Original Research Article

Frontal plane tibio-femoral alignment and its association with knee pain among patients with early osteoarthritis of the knee in a population presenting to a tertiary hospital in South India

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ABSTRACT

Background: Frontal plane knee malalignment may increase the progression of knee osteoarthritis (OA) and worsen functional capacity.

Methods: In our study, the aim was to find the correlation of frontal plane tibiofemoral alignment with knee pain in early OA knee patients. After meeting the inclusion and exclusion criteria, 195 patients with 314 knees (104 females, 91 males) were studied. Clinical and radiological measurements of frontal plane tibiofemoral alignment, using landmark of hip, knee, and ankle, compared with knee pain.

Results: The accepted Statistical significance was $p < 0.05$. Patients with 130 knees (41%) were normal alignment, and 184 knees (59%) were abnormal alignment. The mean±SD age in our study was 54.6±8.9 years. The mean±SD BMI in our study to be 25.86±1.96. Mean±SD Q-angle in patients with normal and abnormal alignment was 14.76±1.54 and 14.63±1.9 respectively. There is statistically no significant correlation between BMI and VAS score (r=0.054, p=0.344). Means±SD of mLDFA, mMPTA, mTFA, aTFA, and JOA were 88.86±2.73, 84.96±3.00, 5.96±4.01, 4.55±3.67, and 2.37±1.88 respectively. JOA and mTFA had statistically significant weak positive correlation with VAS (knee pain) score, (r=0.281) (p=0.000) and (r=0.236) (p=0.000) respectively. The rest of the angles were not had statistically significant correlation with VAS score. The mTFA had statistically significant weak positive correlation with all the angles. We found that Frontal plane tibiofemoral alignment correlates with knee pain in patients with early OA.

Conclusions: The mTFA may be considered one important criterion in designing treatment and planning surgery for patients with primary osteoarthritis. The Q angle acts as a good alternative clinical tool in assessing frontal plane alignment. BMI was not correlating with knee pain (VAS score).

Keywords: Frontal plane tibio-femoral alignment, Osteoarthritis, VAS score

INTRODUCTION

Osteoarthritis (OA) is a degenerative disease of joint characterized by the breakdown of the articular cartilage and imbalance between its regeneration and repair.[1] Osteoarthritis (OA) is a disabling disease affecting approximately 20% of the adult population.[2] It is a significant cause of pain and disability in our aging population. Primary OA is known to affect the hip and knee. In the Asian population, the prevalence of osteoarthritis of the knee is known to be higher than that of the hip. This high prevalence in Asian population is presumed to be because of kneeling activities and floor activities being more compared to the western population.

In Asian population, we have observed that osteoarthritis presents early and is progressive to require replacement at an earlier age.[3]

Patient characteristics that can predict progression of knee OA are age, presence of OA in multiple joints and alignment of the knee. Radiographic features like joint space narrowing (JSN), chondrocalcinosis, and severity of OA as measured by Kellegren Lawrence (K/L) grade and osteophyte score are also predictors of OA. Lower limb alignment is one of the predictors of the progression of knee OA.[4] Recently a study has shown an association between baseline static knee angle and rate of cartilage loss in patients with knee OA.[2] Cartilage defects in the knee, are recognized as important early determinants of potential arthritic change.[5] Sharma et al demonstrated an association between knee malalignment and progression of uni-compartmental joint space narrowing.[6] Varus alignment increases the risk of medial knee OA progression, and valgus alignment increases the risk of subsequent lateral knee OA progression. The severity of malalignment is directly proportional to the loss of joint space, and the resultant decline in the physical function.

Evaluation of knee alignment is useful for the diagnosis of arthritis and surgical planning.[6] It can also serve as a guide for surgical planning. Radiographic frontal plane knee malalignment causes altered weight bearing stresses across the cartilage. This malalignment may predispose to early and rapid development of degenerative osteoarthritis.[9] Frontal plane knee alignment measured radiographically indicates both presence and severity of knee osteoarthritis OA. It is prognostic of future worsening in persons with knee OA.[6,7] Frontal plane alignment also is frequently considered during surgical and non-surgical approaches to treating knee pain.

