)	Control group (n=40)	P value
FIA, deg	26.82±7.97 (24.27, 29.37)	31.99±7.92 (29.46, 34.53)	0.005
TIA, deg	26.91±7.30 (24.58, 29.25)	33.44±6.85 (31.25, 35.63)	0.000

[a], data are presented as mean ± standard deviation (95% confidence interval for mean). FIA, fibular inclination angle; TIA, tibial inclination angle.

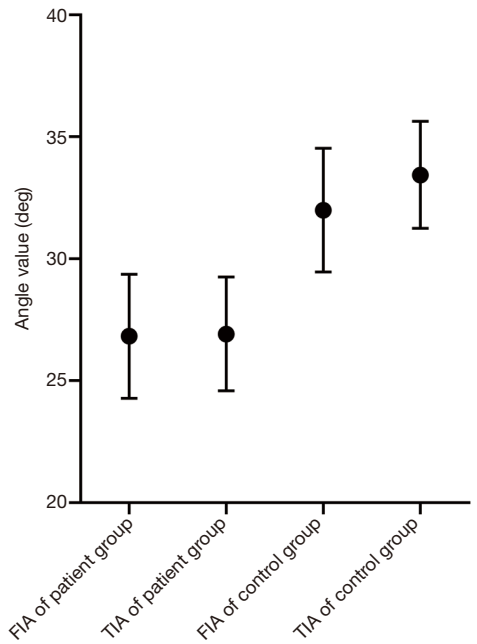

Figure 2 Mean values (center point) and 95% confidence intervals (upper and lower lines) for FIA and TIA in the patient group and control group. FIA, fibular inclination angle; TIA, tibial inclination angle.

FIA and 0.95 for TIA, while the ICCs for interobserver reliability were 0.91 for FIA and 0.82 for TIA, indicating excellent agreement.

Summary statistics for FIA and TIA for the patient group and control group are provided in *Table 2*, and *Figure 2* shows the mean values and 95% confidence intervals of FIA and TIA. The patient group had lower FIA and TIA compared with the control group (P<0.05).

The ORs and 95% confidence intervals for risk factors are provided in *Table 3*, and show FIA, TIA, and age were associated with the risk of medial compartment knee osteoarthritis.

The mean FIA and mean TIA of all participants were 29.41±8.31 degrees and 30.18±7.76 degrees, respectively, and there was no statistically significant difference between the two (P=0.128).

In the patient group, 20 (50%), 14 (35%), and 6 (15%) cases had PTFJ osteoarthritis grades 0, grade I, and grade II according to the Kellgren-Lawrence staging system, respectively. In the control group, 30 (75%), 8 (20%), and 2 (5%) participants had PTFJ osteoarthritis grades 0, grade I, and grade II according to the Kellgren-Lawrence staging system, respectively. Grade III and grade IV were not observed in either group. PTFJ osteoarthritis was more common in the patient group, and there was statistically significant difference between the two groups (P=0.018).

Discussion

The purpose of this study was to assess the association between the inclination angle of the PTFJ surface and medial compartment knee osteoarthritis. We found that patients with medial compartment knee osteoarthritis had lower FIA and TIA than controls, and the mean differences in FIA and TIA between the patient group and control group were 5.17° (19.28% of the mean value in the patient group) and 6.53° (24.27% of the mean value in the patient group), respectively. The mean differences in FIA and TIA amounted to a substantial percentage of the mean value of the patient group, and logistic regression analysis showed that low FIA, low TIA, and age were associated with the risk of medial compartment knee osteoarthritis.

It was reported that about 12.1% of individuals aged 60 years and older have symptomatic radiographic knee osteoarthritis (19). However, the medial and lateral compartments of the knee are not equally likely to be affected. The incidence of isolated medial compartment knee osteoarthritis and isolated lateral compartment knee osteoarthritis were about 3.3% and 0.6% respectively; the risk of developing osteoarthritis in the medial compartment was 5.4 times higher than that in the lateral compartment (20). This phenomenon is related to the bone settlement and

Table 3 Odds ratio estimates

Effect	Point estimate	Lower limit of 95% CI	Upper limit of 95% CI
FIA	5.000	1.914	13.061
TIA	7.154	2.647	19.335
Age	2.914	1.149	7.393

CI, confidence interval; FIA, fibular inclination angle; TIA, tibial inclination angle.

