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Coronal Plane Proximal Tibial Geometry in Knee Osteoarthritis: A Case – Control Study

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ABSTRACT

Background: Coronal plane proximal tibial geometry influences knee biomechanics and load distribution across the tibiofemoral joint and may contribute to the development of knee osteoarthritis (OA). However, data regarding coronal proximal tibial geometric parameters in the Indian population remain limited.

Objective: To compare coronal proximal tibial geometric parameters between normal and osteoarthritic knees, evaluate their association with radiographic severity of knee OA, assess the relationship between body mass index (BMI) and Kellgren–Lawrence (KL) grades, and determine the discriminatory performance of these parameters.

Methods: A hospital-based observational case–control study was conducted among 500 participants, comprising 250 patients with radiographic knee osteoarthritis (OA) and 250 controls. Standardized weight-bearing anteroposterior knee radiographs were used to measure the coronal Tibial Plateau Slope (cTPS), coronal Medial Tibial Plateau Slope (cMTPS), and coronal Lateral Tibial Plateau Slope (cLTPS). Osteoarthritis severity was graded using the Kellgren–Lawrence (KL) classification. Statistical analysis was performed using the Mann–Whitney U test for group comparisons, the Kruskal–Wallis test with post hoc analysis for comparisons across KL grades, Spearman's rank correlation to assess associations between tibial plateau geometry and OA severity, and receiver operating characteristic (ROC) curve analysis to evaluate the diagnostic performance of the measured parameters.

Results: Patients with knee osteoarthritis were significantly older and had a higher body mass index than controls. The mean coronal Tibial Plateau Slope (cTPS) ($3.05 \pm 2.16°$ vs $2.70 \pm 2.09°$; $p = 0.004$) and coronal Medial Tibial Plateau Slope (cMTPS) ($18.91 \pm 2.63°$ vs $16.60 \pm 1.74°$; $p < 0.001$) were significantly greater in the OA group, whereas the coronal Lateral Tibial Plateau Slope (cLTPS) showed no significant difference ($p = 0.671$). No significant sex-based differences were observed in any of the measured parameters. Among the coronal tibial plateau parameters, only cMTPS demonstrated a significant progressive increase with advancing Kellgren–Lawrence grades ($p < 0.001$). Receiver operating characteristic (ROC) analysis identified cMTPS as the best discriminator for knee OA, with an area under the curve (AUC) of 0.771 (95% CI: 0.730–0.813), corresponding to 72.4% sensitivity, 80.0% specificity, and an optimal cut-off value of 17.87°.

Conclusion: Coronal proximal tibial geometry is associated with knee osteoarthritis, with cMTPS demonstrating a significant association with both the presence and radiographic severity of disease. Among the evaluated parameters, cMTPS showed the best discriminatory performance and may serve as a useful adjunctive radiographic marker during the assessment of knee osteoarthritis. The study also provides population-specific reference data that may assist clinical assessment, preoperative planning, and future implant design.

***Keywords**: Knee osteoarthritis; Coronal tibial plateau slope; Medial tibial plateau slope; Coronal proximal tibial geometry; Coronal Tibial Plateau Slope (cTPS); Coronal Medial Tibial Plateau Slope (cMTPS); Coronal Lateral Tibial Plateau Slope (cLTPS); Kellgren–Lawrence grading; Body mass index.*

INTRODUCTION

Osteoarthritis (OA) is the most common degenerative disorder of synovial joints and a major cause of chronic pain, disability, and reduced quality of life worldwide. Globally, approximately 302 million individuals are affected by osteoarthritis, making it one of the leading causes of disability among the elderly[1]. The prevalence of OA in the Indian population is high compared to the global community, with more point prevalence in the rural areas compared to the urban[2,3]. The knee joint is the one commonly affected, and the burden of knee osteoarthritis has increased substantially with increasing life expectancy, obesity, and sedentary lifestyles.