The range of values for the Asian/Indian population has not been described separately. Abnormal load distribution across the joint can be influenced by minor alterations in knee alignment. A 4–6% increase in varus alignment has been reported to increase loading in the medial compartment by up to 20%. The increase in compartment loading that is thought to increase stress on articular cartilage and other joint structures leads to degenerative changes.[8,9]

Mechanical alignment measurements of the hip-knee-ankle (HKA) angle from whole limb radiographs is superior to all other forms of radiographic measurement of frontal plane alignment.[10,11] Malalignment of the lower extremity in the frontal plane like valgus and varus is a risk factor for the onset and progression of OA knee.[12] These values are not defined for our population which sees early onset and greater severity of degenerative osteoarthritis. There is no literature studying that the effect of frontal tibiofemoral malalignment on osteoarthritis in Indian sub-continent and few studies are available on the relationship of tibiofemoral alignment and osteoarthritis.

It is worthwhile to know the presence of radiological malalignment of the lower extremities in individuals with early degenerative knee pain individuals to be able to correlate the onset of knee pain to the malalignment.[13] This study aims to evaluate the frontal plane alignment around the knee in patients who are presenting with early onset of degenerative knee pain in an attempt to understand the prevalence of malalignment, and the possible correlation of clinical and radiological malalignment to knee pain in the population under study.

Sufficient study data for Indian or Asian Population for these parameters is not available. The knowledge of the normal frontal plane tibiofemoral can influence the planning of replacements as well as deformity corrections around the knee. Early detection can allow steps to prevent progression with less extensive options like osteotomy or braces.

Present study aimed to look for a possible correlation between frontal plane alignment and knee pain.

METHODS

This cross sectional study was conducted from July 2014 to July 2016 in the department of orthopedics JIPMER, Pondicherry. The study was approved by Institutional scientific committee and ethics committee. Patients presenting with degenerative knee pain as defined by American Rheumatology Association were evaluated for their knee pain. A detailed history and examination of the patients were done before including them into the study. Standard anteroposterior (weight bearing) and lateral radiographs of the knee were obtained for the patients with degenerative knee pain. The degenerative knee pain of the arthritic knee defined by the American College of Rheumatology Association (1986) is; Knee pain and osteophytes on radiographs; or Knee pain and patient's age of 40 years or more with morning stiffness lasting 30 minutes or less and crepitus on the motion.[14]

Inclusion criteria

Inclusion criteria were patients presenting to the OPD with knee pain of degenerative type and meeting the American College of Rheumatology criteria for the classification of OA of the knee.[15,16] Radiographs showing Kellegren–Lawrence grades 1, 2 OA on anteroposterior view; patients having complete or near complete range of motion.

Exclusion criteria

Exclusion criteria were knee pain secondary to all other causes of arthritis like rheumatoid arthritis, secondary osteoarthritis, neoplasia and trauma; Radiographs showing greater than stage 2 Kellegren–Lawrence i.e., stages 3,4 OA on anteroposterior view; pre-existing bilateral congenital or developmental deformities like genu varum or valgum; presence of fixed deformities of knee; pre-existing hip or ankle deformities

Kellegren -Lawrence[17]

Grade I: Unlikely narrowing of the joint space, possible osteophyte

Grade II: Small osteophytes, possible narrowing of the jointspace

Grade III: Multiple, moderately sized osteophytes, definite joint space narrowing, some sclerotic areas, possible deformation of bone ends

Grade IV: Multiple large osteophytes, severe joint space narrowing, marked sclerosis and definite bony end deformity.

The sample size was calculated to be 190. After meeting the inclusion criteria and exclusion criteria 195 patients who met the inclusion criteria were included into the study. The demographic and anthropometric data were obtained from all the patients. Severity of knee pain was measured on a visual analog scale (VAS).