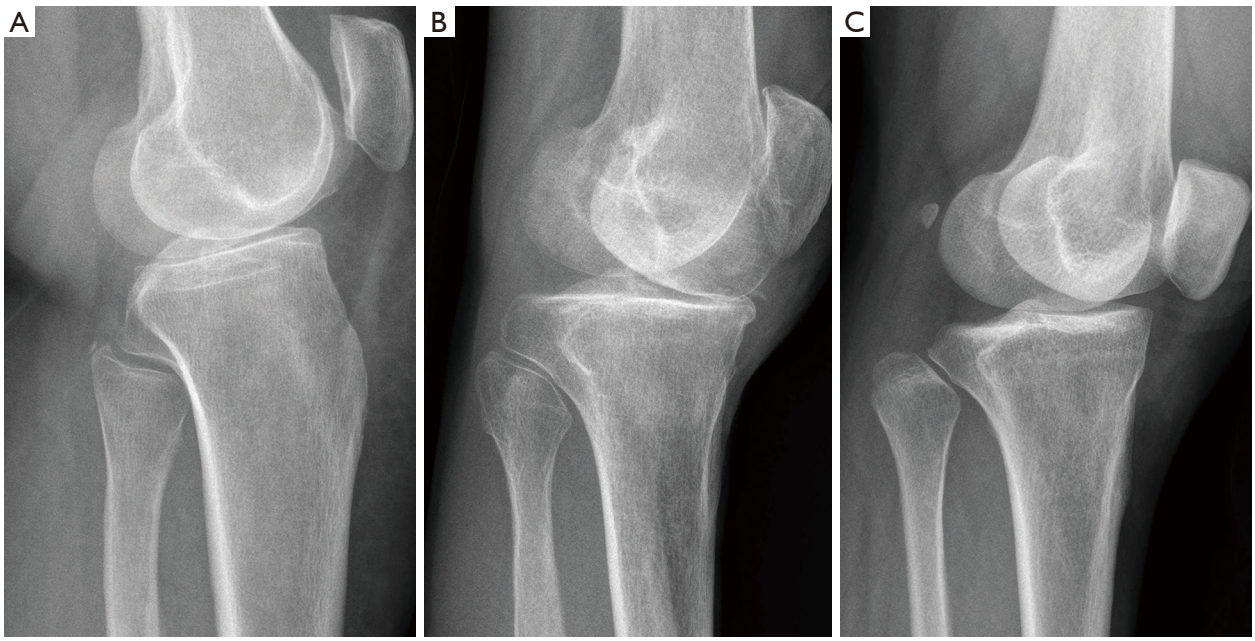

Figure 3 Representative radiographs images of different inclination angle of the PTFJ surface. (A) FIA and TIA are 13.99° and 13.15°, respectively. (B) FIA and TIA are 26.69° and 26.51°, respectively. (C) FIA and TIA are 45.39° and 44.25°, respectively. PTFJ, proximal tibiofibular joint; FIA, fibular inclination angle; TIA, tibial inclination angle.

bony structure asymmetry of the knee, with the lateral tibial plateau, but not the medial, having extra support from the fibula. In the aging process, the incidence of osteoporosis increases significantly, and under the action of body weight, different degrees of settlement will inevitably occur at weight-bearing sites, including the spine, hip, knee, and ankle (7). McNeil *et. al* demonstrated that while the percentage of cortical bone in the proximal fibula is higher than that in the proximal tibia in young persons, with aging there is little change to cortical thickness in the former but a significant decrease in the latter (21). The stiff fibula provides support and tamponade to the lateral tibial plateau, resulting in less settlement of it compared to the medial plateau in the presence of the bone density and mechanical strength decrease (7). The nonuniform settlement of the tibial plateau leads to knee varus which increases the load in the medial compartment, and the nonuniform settlement of the knee is further accentuated. The persistent and significant increase of medial compartment load can provoke and aggravate medial compartment knee osteoarthritis (6,7).

