Journal of Orthopaedics, Traumatology and Rehabilitation

Is Conventional Knee Radiograph Reliable Enough to Assess the Anatomical Knee Alignment and Total Knee Prosthesis Position in Indian Population?

Suryamanikanta Balabadra, Ratnakar Vecham, Maryada Venkateshwar Reddy, Adarsh Annapareddy, M. Mahendra Kumar[1], A. V. Gurava Reddy[2]

Departments of Orthopedics, [1]Radiology and [2]Radiology and Imaging, Sunshine Hospitals, Secunderabad, Telangana, India

Abstract

Background: The success and survivorship of primary total knee replacement mainly depend on the postoperative alignment and implant position. Long-leg radiograph (LLR) is considered gold standard in assessing knee alignment postoperatively. Studies have reported that bowing of the femoral shaft in the coronal plane is prevalent in Asian population, which is not fully visualized on a conventional knee radiograph (CKR) and may affect the assessment of coronal alignment. However, postoperatively, CKR is easy to perform and has several advantages if it provides similar precision. **Purpose:** The purpose was to evaluate the validity of CKR in assessing the anatomical knee alignment and prosthesis position as compared with the LLR in Indian population. **Materials and Methods:** One hundred knees in 83 patients were subjected to CKR and LLR during postoperative follow-up at 6 weeks. Three parameters were evaluated to assess the coronal alignment and the component positions - femoral component angle (FCA), tibial component angle (TCA), and tibiofemoral angle (TFA). **Results:** There was an excellent correlation between the TCA as measured from the long and CKRs ($r = 0.884$, $P = 0.01$). There was a high positive correlation between the FCA ($r = 0.703$, $P = 0.01$) and TFA ($r = 0.754$, $P = 0.01$) as measured from the long radiographs and the conventional radiographs. Regression analysis defined these relationships to be linear. **Conclusion:** CKR could be an appropriate alternative for the LLR in evaluating the postoperative knee alignment and total knee prosthesis position despite the fact that there is excessive femoral bowing in Indian population.

Keywords: Conventional knee radiograph, coronal alignment posttotal knee arthroplasty, femur component angle, long-leg radiograph, tibial component angle, tibiofemoral angle

INTRODUCTION

Total knee arthroplasty (TKA) has become a common surgical procedure worldwide. The long-term outcome of primary total knee replacement mainly depends on the postoperative alignment. Furthermore, the survivorship of the implant depends on the postoperative coronal alignment and implant position.[1-4] Although long-leg radiograph (LLR) is considered to be the gold standard to assess coronal alignment.[5,6] Selecting the most efficient radiograph, with the best precision, in economically constrained settings is necessary. Previous studies in literature report that the bowing of the femoral shaft in the coronal plane affects lower limb alignment and is prevalent in Asian population, and the same femoral bowing is reflected in postoperative coronal alignment.[7-9] Femoral bowing is better visualized on a LLR.[10] However, LLR is not always used because of limited accessibility, greater exposure to radiation, more sophisticated techniques required, and higher cost. Conventional knee radiograph (CKR) is a cheaper and readily available alternative with less radiation exposure.[11,12] Therefore, using CKR to measure the anatomical knee alignment and prosthesis position in the coronal plane may offer some advantages over LLR if it provides similar precision. The purpose of the present study was to evaluate the validity of CKR in assessing the anatomical knee alignment and prosthesis position as compared with the LLR in Indian

Access this article online

Quick Response Code:

Website:
www.jotr.in

DOI:
10.4103/jotr.jotr_59_21

population. We hypothesized that LLR would be more accurate than a CKR to assess prosthesis position and knee alignment, considering the prevalence of femoral bowing.