Q angle

The Q-angle was measured by a hand-held goniometer, with the patient in supine position. The hip was kept in extension, neutral rotation, and the knee in complete extension. The feet were in the neutral position. The Q-angle was made by intersecting two lines at the center of the patella. The first line was drawn from the antero superior iliac spine (ASIS) to the center of the patella and the second line was drawn from the tibial tuberosity to the center of the patella.[20] The intra and inter-observer reliability after the measurement of the Q-angle using a goniometer are well established across published studies.[21]

After that, a standard standing long leg hip knee ankle radiograph obtained as mentioned below.

Imaging

Antero-posterior lower limb long radiographs (scanograms) imaging femur, tibia, ankle joints and feet were obtained in weight bearing position. Images were archived through PACS (picture archiving communication system) (GE Centricity universal viewer zero footprint Version: 6.0 SP1.1) and retrieved on the computer for analysis.

Measurement of frontal plane knee alignment

Centre of the femoral head was drawn by joining two points from center to periphery drawing radius equally as shown in Figure 1. The centre of the knee joint was made at the apex of the femoral notch. The Centre of the ankle joint was marked by the Centre of the talus Figure 1.
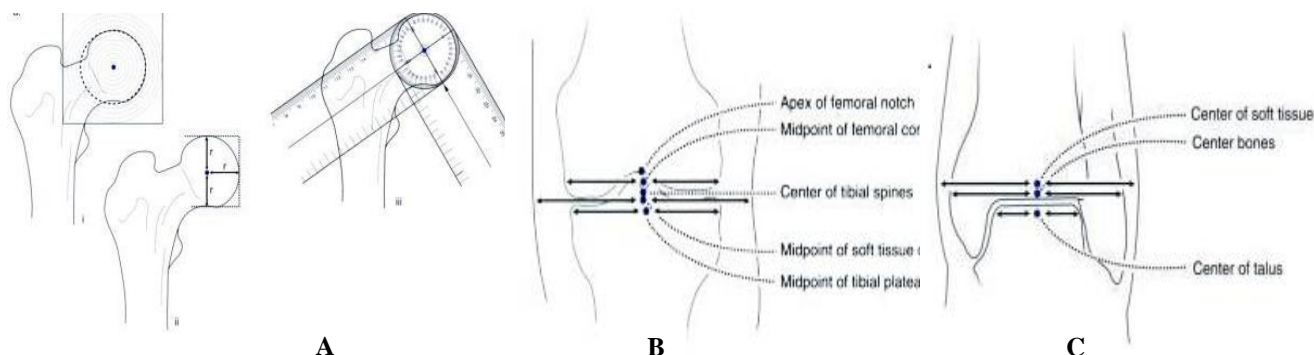

Figure 1: A=centre of femoral head, B=centre of knee, C=centre of ankle.

HKA (mechanical) axis: The mechanical axis of the femur (FM) is as a line drawn from the center of the femoral head to the Centre of the knee joint. The mechanical axis of tibia (TM) is a line drawn from center of the knee joint to the Centre of the talus.

Mechanical tibio-femoral angle: Angle between mechanical axes of femur and tibia.

m MDFA (mechanical medial distal femoral angle): Angle between mechanical axis of femur and femoral joint orientation line medially.

m LDFA (mechanical lateral distal femoral angle): Angle between mechanical axis of femur and femoral joint orientation line laterally.

m LPTA (mechanical lateral proximal tibial angle): Angle between mechanical axis of tibia and tibial joint orientation line laterally.

M MPTA (mechanical medial proximal tibial angle): Angle between mechanical axis of tibia and tibial joint orientation line laterally.

Anatomical tibio-femoral angle: Angle between anatomical axes of femur and tibia.

Joint orientation angle: Angle between femoral and tibial joint lines.