Knee OA is a multifactorial disease resulting from the interaction of mechanical, biological, and genetic factors, leading to progressive cartilage degeneration, alterations in subchondral bone, narrowing of the joint space, and osteophyte formation, ultimately resulting in pain, stiffness, deformity, and functional limitation. OA will cause changes in bone, but on the other hand, studies have shown that the changes in the architecture of bone may also contribute to the development of osteoarthritis. The quality of bone in part determines the distribution of biomechanical forces across the joint. The changes in proximal tibial geometry may have a substantial influence on knee joint biomechanics[4].

Among the biomechanical factors, the **coronal plane geometry of the proximal tibia** has emerged as an important determinant of knee joint mechanics. The morphology of the proximal tibia influences coronal alignment, tibiofemoral load distribution, ligament balance, and joint stability. Variations in coronal plane proximal tibial geometry can alter the distribution of forces across the medial and lateral compartments of the knee, predisposing to abnormal cartilage loading and accelerated osteoarthritic changes.

The increasing use of total knee arthroplasty (TKA) has highlighted the importance of understanding population-specific proximal tibial morphology, as most currently available tibial prostheses are based on Caucasian anthropometric data[5,6]. Accurate assessment of proximal tibial morphology aids in understanding lower limb alignment, planning corrective osteotomies, and optimizing component positioning during total knee arthroplasty.

To quantify these coronal plane morphological changes, several radiographic parameters have been described. These include the coronal Tibial Plateau Slope (cTPS), coronal Medial Tibial Plateau Slope (cMTPS) and coronal Lateral Tibial Plateau Slope (cLTPS). These parameters reflect the orientation of the tibial plateau and its anatomical axis in the coronal plane and have been reported to influence knee biomechanics, joint loading and limb alignment[7,8,9].

Although advanced imaging modalities such as computed tomography and magnetic resonance imaging provide detailed assessment of proximal tibial morphology, their routine use is limited by cost, availability, and radiation exposure in the case of CT. Standardized weight-bearing digital radiographs provide a simple, economical, reproducible, and clinically practical method for evaluating coronal proximal tibial geometry, while also reflecting physiological loading conditions encountered during routine weight-bearing activities.

Despite growing interest in coronal proximal tibial geometry, studies evaluating these parameters in the Indian population remain limited. In particular, few studies have compared coronal proximal tibial geometric parameters between normal and osteoarthritic knees or examined their association with radiographic severity of OA. Addressing this knowledge gap may improve the understanding of biomechanical factors contributing to knee OA and provide population-specific reference data for clinical assessment and surgical planning. We hypothesised that alterations in coronal proximal tibial geometry are associated with both the presence and severity of knee OA. Therefore, the present study aimed primarily to compare coronal proximal tibial geometric parameters between normal and osteoarthritic knees and to evaluate their association with Kellgren–Lawrence grades using standardized weight-bearing radiographs. A secondary objective was to assess the relationship between body mass index and radiographic severity of knee OA.

MATERIALS AND METHODS

AIMS

To compare the coronal proximal tibial geometric parameters in normal and osteoarthritic knees, to evaluate their association with the radiographic severity of knee osteoarthritis, and to determine their discriminatory performance in differentiating osteoarthritic knees from normal knees. The study also aims to evaluate the relationship between body mass index (BMI) and Kellgren–Lawrence(KL) grades of OA.

OBJECTIVES

- To compare coronal plane proximal tibial geometric parameters (cTPS, cMTPS and cLTPS) between normal and osteoarthritic knees.
- To compare coronal plane proximal tibial geometric parameters between males and females.
- To evaluate the association between body mass index (BMI) and knee OA grades.
- To compare the coronal proximal tibial geometric parameters among different Kellgren–Lawrence grades of knee OA.
- To determine the discriminatory performance of coronal proximal tibial geometric parameters in differentiating osteoarthritic knees from normal knees using receiver operating characteristic (ROC) curve analysis

Study design and setting

This hospital-based observational case-control study was conducted in the Department of Orthopaedic Surgery, Little Flower Hospital and Research Centre, Angamaly, Kerala, India, over a period of 18 months (March 2021 to August 2022). Institutional Ethics Committee approval was obtained before commencement of the study, and written informed consent was obtained from all participants.