Fibular support of the lateral tibial plateau is achieved through the PTFJ. The inclination angle of the PTFJ surface in different individuals varies widely from 0–10 degrees to 76 degrees (12). Representative radiographs images of different angle are provide in *Figure 3*. A lower PTFJ inclination angle can enable a greater component force parallel to the mechanical axis of the lower limb. The greater component force is manifestation of greater extra support from the fibula to the lateral tibial plateau making the knee more susceptible to nonuniform settlement and

medial compartment osteoarthritis. The results of the present study supported the above-described hypothesis by demonstrating that a lower inclination angle of the PTFJ surface was associated with a risk of medial compartment knee osteoarthritis. The PTFJ inclination angle can be measured from either the fibular or tibial articular surface as the FIA and TIA, respectively and in our study, as expected, there was no statistically significant difference between the mean FIA and mean TIA of all participants. We found that the fibular joint surface and tibial joint surface of the PTFJ were close to parallel in PTFJ radiographs, and the intraobserver reliability and interobserver reliability in the FIA and TIA measurement were excellent. Therefore, both FIA and TIA were reliable predictors for medial compartment knee osteoarthritis. In order to accurately measure FIA and TIA, it was important to place the knee at an appropriate internal rotation angle when taking PTFJ radiograph, so as to clearly identify the PTFJ articulation.

For treatment of advanced medial compartment knee osteoarthritis, high tibial osteotomy, unicondylar knee arthroplasty, and total knee arthroplasty are commonly used procedures. However, these procedures are complex, relatively costly, and potential to cause complications (9,22,23). Therefore, early prevention and treatment is very important. The risk of medial compartment knee osteoarthritis could be assessed by age, body mass index, bone mineral density, lower extremity alignment (3-5), PTFJ inclination angle and other factors. Clinically, for middle-aged and elderly people with obesity, osteoporosis, knee varus, and low PTFJ inclination angles, early prevention of medial compartment knee osteoarthritis should be considered, including weight loss and anti-osteoporosis (4,5). For patients with early medial space knee osteoarthritis, conservative treatment with non-steroidal anti-inflammatory drugs, gait modification, valgus knee braces, or lateral wedge insoles is indicated (4,11,24); if conservative treatment has failed, proximal fibular osteotomy should be considered which can remove the lateral support of fibula and reduce the stress of medial compartment, so as to delay or prevent the progress of medial compartment osteoarthritis (11,22,25-30).

Another case-control study performed by Chang *et al.* (31) found that the association between the PTFJ inclination angle and medial compartment joint space narrowing were of borderline significance. Their findings were based on magnetic resonance images, and angles in the coronal and sagittal planes were chosen as the PTFJ inclination angle. There were seven PTFJ joint types, including irregular joint types (2), and the angle values in the coronal and sagittal planes of the magnetic resonance image were probably influenced by these. In contrast, the PTFJ radiograph used in our study allowed for direct measurement of the PTFJ inclination angle. Furthermore, Chang *et al.* found that a large contact area and large load-bearing area of the PTFJ were risk factors for medial compartment knee osteoarthritis (31,32). Anatomy studies have shown that the lower the PTFJ inclination angle is, the larger the PTFJ contacting area, and the PTFJ load-bearing area was positively associated with the PTFJ contacting area (12,33). Therefore, the findings by Chang *et al.* that a large contacting area and a large load-bearing area of the PTFJ were risk factors for medial compartment knee osteoarthritis were in accordance with our results.

Comparison of the PTFJ osteoarthritis grades between the patient group and control group showed PTFJ osteoarthritis was more common in the former. This result was consistent with the finding of Boya *et al.* (18), who found a significant association between tibiofemoral joint arthritis grades and PTFJ arthritis grades. It has been suggested that the correlation is due to a communication channel existing between the PTFJ and tibiofemoral joint, which was confirmed in a proportion of people by anatomy research (15), allowing inflammatory mediators to potentially flow from the tibiofemoral joint to the PTFJ and trigger osteoarthritis (34).