The distribution of data on demographic variables like age, gender, BMI status was expressed as frequency and percentages. The data on all continuous variables such as tibio-femoral angle, Q-Angle etc. was expressed as mean with standard deviation. The linear relationship between measures the frontal plane tibio-femoral alignment and osteoarthritic knee pain was carried out by using correlation analysis. All statistical analysis was done keeping 5 percent level of significance and p-value was <0.05 considered as significant.

Significant Figures

* Significant (P value: 0.05<P<0.10)
** Moderate significant- (P value of 0.01 to 0.05)
*** Strong significant (P value of <0.01)
*Weak correlation(r=0)
**Moderate correlation(r=0.5 to 0.8)
***Strong correlation (=-1 or +1).

RESULTS

After meeting the inclusion and exclusion criteria 195 patients with 314 knees were included in the study. 40% patients were Normal Weight, 56.5% patients were Overweight and 3.5% patients were obese (Table 2). Mean and Standard deviation of VAS score is 6.63±1.149 and BMI is 25.93±1.98. There was no significant correlation between BMI and VAS score (Table 3).

Table 1: Demographic data.

Characteristics	Number	Percentage (%)
Gender		
Male	91	47
Female	104	53
Age group		
40-50	74	37.9
51-60	67	34.4
61-70	49	25.1
71-80	5	2.6
Mean age	54.75	
Mean BMI	25.865	
Total cases	195	

Table 2: Body mass index wise analysis of sample.

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Normal	78	40	40	40
	Over weight	110	56.5	56.5	96.5
	Obese	7	3.5	3.5	100.0
	Total	195	100.0	100.0	

Table 3: Correlation between BMI and VAS.

		VAS score	BMI
VAS score	Pearson correlation	1	.054
	Sig. (2-tailed)		.344
	N	314	314
BMI	Pearson correlation	.054	1
	Sig. (2-tailed)	.344	
	N	314	314

Correlation between angles and VAS score

JOA and mTFA were had statistically significant weak positive correlation with VAS (knee pain) score, (r-0.281) (p-0.000) and (r-0.236) (p-0.000) respectively. The rest of the angles were not had statistically significant correlation with VAS score.

Correlation between different angles

Q angle had statistically significant weak negative correlation with mTFA and JOA, (r: -0.162) (p-0.004) and (r-0.282) (p-0.000) respectively. The mTFA had statistically significant weak positive correlation with all

the other angles. The mean and standard deviation of m LDFA, m MDFA, m LPTA, m MPTA, m TFA,

anatomical TFA and JOA Q-angle demonstrated in Table 4 and 5.

Table 4: Descriptive Statistics of different angles.

In degrees	Mean	Std. deviation	N
VAS score	6.63	1.149	314
m LDFA	88.86	2.739	314
m MDFA	91.24	2.750	314
m LPTA	95.05	2.974	314
m MPTA	84.96	3.008	314
m TFA	5.96	4.014	314
anatomical TFA	4.55	3.674	314
JOA	2.37	1.887	314
Q-angle	14.68	1.777	314

Table 5: Correlation matrix between different angles of knee alignment and VAS score.