Study Population

Patients aged 35 years and above presenting to the Orthopaedic Outpatient Department or Emergency Department with knee complaints requiring radiographic evaluation were screened for eligibility. Participants were categorized into two groups: a control group comprising individuals without radiographic evidence of knee OA and a case group comprising patients with radiographic knee OA.

Sample Size

Based on a pilot study conducted at the institution involving 20 participants in each group, the minimum sample size was calculated to be 247 participants per group using a 95% confidence level and a 5% allowable error. To compensate for possible exclusions and incomplete data, 250 participants were recruited into each group, giving a total study population of 500 participants.

Eligibility Criteria

Inclusion Criteria

Control Group

- Patients aged ≥35 years.
- Knee complaints requiring radiographic evaluation.
- No radiographic evidence of knee osteoarthritis.

Osteoarthritis (OA) Group

- Patients aged ≥35 years.
- Patient's X-ray should show radiological osteoarthritic degenerative changes (Kellgren-Lawrence grades 1, 2 and 3).

Exclusion Criteria

Patients with any of the following were excluded:

- Fractures involving the knee or proximal tibia.
- Ligamentous injuries around the knee.
- Inflammatory arthropathies.
- Severe osteoporosis.
- Bone tumours.
- Charcot arthropathy.
- Congenital skeletal deformities.
- Previous surgery involving the knee or tibia.
- Osteolytic lesions affecting the proximal tibia.
- Kellgren–Lawrence grade 4 OA.
- Refusal to provide informed consent.

Radiographic Assessment

All participants underwent standardized weight-bearing digital radiographic evaluation consisting of standing anteroposterior radiograph of the affected knee using a uniform institutional imaging protocol. Digital images were archived in the Picture Archiving and Communication System (PACS). Demographic and anthropometric data including age, sex, height, weight, and body mass index (BMI) were recorded for all participants.

Image Analysis
Radiographic measurements were independently performed by two blinded observers (an orthopaedic surgeon and an orthopaedic resident) using TiaMD NuMR digital radiographic software. In cases of disagreement, measurements were reviewed jointly and a consensus value was recorded. Radiographic severity of OA was graded according to the Kellgren–Lawrence(KL) classification.

The following **coronal plane proximal tibial geometric parameters** were evaluated:

- Coronal Tibial Plateau Slope (cTPS)
- Coronal Medial Tibial Plateau Slope (cMTPS)
- Coronal Lateral Tibial Plateau Slope (cLTPS)

The coronal Tibial Plateau Slope (cTPS) was measured as the angle between a line perpendicular to the anatomical axis of the tibia and a line connecting the medial and lateral margins of the tibial plateau (Figure 1). The anatomical axis of the tibia was determined using the two-circle technique. Positive values indicated that the lateral tibial plateau was positioned more proximally than the medial tibial plateau, whereas negative values indicated the reverse orientation.

Figure 1: Coronal Tibial Plateau Slope (cTPS).

Similarly, both the coronal Medial and Lateral Tibial Plateau Slopes (cMTPS and cLTPS) are determined by measuring the angle formed between two specific lines. The first line is perpendicular to the longitudinal anatomical axis of the tibia, while the second line is drawn from the apex of the respective (medial or lateral) tibial eminence to the edge of its corresponding tibial plateau (Figure 2 and 3).