Materials and Methods

Approval from the Institutional Ethics committee was obtained. The current study prospectively evaluated 100 knees in 83 patients who underwent primary TKA with posterior stabilized prosthesis (Maxx Implant) between July 2018 and September 2018. Subjects were excluded if they had flexion contracture or recurvatum >10°, those with extra-articular deformity, and those who underwent previous lower extremity surgery other than total knee replacement. All the 100 knees were subjected to CKR and LLR during postoperative follow-up at 6 weeks. Patients were positioned at standard distance of 180 cm from the radiographic tube in a bipedal stance with both patellae facing forward to prevent rotational error. For the CKR, cassette size of 35 cm × 43 cm was used. The center of the film was focused on the lower part of the patella. Radiographs were performed using 50–120 mAs and 80–120 kVp, depending on the patient's body mass, and the digital radiographs were electronically transferred to a picture archiving and communication system (PACS). The 3 feet LLRs were taken using three cassettes each of size 35 cm × 43 cm stacked one above the other in a customized chamber. Anteroposterior view of the knee including hip and ankle was taken, and the three images were merged using FLFS software in AGFA DX-G machine to obtain LLR. Outcome measures: three parameters were evaluated to assess the coronal alignment and the component positions - femoral component angle (FCA), tibial component angle (TCA), and tibiofemoral angle (TFA). The angles were measured digitally using tool devices in PACS as described by Tammachote *et al*.[13] FCA is the medial angle between the anatomical femoral axis and the articular surface of femoral component [Figures 1 and 2, on conventional and long leg radiograph respectively], whereas TCA is the medial angle between the anatomical tibial axis and the base plate of the tibial component [Figures 1 and 2, on conventional and long leg radiograph respectively]. TFA is defined as the angle between the anatomical axis of the femur and the anatomical axis of the tibia on the medial side [Figures 3 and 4, on conventional and long leg radiograph respectively]. Femoral axis on conventional radiograph is a line that connects the center of medial and lateral condyles of femoral component with the center of the femoral shaft 15 cm above the joint line [Figures 1 and 3] , whereas on long radiograph, it is a line that connects the center of the femoral shaft 1 cm below the lesser trochanter and 10 cm above the joint line [Figures 2 and 4]. Tibial axis on long radiograph is a line that connects the center of tibial component and the center of the talus, whereas on conventional radiograph, it is the line that connects the center of tibial component and the center of the tibial shaft 15 cm below the joint line.

Statistical analysis

Data were entered in a Microsoft Excel Sheet, and the SPSS

Figure 1: Femoral component angle (FCA) and tibial component angle (tca) measurement on conventional knee radiograph
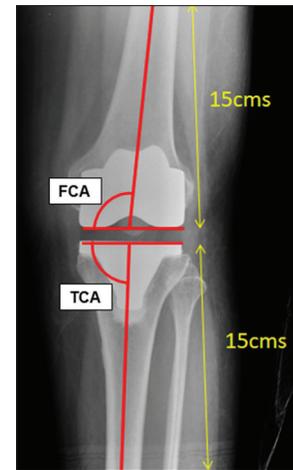

Figure 2: Femoral component angle (FCA) and tibial component angle (tca) measurement on long leg radiograph
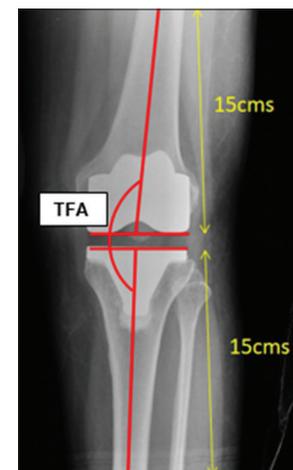

Figure 3: Tibio-femoral angle (TFA) measurement on conventional knee radiograph

Statistics 24 software (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.)

was used for statistical analysis. Data were analyzed using Pearson's correlation coefficient (*r*) values and simple linear regression. Descriptive statistics such as mean, standard deviation, and 95% confidence intervals (CIs) were assessed. Differences between the measured values were analyzed by paired *t*-test. Intra-rater and inter-rater reliabilities were first evaluated in 25 randomly selected LLR, and 25 randomly selected CKR using intraclass correlation coefficients (ICCs). Blinded measurements by two observers (ICC model 2, 1) and repeated measurements by one observer with a 2 weeks interval (ICC model 1, 1) were performed. Intra-rater and inter-rater reliabilities exceeded 0.8 for all measurements except one and were regarded as good to excellent [Table 1]. Because these results indicated that measurements were highly reliable, measurements taken by a single observer were used in the analyses.

RESULTS

A total of 100 knee radiographs in 83 patients (61 women and 22 men) were evaluated. Seventeen patients had bilateral TKA. The mean age at the time of TKA was 62.15 years. The alignment characteristics of each measurement are shown in Table 2. The CKR measurements resulted in a mean increment of 0.74 (95% CI, 0.20–1.28; *P* = 0.007) for TCA, 1.58 (95% [CI], 1.08–2.09; *P* = 0.000) for FCA, and 1.98 (95% 1 CI, 1.23–2.73; *P* = 0.000) for TFA compared to LLR [Table 3]. There was an excellent correlation between the TCA as measured from the long and CKRs (*r* = 0.884, *P* = 0.01). Regression analysis defined this relationship to be linear. TCA angles measured from the conventional radiographs accounted for r^2 = 0.782% of the total variability in TCA measured from the long radiographs. There was a high positive correlation between the FCA (*r* = 0.703, *P* = 0.01) and TFA (*r* = 0.754, *P* = 0.01) as measured from the long radiographs and the conventional radiographs. Regression analysis defined these relationships to be linear. The FCA and TFA measured from the conventional radiograph accounted for r^2 = 0.495% and r^2 = 0.568%, respectively, of the total variability in angles measured from long radiograph.