This study has some limitations. First, all participants were enrolled at a single urban hospital, and sampling bias was inevitable. Large multicenter studies are needed to confirm the results. Second, this is a case-control study, and causality between the inclination angle of the PTFJ and medial compartment knee osteoarthritis cannot be established. The causality needs to be examined in future longitudinal studies.

Conclusions

A lower inclination angle of the PTFJ surface is associated with a risk of medial compartment knee osteoarthritis. Clinically, the early prevention of medial compartment knee osteoarthritis should be considered for middle-aged and elderly people with low PTFJ inclination angles.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://dx.doi.org/10.21037/apm-21-1348

Data Sharing Statement: Available at https://dx.doi.org/10.21037/apm-21-1348

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://dx.doi.org/10.21037/apm-21-1348).The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Ethics Review Committee of the No.113 Hospital of the People's Liberation Army (ERC No. 113YY-LUNLI-2017005). Written informed consent was obtained from all participants.

References

1. Felson DT, Naimark A, Anderson J, et al. The prevalence of knee osteoarthritis in the elderly. The Framingham Osteoarthritis Study. Arthritis Rheum 1987;30:914-8.
2. Lu M, Han W, Wang K, et al. Associations between proximal tibiofibular joint (PTFJ) types and knee osteoarthritic changes in older adults. Osteoarthritis Cartilage 2017;25:1452-8.
3. Mochizuki T, Omori G, Nishino K, et al. The medial inclination of the proximal tibia is associated with the external knee adduction moment in advanced varus knee osteoarthritis. Knee Surg Sports Traumatol Arthrosc 2020. [Epub ahead of print]. doi: 10.1007/s00167-020-06323-8.
4. Glyn-Jones S, Palmer AJ, Agricola R, et al. Osteoarthritis. Lancet 2015;386:376-87.
5. Felson DT, Lawrence RC, Dieppe PA, et al. Osteoarthritis: new insights. Part 1: the disease and its risk factors. Ann Intern Med 2000;133:635-46.
6. Yang ZY, Chen W, Li CX, et al. Medial Compartment Decompression by Fibular Osteotomy to Treat Medial Compartment Knee Osteoarthritis: A Pilot Study. Orthopedics 2015;38:e1110-4.
7. Dong T, Chen W, Zhang F, et al. Radiographic measures of settlement phenomenon in patients with medial compartment knee osteoarthritis. Clin Rheumatol 2016;35:1573-8.
8. Lambert KL. The weight-bearing function of the fibula. A strain gauge study. J Bone Joint Surg Am 1971;53:507-13.
9. Baldini T, Roberts J, Hao J, et al. Medial Compartment Decompression by Proximal Fibular Osteotomy: A Biomechanical Cadaver Study. Orthopedics 2018;41:e496-501.
10. Yazdi H, Mallakzadeh M, Mohtajeb M, et al. The effect of partial fibulectomy on contact pressure of the knee: a cadaveric study. Eur J Orthop Surg Traumatol 2014;24:1285-9.
11. Nie Y, Ma J, Huang Z, et al. Upper partial fibulectomy improves knee biomechanics and function and decreases knee pain of osteoarthritis: A pilot and biomechanical study. J Biomech 2018;71:22-9.
12. Ogden JA. The anatomy and function of the proximal tibiofibular joint. Clin Orthop Relat Res 1974;(101):186-91.
13. Altman R, Asch E, Bloch D, et al. Development of criteria for the classification and reporting of osteoarthritis. Classification of osteoarthritis of the knee. Diagnostic and Therapeutic Criteria Committee of the American Rheumatism Association. Arthritis Rheum 1986;29:1039-49.
14. Ahlbäck S. Osteoarthrosis of the knee. A radiographic investigation. Acta Radiol Diagn (Stockh) 1968;Suppl 277:7-72.
15. Resnick D, Newell JD, Guerra J Jr, et al. Proximal