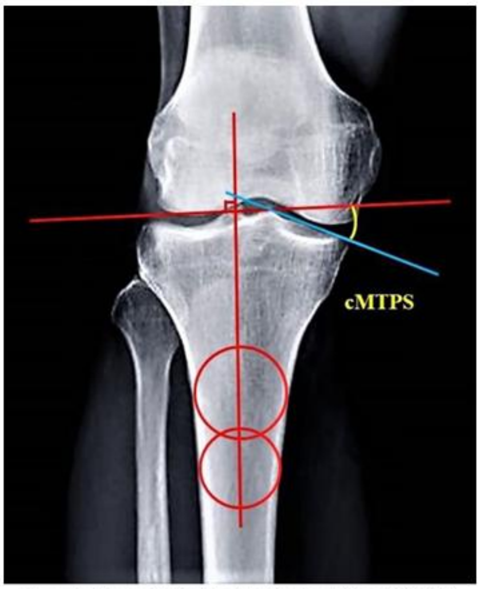


Figure 2: Coronal Medial Tibial Plateau Slope (cMTPS).

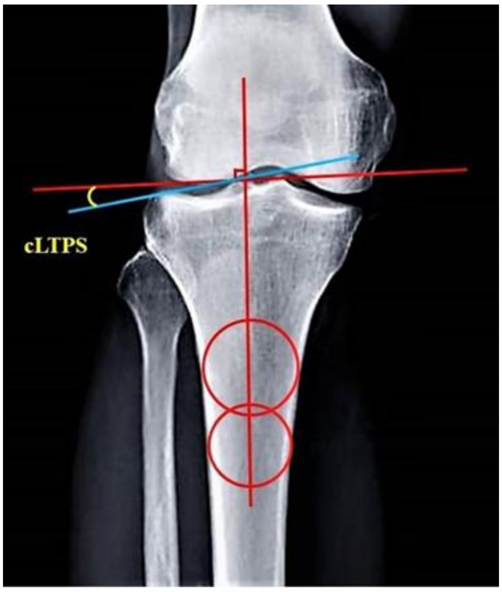


Figure 3: Coronal Lateral Tibial Plateau Slope (cLTPS).

Outcome Measures
Primary Outcome

- Comparison of coronal plane proximal tibial geometric parameters (cTPS, cMTPS and cLTPS) between normal and osteoarthritic knees.

Secondary Outcomes

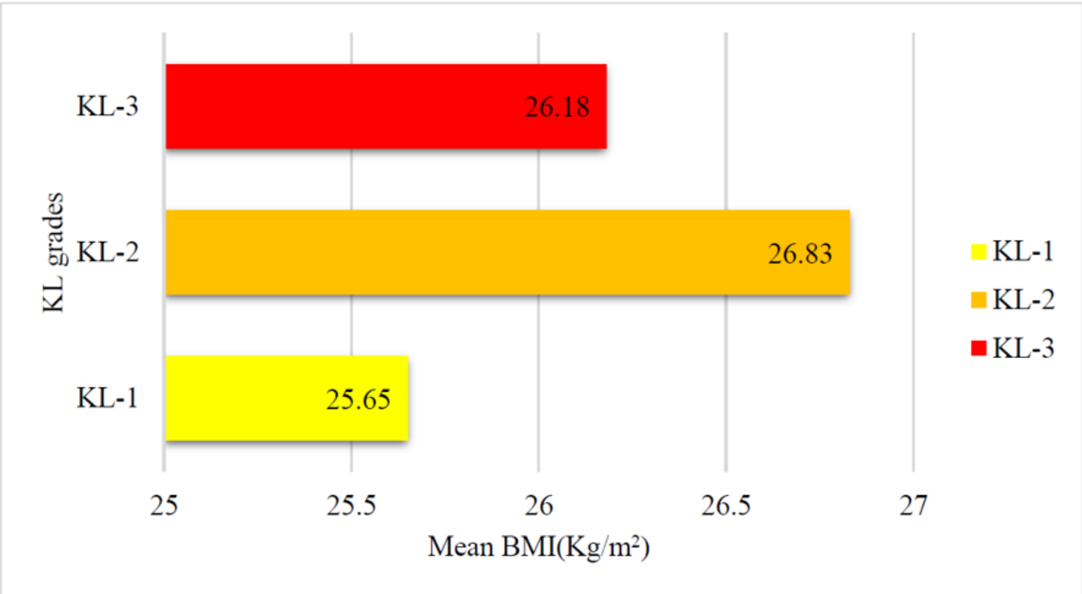
- Sex-wise differences in coronal plane proximal tibial geometry.
- Relationship between body mass index and knee OA grades.
- Association between coronal plane proximal tibial geometric parameters and Kellgren–Lawrence grade.
- Discriminatory performance of coronal plane proximal tibial geometric parameters for identifying knee OA.