Figure 4: Tibio-femoral angle (TFA) measurement on long leg radiograph

DISCUSSION

Adequate assessment of the postoperative coronal alignment of the lower extremity is important to find the success of TKA. In addition, longevity of TKA in large part depends on the ability to achieve proper alignment because numerous studies in the current literature have shown that malalignment of a TKA adequately increases contact stresses through the implant and can be one of the factors leading to failure.[14,15] Full-length radiograph is considered gold standard to assess the mechanical alignment, but in the existing literature, there are reports of both long and conventional radiographs being used in assessing the alignment.[5,16,17] Radiographic features of the femur and tibia in the coronal plane have implications on measurement of alignment. Studies have reported variations in femoral bowing between ethnicities.[18,19] Many Asian studies found excessive lateral femoral bowing in knees with advanced osteoarthritis.[7,8,10] Femoral bowing is better

Table 1: Intra-rater and inter-rater correlation coefficients

Parameter	ICC (*P*)	
	Intra-rater	Inter-rater
Long radiograph		
TCA	0.871 (0.000)	0.777 (0.000)
FCA	0.812 (0.000)	0.838 (0.000)
TFA	0.804 (0.000)	0.861 (0.000)
Conventional knee radiograph		
TCA	0.961 (0.000)	0.866 (0.000)
FCA	0.906 (0.000)	0.808 (0.000)
TFA	0.824 (0.000)	0.849 (0.000)

Two-way random effects, single-rater measurement, consistency.
ICC: Intraclass correlation coefficient, TCA: Tibial component angle, FCA: Femoral component angle, TFA: Tibiofemoral angle

Table 2: Alignment characteristics of the cohort

Measurement	Mean±SD
Long radiograph	
TCA	89.44±1.99
FCA	93.84±1.98
TFA	183.01±3.09
Conventional radiograph	
TCA	90.19±1.87
FCA	95.43±1.61
TFA	185.10±2.22

SD: Standard deviation, TCA: Tibial component angle, FCA: Femoral component angle, TFA: Tibiofemoral angle

Table 3: Mean differences and *t*-test results

	T	Df	*P*	Mean difference	95% CI of the difference	
					Lower	Upper
TCA	2.732	198	0.007	0.74667	0.20774	1.28560
FCA	6.227	198	0.000	1.58842	1.08537	2.09147
TFA	5.225	198	0.000	1.98676	1.23692	2.73660

CI: Confidence interval, TCA: Tibial component angle, FCA: Femoral component angle, TFA: Tibiofemoral angle

visualized on LLRs. However, long radiographs are not readily accessible and are costly. The study evaluates the effectiveness of CKRs as compared with that of LLRs in the assessment of postoperative limb alignment and total knee prosthesis position in Indian population.

Skyttä *et al*.[20] conducted a similar study and reported TFA had an excellent correlation, whereas FCA and TCA had good correlations between the long and regular knee radiographs. However, the measurements were taken manually using goniometer. Our study aimed at minimizing the error by measuring precisely using digital films. In our study, TCA angle showed excellent correlation, whereas FCA and TFA showed a high correlation between the conventional and LLRs which suggest that alignment of components and tibiofemoral angle can be reliably measured on CKRs. In the current study, the mean TCAs, FCAs, and TFAs measured from conventional radiographs slightly overestimated valgus alignment by 0.74°, 1.58°, and 1.98°, respectively. The valgus overestimation in the CKR could be due to a shorter distance above the joint line where it meets the lateral bowing of the femur.[21]

Kim *et al*. in their study concluded that surgeons should aim at overall anatomical knee coronal alignment at an angle of 3°–7.5° valgus; femoral component alignment, 2°–8° valgus; and tibial coronal alignment, 90°, to improve the survival of total knee prosthesis.[22] Another study by Fang *et al*. has proposed that alignment between 2.4° and 7.2° of valgus is acceptable, and they have the best survival rates.[4] Even though CKRs in this study have slightly overestimated valgus alignment, the mean values of the alignment characteristics fell within the acceptable range. Therefore, clinical outcomes and survivorship of implants may not vary. However, in cases with excessive femoral or tibial bowing and in those with conflicting clinical and radiological findings, full-length radiograph in at least one follow-up is advisable.

Limitations of the study

The study has looked only at the coronal alignment, but it is important to understand that alignment concerns are three dimensional. Second, rotation of the limb when obtaining the radiograph can have an effect on the value of the measured angles. However, all of our radiographs were obtained under a single-institutional protocol, and this approach has minimized this potential limitation.