		VAS score	m LDFA	m MDFA	m LPTA	m MPTA	m TFA	a TFA	JOA	Q-angle
VAS score	Pearson correlation	1	0.091	-0.085	0.053	-0.054	0.236**	0.085	0.281**	-0.072
	Sig. (2-tailed)		0.109	0.131	0.352	0.342	0.000	0.135	0.000	0.201
	N	314	314	314	314	314	314	314	314	314
m LDFA	Pearson correlation	0.091	1	-0.949**	0.241**	-0.241**	0.478**	0.098	-0.056	-0.022
	Sig. (2-tailed)	0.109		0.000	0.000	0.000	0.000	0.084	0.323	0.699
	N	314	314	314	314	314	314	314	314	314
m MDFA	Pearson correlation	-0.085	-0.949**	1	-0.260**	0.260**	-0.512**	-0.121*	0.045	0.041
	Sig. (2-tailed)	0.131	0.000		0.000	0.000	0.000	0.032	0.422	0.470
	N	314	314	314	314	314	314	314	314	314
m LPTA	Pearson correlation	0.053	0.241**	-0.260**	1	-0.998**	0.529**	0.329**	-0.006	-0.182**
	Sig. (2-tailed)	0.352	0.000	0.000		0.000	0.000	0.000	0.918	0.001
	N	314	314	314	314	314	314	314	314	314
m MPTA	Pearson correlation	-0.054	-0.241**	0.260**	-0.998**	1	-0.521**	-0.326**	0.007	0.178**
	Sig. (2-tailed)	0.342	0.000	0.000	0.000		0.000	0.000	0.904	0.001
	N	314	314	314	314	314	314	314	314	314
m TFA	Pearson correlation	0.236**	0.478**	-0.512**	0.529**	-0.521**	1	0.515**	0.364**	-0.162**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.004
	N	314	314	314	314	314	314	314	314	314
a TFA	Pearson correlation	0.085	0.098	-0.121*	0.329**	-0.326**	0.515**	1	0.202**	-0.109
	Sig. (2-tailed)	0.135	0.084	0.032	0.000	0.000	0.000		0.000	0.054
	N	314	314	314	314	314	314	314	314	314
JOA	Pearson correlation	0.281**	-0.056	0.045	-0.006	0.007	0.364**	0.202**	1	-0.282**
	Sig. (2-tailed)	0.000	0.323	0.422	0.918	0.904	0.000	0.000		0.000
	N	314	314	314	314	314	314	314	314	314
Q-angle	Pearson correlation	-0.072	-0.022	0.041	-0.182**	0.178**	-0.162**	-0.109	-0.282**	1
	Sig. (2-tailed)	0.201	0.699	0.470	0.001	0.001	0.004	0.054	0.000	
	N	314	314	314	314	314	314	314	314	314

**. Correlation is significant at the 0.01 level (2-tailed).*. Correlation is significant at the 0.05 level (2-tailed).

DISCUSSION

The incidence and progression of OA knee are multifactorial. Alignment plays the pivotal role in the etiology of OA. Frontal plane knee alignment is one of the important factors that is responsible for variations in the forces directed at the knee. The risk factors for progression of knee OA, are obesity, quadriceps strength,

laxity, and the stage of the disease. These factors influence the malalignment as well. The mean age, sample size, and gender distribution of the patients across published studies were similar to that of our study.[18,19] The mean±SD age of the patients in our study was 54.6±8.9 years. In our study, the mean age was less compared to other studies (64±11.1, 64±10.8 and 66.6±9.2 years for Sharma et al, Cerejo et al and Felson

et al respectively) reflecting the onset of disease early in the study population.[6,18,20] The present study investigated 195 patients (314 knees) with degenerative knee pain, of which 104 (53%) were females. More females with knee pain in our study reflect that early OA is common in women than men. The number of knees (women) with degenerative knee pain in studies by Sharma et al, Cerejo et al, Evcik et al and Felson et al was 230 (75%), 230 (75%), 35 (77%) and 270 (40%) respectively.[18,20,21]

Knee malalignment and obesity are risk factors for the incidence and progression of knee OA due to increased joint loading.[6] We found the mean±SD BMI in our study to be 25.86±1.96. The above findings comparable to other studies.[13,20] In our study 56.5% of patients were overweight (BMI=25-29.9). There was no correlation between BMI and VAS score (r=0.054 and p=0.344). This result was comparable to a similar study done by Evcik et al (r=0.47, p<0.05).[21]

The Q-angle is used for evaluating patients with knee diseases, especially patellofemoral pain syndrome (PFPS). The static alignment of the lower limb in the frontal plane affects the Q-angle. In our study mean±SD Q-angle in patients was 14.68±1.77. Q angle had weak negative correlation with mTFA, (r=-0.162) (p=0.004) and similarly with JOA (r=-0.282) (p=0.000).