Statistical Analysis
Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics for Windows, Version 20.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages. Comparisons between the osteoarthritis and control groups, as well as sex-wise comparisons, were performed using the Mann–Whitney U test. Comparison of body mass index (BMI) and coronal proximal tibial geometric parameters among different Kellgren–Lawrence grades was performed using the Kruskal–Wallis test, followed by post hoc analysis wherever appropriate. The association between coronal proximal tibial geometric parameters and Kellgren–Lawrence grades was assessed using Spearman's rank correlation coefficient. Receiver operating characteristic (ROC) curve analysis was performed to evaluate the discriminatory performance of the coronal proximal tibial geometric parameters in differentiating osteoarthritic knees from normal knees. The area under the curve (AUC), cut-off values, sensitivity, specificity, and 95% confidence intervals were calculated. A p value of <0.05 was considered statistically significant.

RESULTS
A total of 500 participants were included in the study, comprising 250 patients with knee OA and 250 controls.

The range of age in the osteoarthritis (OA) group varied from 41 to 94 years with a mean of 63.64±13.31 years and in the control group, the age ranged from 35-89 years with a mean of 55.14±13.91 years. In the OA group, the majority were females (74%) and 26% were males. In the control group, 56% were males and 44% were females.

In the OA group, BMI ranges from 19.84-39.24 Kg/m^2 with a mean BMI of 26.27±2.26 Kg/m^2 while in control group the mean BMI was 24.33±2.27 Kg/m^2 (range: 19-29.76 Kg/m^2). Within the OA group, body mass index varied significantly across Kellgren–Lawrence (KL) grade 1 and 2, with the highest mean BMI observed in patients with KL grade 2, but no consistent pattern of association with disease severity was observed. (Graph 1 and Table 1)



Graph 1: Comparison of BMI with Kellgren-Lawrence grades in the OA group.

Dependent Variable			Mean Difference (I-J)	Standard Error	Significance
BMI	KL-1	KL-2	-1.176	0.317	0.001
		KL-3	-0.527	0.381	0.352
	KL-2	KL-1	1.176	0.317	0.001
		KL-3	0.650	0.368	0.184
	KL-3	KL-1	0.527	0.381	0.352
		KL-2	-0.650	0.368	0.184
Tukeys post-hoc test, $p<0.05$ shows significance.					

Table 1: Post-hoc test for BMI according to Kellgren-Lawrence grades in the OA group.

Among the coronal plane proximal tibial geometric parameters evaluated, the cTPS and cMTPS were significantly higher in the OA group compared with the control group, whereas cLTPS did not differ significantly between the groups (Table 2).

Parameters	Osteoarthritis (OA) group		Control group		Z-value	p-value
	Range(°)	Mean(°)±SD	Range(°)	Mean(°)±SD		
cTPS	-3.04–9.04	3.05±2.16	-2.67–8.13	2.7±2.09	-2.908	0.004*
cMTPS	13.26 –27.48	18.91±2.63	11.73–24.04	16.6±1.74	-10.49	<0.005*
cLTPS	5.27–16.23	8.87±2.06	5.14–14.84	8.63±1.89	-0.425	0.671
Mann Whitney U Test, $p>0.05$ shows insignificance.						

Table 2: Distribution and comparison of cTPS, cMTPS and cLTPS between OA and Control groups.