Conclusion

CKR could be an appropriate alternative for the LLR in evaluating the postoperative knee alignment and total knee prosthesis position despite the fact that there is excessive femoral bowing in Indian population.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Ritter MA, Faris PM, Keating EM, Meding JB. Postoperative alignment of total knee replacement. Its effect on survival. Clin Orthop Relat Res 1994;299:153-6.
2. Abdel MP, Ollivier M, Parratte S, Trousdale RT, Berry DJ, Pagnano MW. Effect of postoperative mechanical axis alignment on survival and functional outcomes of modern total knee arthroplasties with cement: A concise follow-up at 20 years. J Bone Joint Surg Am 2018;100:472-8.
3. Berend ME, Ritter MA, Meding JB, Faris PM, Keating EM, Redelman R, *et al*. Tibial component failure mechanisms in total knee arthroplasty. Clin Orthop Relat Res 2004;14:26-34.
4. Fang DM, Ritter MA, Davis KE. Coronal alignment in total knee arthroplasty: Just how important is it? J Arthroplasty 2009;24:39-43.
5. Colebatch AN, Hart DJ, Zhai G, Williams FM, Spector TD, Arden NK. Effective measurement of knee alignment using AP knee radiographs. Knee 2009;16:42-5.
6. Rauh MA, Boyle J, Mihalko WM, Phillips MJ, Bayers-Thering M, Krackow KA. Reliability of measuring long-standing lower extremity radiographs. Orthopedics 2007;30:299-303.
7. Lasam MP, Lee KJ, Chang CB, Kang YG, Kim TK. Femoral lateral bowing and varus condylar orientation are prevalent and affect axial alignment of TKA in Koreans. Clin Orthop Relat Res 2013;471:1472-83.
8. Yau WP, Chiu KY, Tang WM, Ng TP. Coronal bowing of the femur and tibia in Chinese: Its incidence and effects on total knee arthroplasty planning. J Orthop Surg (Hong Kong) 2007;15:32-6.
9. Kim CW, Lee CR. Effects of femoral lateral bowing on coronal alignment and component position after total knee arthroplasty: A comparison of conventional and navigation-assisted surgery. Knee Surg Relat Res 2018;30:64-73.
10. Mullaji AB, Marawar SV, Mittal V. A comparison of coronal plane axial femoral relationships in Asian patients with varus osteoarthritic knees and healthy knees. J Arthroplasty 2009;24:861-7.
11. Hinman RS, May RL, Crossley KM. Is there an alternative to the full-leg radiograph for determining knee joint alignment in osteoarthritis? Arthritis Rheum 2006;55:306-13.
12. Hart D, Wall BF. UK population dose from medical X-ray examinations. Eur J Radiol 2004;50:285-91.
13. Tammachote N, Kriengburapha N, Chaiwuttisak A, Kanitnate S, Boontanapibul K. Is regular knee radiograph reliable enough to assess the knee prosthesis position? J Arthroplasty 2018;33:3038-42.
14. D'Lima DD, Chen PC, Colwell CW Jr. Polyethylene contact stresses, articular congruity, and knee alignment. Clin Orthop Relat Res 2001;392:232-8.
15. Lad DG, Thilak J, Thadi M. Component alignment and functional outcome following computer assisted and jig based total knee arthroplasty. Indian J Orthop 2013;47:77-82.
16. Ritter MA, Davis KE, Meding JB, Pierson JL, Berend ME, Malinzak RA. The effect of alignment and BMI on failure of total knee replacement. J Bone Joint Surg Am 2011;93:1588-96.
17. Parratte S, Pagnano MW, Trousdale RT, Berry DJ. Effect of postoperative mechanical axis alignment on the fifteen-year survival of modern, cemented total knee replacements. J Bone Joint Surg Am 2010;92:2143-9.
18. Khattak MJ, Umer M, Davis ET, Habib M, Ahmed M. Lower-limb alignment and posterior tibial slope in Pakistanis: A radiographic study. J Orthop Surg (Hong Kong) 2010;18:22-5.
19. Nagamine R, Miura H, Bravo CV, Urabe K, Matsuda S, Miyanishi K, *et al*. Anatomic variations should be considered in total knee arthroplasty. J Orthop Sci 2000;5:232-7.
20. Skyttä ET, Lohman M, Tallroth K, Remes V. Comparison of standard anteroposterior knee and hip-to-ankle radiographs in determining the lower limb and implant alignment after total knee arthroplasty. Scand J Surg 2009;98:250-3.
21. Chang CB, Choi JY, Koh IJ, Seo ES, Seong SC, Kim TK. What should be considered in using standard knee radiographs to estimate mechanical alignment of the knee? Osteoarthritis Cartilage 2010;18:530-8.
22. Kim YH, Park JW, Kim JS, Park SD. The relationship between the survival of total knee arthroplasty and postoperative coronal, sagittal and rotational alignment of knee prosthesis. Int Orthop 2014;38:379-85.