There was no correlation between the Q-angle and LDFA (r=0.001, p=0.99), and weak positive correlation with MPTA (r=-0.051, p=0.64) in our study. The above finding infers a correlation between the Q-angle and alignment.

A study by Kaya et al.found that there was no correlation between the Q-angle and LDFA (r=0.001, p=0.99), and MPTA (r=-0.051, p=0.64).[22] There was no correlation between the Q-angle and lower extremity malalignment. The Q-angle did not present any significant correlation with severity of knee pain (r=−0.072; p=0.201).

Q angle is a clinical parameter which measured on the patient without a radiograph. It will act as a useful tool in assessing frontal plane alignment because it had statistically significant negative correlation with mTFA and JOA which are affecting the alignment most.

Measurements of lower extremity alignment have considerable influence on decision making and assessing outcomes of the various operative procedures like high tibial osteotomy and total knee replacement. In our study, the frontal plane alignment of the knee was measured by using mechanical axis on full-limb radiographs. The method described above using mechanical axis is the gold standard method for assessing the knee alignment. It has frequently been used in previous studies with similar purposes.[6,12,20] There are practical and economic limitations that restrict the use of full-limb radiography for assessing mechanical alignment of the knee. Anatomical alignment of the knee measured by standard

knee radiography is still widely used as a proxy for mechanical alignment of the knee. Although assessing the tibiofemoral anatomical angle from standardized short knee radiographs has been shown to correlate reliably to the full-length hip-knee axis in numerous studies with Pearson's r values referenced at 0.65 and above, the method is still subject to some debate.[9] Reported differences between mechanical and anatomical alignments of the knee show wide variations. If variations between mechanical and anatomical alignments of the knee are considerable, interpretations of epidemiologic and clinical studies based on the anatomical alignment of the knee on standard knee radiographs are likely to be inaccurate.[19,23]

Absolute conclusions can't be drawn from our findings because this is a cross-sectional observation. The presumption that radiographic osteoarthritis is a condition with a linear course of deterioration in radio morphological severity. It does suggest that the marked shift in alignment in either direction in osteoarthritic knees is a consequence of the disease rather than a precursor. Because this shift is significantly linearly related to the observed severity of the condition. This point is also in part comparable to a study performed by Sharma et al.[6] Here, baseline alignment of diagnosed primary OA was assessed and followed up after 18 months, and it was shown that in primary knee OA varus alignment increased the risk of medial OA progression and that valgus alignment increased the risk of lateral OA progression. Measurement, any angles in short knee radiographs are, however, well correlated in experimental studies, only surrogates to measurements made in full limb images. This is a strength in our study as well as in any detailing the angles in standard clinical knee radiographs. We measured the different orientation angles around the knee in patients. Means±SD of mLDFA, mMPTA, mTFA, aTFA and JOA were 88.86±2.73, 84.96±3.00, 5.96±4.01, 4.55±3.67, and 2.37±1.88.

The various angles like mLDFA, mMDFA, mLPTA, mMPTA, mTFA, aTFA, and JOA affect the tibiofemoral alignment and out of which mTFA was considered as the gold standard proven in studies done by Paley et al.[24] In our study mTFA had statistically significant weak positive correlation with all the angles. These data are comparable with several similar studies.[6,13,20]

Different orientation angles around the knee which were measurements of frontal plane alignment correlated with VAS score (knee pain). JOA and mTFA were had statistically significant weak positive correlation with VAS (knee pain) score, (r=0.281) (p=0.000) and (r=0.236) (p=0.000) respectively. The rest of the angles were not had statistically significant correlation with VAS score. The above findings reflects that JOA and mTFA which will define the alignment correlate with knee pain. These results were comparable with a similar study by Evcik et al (r=0.47) (p<0.05).[21]

CONCLUSION

In our study, we found that Frontal plane tibiofemoral alignment correlates with knee pain in patients with early OA. The mTFA may be considered one important criterion in designing treatment and planning surgery for patients with early osteoarthritis. The Q angle will act as a good alternative clinical tool in assessing frontal plane alignment.

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