No statistically significant sex-based differences were observed in any of the coronal plane proximal tibial geometric parameters in either group (Table 3).

Parameters	Control Group (Mean (°)±SD)			Osteoarthritis (OA) group (Mean (°)±SD)		
	Male	Female	p-value	Male	Female	p-value
cTPS	2.73±1.92	2.66±2.32	0.893	3.29±1.8	2.97±2.27	.342
cMTPS	16.52±1.66	16.81±1.85	0.053	19.03±2.49	18.88±2.69	.529
cLTPS	8.54±2.01	8.75±1.75	0.141	8.58±1.69	8.97±2.17	.302
Mann Whitney U Test, $p>0.05$ shows insignificance.						

Table 3: Gender-wise comparison of cTPS, cMTPS and cLTPS in Control and OA groups.

We found that cMTPS significantly varied between the Kellgren-Lawrence grades. cMTPS increase from KL grade 1 to KL grade 3 and we have observed that these changes are statistically significant ($p<0.05$). (Table 4)

Parameters	KL grade 1		KL grade 2		KL grade 3		Chi-square value	p-value
	Range(°)	Mean(°)±SD	Range(°)	Mean(°)±SD	Range(°)	Mean(°)±SD		
cTPS	-11.63	2.75±2.18	-8.96	3.15±1.43	-12.08	3.36±3.11	1.568	0.211
cMTPS	13.26-20.88	17±1.78	14.02-26.73	19.76±2.06	15.03-27.48	20.42±2.99	82.69	<0.0001*
cLTPS	5.84-14.28	8.82±2	5.27-14.28	8.64±1.42	5.94-16.23	9.4±2.97	2.5	0.084
Kruskal Wallis test, $p<0.05$ shows significance.								

Table 4: Comparison of cTPS, cMTPS and cLTPS between Kellgren-Lawrence grades in the OA group.

A post hoc assessment was done for the paired comparison, to cross-verify the significance obtained between the three grades which showed that cMTPS significantly varied between KL grade 1 to grade 2 and KL grade 1 to 3 ($p<0.05$) and the difference between KL grade 2 to grade 3 is found to be insignificant ($p>0.05$). (Table 5)

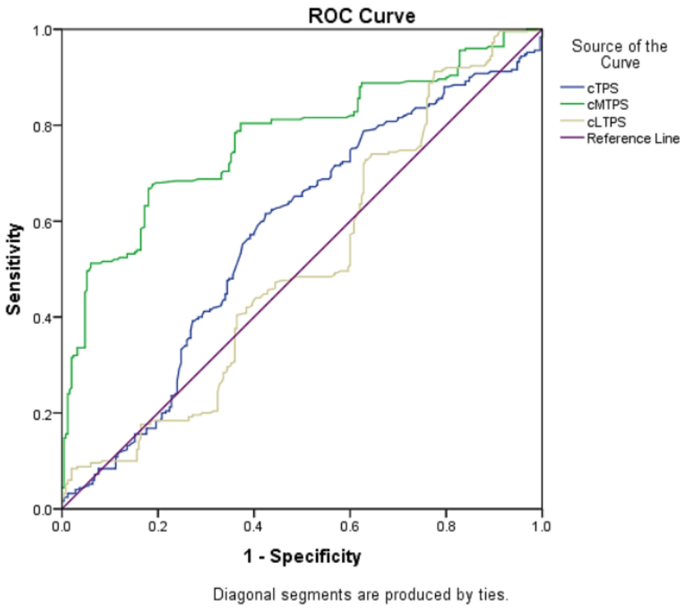
Dependent Parameter			Mean Difference (I-J)	Standard Error	Significance
cMTPS	KL-1	KL-2	-2.760	.316	.000
		KL-3	-3.427	.380	.000
	KL-2	KL-1	2.760	.316	.000
		KL-3	-.667	.368	.167
	KL-3	KL-1	3.427	.380	.000
		KL-2	.667	.368	.167
Tukeys post-hoc test, p<0.05 shows significance.					