tibiofibular joint: anatomic-pathologic-radiographic correlation. AJR Am J Roentgenol 1978;131:133-8.
16. Bozkurt M, Yilmaz E, Akseki D, et al. The evaluation of the proximal tibiofibular joint for patients with lateral knee pain. Knee 2004;11:307-12.
17. Bauer GC, Insall J, Koshino T. Tibial osteotomy in gonarthrosis (osteo-arthritis of the knee). J Bone Joint Surg Am 1969;51:1545-63.
18. Boya H, Ozcan O, Oztekin HH. Radiological evaluation of the proximal tibiofibular joint in knees with severe primary osteoarthritis. Knee Surg Sports Traumatol Arthrosc 2008;16:157-9.
19. Dillon CF, Rasch EK, Gu Q, et al. Prevalence of knee osteoarthritis in the United States: arthritis data from the Third National Health and Nutrition Examination Survey 1991-94. J Rheumatol 2006;33:2271-9.
20. Stoddart JC, Dandridge O, Garner A, et al. The compartmental distribution of knee osteoarthritis - a systematic review and meta-analysis. Osteoarthritis Cartilage 2021;29:445-55.
21. McNeil CJ, Raymer GH, Doherty TJ, et al. Geometry of a weight-bearing and non-weight-bearing bone in the legs of young, old, and very old men. Calcif Tissue Int 2009;85:22-30.
22. Utomo DN, Mahyudin F, Wijaya AM, et al. Proximal fibula osteotomy as an alternative to TKA and HTO in late-stage varus type of knee osteoarthritis. J Orthop 2018;15:858-61.
23. Barrett MC, Wilkinson FO, Blom AW, et al. Incidence, temporal trends and potential risk factors for aseptic loosening following primary unicompartmental knee arthroplasty: A meta-analysis of 96,294 knees. Knee 2021. [Epub ahead of print]. doi: 10.1016/j.knee.2021.04.005.
24. Kloppenburg M, Berenbaum F. Osteoarthritis year in review 2019: epidemiology and therapy. Osteoarthritis Cartilage 2020;28:242-8.
25. Wang X, Wei L, Lv Z, et al. Proximal fibular osteotomy: a new surgery for pain relief and improvement of joint function in patients with knee osteoarthritis. J Int Med Res 2017;45:282-9.
26. Xie W, Zhang Y, Qin X, et al. Ground reaction vector re-adjustment-the secret of success in treatment of medial compartment knee osteoarthritis by novel high fibular osteotomy. J Orthop 2018;15:143-5.
27. Huang W, Lin Z, Zeng X, et al. Kinematic Characteristics of an Osteotomy of the Proximal Aspect of the Fibula During Walking: A Case Report. JBJS Case Connect 2017;7:e43.
28. Qin D, Chen W, Wang J, et al. Mechanism and influencing factors of proximal fibular osteotomy for treatment of medial compartment knee osteoarthritis: A prospective study. J Int Med Res 2018;46:3114-23.
29. Liu B, Chen W, Zhang Q, et al. Proximal fibular osteotomy to treat medial compartment knee osteoarthritis: Preoperational factors for short-term prognosis. PLoS One 2018;13:e0197980.
30. Prakash L, Dhar SA. Proximal Fibular Osteotomy: Biomechanics, Indications, Technique, and Results. Orthopedics 2020;43:e627-31.
31. Chang J, Zhu Z, Han W, et al. The morphology of proximal tibiofibular joint (PTFJ) predicts incident radiographic osteoarthritis: data from Osteoarthritis Initiative. Osteoarthritis Cartilage 2020;28:208-14.
32. Chang J, Zhu Z, Liao Z, et al. A novel method for assessing proximal tibiofibular joint on MR images in patients with knee osteoarthritis. Osteoarthritis Cartilage 2018;26:1675-82.
33. Espregueira-Mendes JD, da Silva MV. Anatomy of the proximal tibiofibular joint. Knee Surg Sports Traumatol Arthrosc 2006;14:241-9.
34. Curatolo CM, Bach G, Mutty CE, et al. Review of Common Clinical Conditions of the Proximal Tibiofibular Joint. Am J Orthop (Belle Mead NJ) 2018. doi: 10.12788/ajo.2018.0105.

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