Table 5: Post-hoc test for cMTPS according to KL grades in the OA group.

Receiver operating characteristic (ROC) analysis demonstrated that cMTPS had the highest discriminatory performance, with an AUC of 0.771 (95% CI 0.730–0.813), sensitivity of 72.4%, and specificity of 80.0% at a cut-off value of 17.87°. Although cTPS and cLTPS showed statistically significant cut-off values, their discriminatory performance was limited because of relatively low sensitivity and specificity. (Table 6 and Graph 2)

Parameters	Cut-off value	AUC (95% CI)	Significance	Sensitivity	Specificity
cTPS	2.88º	0.575 (0.525-0.626)	0.004	61.60%	57.60%
cMTPS	17.87º	0.771 (0.730-0.813)	<0.0001*	72.40%	80.00%
cLTPS	8.92º	0.511 (0.460-0.562)	0.026	40.40%	63.60%
*p<0.001 shows statistical significance.					

Table 6: Discriminatory performance of cTPS, cMTPS and cLTPS for Knee Osteoarthritis.



Graph 2: ROC-Curve for Discriminatory performance of cTPS, cMTPS and cLTPS for Knee OA.

DISCUSSION

The present study demonstrated that patients with knee osteoarthritis (OA) were significantly older than the control population, with a mean age of 63.64 ± 13.31 years compared to 55.14 ± 13.91 years in controls. 69% of patients with OA were older than 55 years, highlighting the strong association between advancing age and knee OA. This finding is consistent with previous epidemiological studies, which have identified age as one of the strongest risk factors for the development and progression of knee OA[10,11,12]. Females constituted 74% of the OA group, confirming the female predominance of the disease reported in several population-based studies. Hormonal changes following menopause, differences in lower limb alignment, ligament laxity, and altered biomechanics have been proposed to explain the increased susceptibility among women.

In the OA group, the mean BMI was 26.27±2.26 Kg/m^2 while in the control group, the mean BMI was 24.33±2.27 Kg/m^2. BMI was significantly higher in patients with OA than in controls. Although BMI varied significantly across Kellgren–Lawrence (KL) grades, a consistent increase with disease severity was not observed. These findings are in agreement with previous studies by Holmberg et al.[13] and Zheng et al.[14], which identified obesity as an important modifiable risk factor for knee OA because of increased mechanical loading and metabolic inflammation. However, no progressive increase with advancing radiographic severity was observed, suggesting that obesity may contribute more to the development of knee OA than to its radiographic progression.

One of the strengths of the present study is the establishment of reference values for coronal plane proximal tibial geometric parameters in the normal Indian population. The mean cTPS in normal population was 2.7º ±2.09 (range: -2.67º – 8.13º). The mean cMTPS and cLTPS in normal population were found to be 16.6º ±1.74 (range: 11.73º –24.04º) and 8.63º ±1.89 (range: 5.14º –14.84º) respectively. The mean cTPS observed in the control group was comparable to that reported by Driban et al.[15] (2.6º ±1.9).

The mean of cMTPS, and cLTPS in the normal population was found to be more in females compared with males and the mean cTPS in normal population was found to be more in males. But these minor differences observed in mean scores between males and females were statistically insignificant.

The mean cTPS in the osteoarthritis population was 3.05º ±2.16 (range: -3.04º –9.04º). The mean cMTPS and cLTPS in OA population were found to be 18.91º ±2.63 (range: 13.26º –27.48º) and 8.87º ±2.06 (range: 5.27º –16.23º) respectively. Driban *et al*.[15] reported a mean cTPS value of 2.7º ±2.1 among common OA patients and 3.1º ±2 among accelerated OA patients. Comparison of coronal plane proximal tibial geometry between OA patients and controls demonstrated significantly higher values of cTPS, and cMTPS in the OA group, whereas cLTPS did not differ significantly. These findings suggest that alterations in coronal plane proximal tibial geometry are associated with the presence of knee OA. The significantly higher cMTPS observed in osteoarthritic knees is likely to reflect progressive remodelling of the medial tibial plateau secondary to chronic varus loading. Repeated mechanical loading across the medial compartment promotes subchondral bone remodelling, resulting in increased medial inclination of the tibial plateau. This mechanism is consistent with the concept of the tibial parallel phenomenon described by Mochizuki et al.[16], in which the medial tibial plateau progressively aligns parallel to the ground during weight-bearing in advanced varus OA. In contrast, cLTPS did not differ significantly between osteoarthritic and normal knees, suggesting that structural remodelling predominantly affects the medial compartment, which bears the majority of load during gait.

The present study is among the few studies evaluating coronal Medial Tibial Plateau Slope (cMTPS) and coronal Lateral Tibial Plateau Slope (cLTPS) in relation to knee OA, thereby providing additional evidence regarding their clinical significance.

Analysis of disease severity demonstrated that cMTPS increased significantly with advancing Kellgren–Lawrence grades, indicating progressive alterations in coronal plane proximal tibial geometry with worsening OA.

Receiver operating characteristic (ROC) curve analysis demonstrated that cMTPS showed the best discriminatory performance among the evaluated coronal parameters for knee OA (acceptable levels of sensitivity and specificity with a cut-off value of 17.87º). These findings indicate that medial coronal tibial morphology provides useful adjunctive radiographic information in identifying osteoarthritic knees.

Overall, the present study demonstrates that alterations in coronal plane proximal tibial geometry, particularly increased cMTPS, is significantly associated with both the presence and radiographic severity of knee osteoarthritis. cMTPS may serve as valuable adjunctive radiographic markers for identifying individuals at increased risk of knee OA and may assist clinicians in the early diagnosis and evaluation of disease progression. Knowledge of population-specific coronal tibial morphology may also contribute to preoperative planning for corrective osteotomy and total knee arthroplasty.

CONCLUSION

The present study demonstrated that knee osteoarthritis is more prevalent among older individuals, females, and those with a higher body mass index. Although obesity was significantly associated with the presence of knee OA, no consistent relationship was observed between BMI and radiographic disease severity. Patients with knee osteoarthritis had significantly higher coronal Tibial Plateau Slope (cTPS) and coronal Medial Tibial Plateau Slope (cMTPS) values than controls, whereas coronal Lateral Tibial Plateau Slope (cLTPS) did not differ significantly between the two groups. No significant sex-based differences were observed in any of the coronal plane proximal tibial geometric parameters.

Among the evaluated parameters, cMTPS showed a significant positive association with increasing Kellgren–Lawrence grades, indicating its association with greater radiographic severity of knee osteoarthritis. cMTPS demonstrated acceptable discriminatory performance in differentiating osteoarthritic knees from normal knees. The findings of this study establish reference values for coronal plane proximal tibial geometric parameters in the Indian population and suggest that cMTPS may serve as a useful adjunctive radiographic marker during the assessment of knee osteoarthritis. These observations improve the understanding of coronal plane knee biomechanics and may provide population-specific morphometric data that could assist preoperative planning and future implant design.

LIMITATIONS

- Standard radiographs were used instead of CT, which may have resulted in minor measurement inaccuracies.
- This was a single-centre study conducted in South India; therefore, the findings may not be generalizable to the entire Indian population.
- The case-control design does not establish a causal relationship between proximal tibial geometry and knee osteoarthritis.

RECOMMENDATIONS FOR FURTHER STUDY

- Larger multicentric studies should be conducted to establish standardized reference values for the Indian population.
- Prospective longitudinal studies are needed to evaluate the role of proximal tibial geometry in the development and progression of knee osteoarthritis.
- Further studies should assess the clinical application of these parameters in preoperative planning and total knee arthroplasty.

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