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Radiographic joint line evaluation and posterior femoral condylar offset using lateral view radiographs of the knee

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Abstract

Background: The purpose of this study is to formulate a simple and effective method of calculating native joint line and Posterior Condylar Offset (PCO) in proper lateral modern lateral radiographs of knee joint with minimal magnification coefficient.

Methods: Knee joint line is measured from a. Posterior condylar flare and b. Tibial tuberosity. Line (A) was drawn from posterior cortex of femur that crossed the flare of posterior condyles. Joint line was measured by a perpendicular line (B) from the proximal most point of tibial tuberosity to the line joining the posterior cortex femoral line on lateral view. Posterior condylar offset: PCO was measured (B) relative to the tangent of the posterior cortex of the femur. The ratio was calculated from these measurements in relation to KSS also. Patients attending to Nizam's Institute of Medical Sciences, Hyderabad, in orthopaedic OPD with ideal body mass index who were evaluated for knee radiographs are included in the study after taking proper consent (n=210). Insta RIS PACS software is used to measure the parameters.

Results: The mean joint line measured was 16 mm (range 14 to 18) with 3.0 as standard deviation and the mean PCO was 25mm (Range 19 to 31) with a standard deviation of 3.0. The KSS score had a mean of 85 (Range 80 to 90) indicating excellent score with standard deviation of 2.0. Joint line ratio was 95% Confidence interval (CI) and the ratio for PCO was also 95% CI. There was a significant difference in the measured joint line between genders.

Conclusion: Using the current measuring method related to standard fixed bony land marks (Posterior femoral line, posterior femoral condyle and tibial tuberosity) which are unaffected even post-surgery the restoration of native joint line and PCO is reliable and reproducible.

Keywords: Knee joint line, PCO, KSS, TKR

Introduction

TKR (Total Knee Replacement) has become one of the prime surgeries of Orthopaedics in India, which has rapidly increased in last two decades with varied satisfaction range. With the advent of newer surgery techniques, modern instrumentation and clear concepts of surgical calculations, preservation of original joint line is coming into reality. As the number of primary TKR are increasing, the rate of revision TKR are also in sudden raise last decade and will continue to increase in near future. It is also a well-known fact that functional outcome of revision TKR is inferior when compared to primary TKR surgery.

The functional outcome has been directly attributed to the Joint line position in a primary TKR [1]. Poor functional outcome have been attributed to revision TKR's in which joint line has not been restored [2]. With the elevation of joint line there is increase in patellofemoral joint contact forces with altered quadriceps function and also has change in centre of rotation of knee joint, which is a well-documented fact in the literature [3].

PCO (Posterior femoral Condylar Offset) restoration is a key step of TKR, which provides flexion stability as well as range of movement [5-6]. In revision TKR it is difficult to restore the PCO due to posterior femoral condyle bone loss, thus resulting in a small femoral component [7]. We will have to use a thicker polyethylene insert in order to balance both the flexion and extension knee gaps, which will cause elevation of the knee joint line [6].

In ability to restore the PCO will also affect the outcome of revision TKR.

In recent times Johal *et al.* [14], Nicolas *et al.* [15], proposed a simple method of measuring the PCO and native joint line prediction on a lateral radiograph of the knee. With this reference we wanted to incorporate some modifications in the technique and to study outcomes of primary TKR and revision TKR which can serve as reference points using simple lateral view radiographs of the knee and to formulate practical simple acceptable recommendations in regards to joint line alterations and PCO in TKR.

Methodology

Patients attending to Nizam's Institute of Medical Sciences, Hyderabad, in orthopaedic OPD with ideal body mass index who were evaluated for knee radiographs are included in the study after taking proper consent (n=210). Knee Society Score (KSS) was calculated in all patients. Distal femur and proximal tibial fractures, severe degenerative knee and bone tumours are excluded from the study. This cohort included 120 (57%) male and 90 (43%) female patients with a mean age of 52 years (range 25 to 80 years).

Fig 1: Flowchart of study

Method for taking radiographical lateral view

Standing [7]: Patient stands parallel to the radiographic cassette, with the lateral aspect touching it and the foot of that knee parallel to the cassette with knee in 30 degrees of flexion. Toe of the back leg touches the heel of the front leg with the back leg locked in full extension. Central ray projection perpendicular to knee.

Patient Lying On Affected Side [8]. Pelvis not rotated. Affected knee forward and extend another limb behind it. Epicondyles perpendicular to the x ray beam. Knee flexion of 30 degrees. Central ray 5 to 7 degrees cephalad at knee joint 1 inch (2.5 cm) distal to medial epicondyle. Slight angulation of CR will prevent joint space from being obscured by magnified image of medial femoral condyle. In lateral recumbent position, medial condyle will be slightly

inferior to lateral condyle.

Lateral view radiographs from a distance of about 100cm from collimeter to the cassette will be taken with above mentioned protocol. Insta RIS PACS software is used to measure the parameters. A standard radiopaque ball of size 50mm is placed on the cassette to calculate magnification. All measurements were made using the graphics tools available on insta RIS PACS picture archiving software communication system.

A work sheet was created in which the patient's details, measurements are documented. The measurements of the same radiographs are repeated one week later in a random order and documented. Statistical analysis was done with unpaired student's *t* test for multiple variabilities and outcome.

A. Line (A) was drawn from posterior cortex of femur that crossed the flare of posterior condyles.

B. Joint line was measured by a perpendicular line (B) from the proximal most point of tibial tuberosity to the line joining the posterior cortex femoral line on lateral view.

Fig 2: Knee joint line is measured from a. Posterior condylar flare and b. Tibial tuberosity.

Fig 3: Posterior condylar offset: PCO was measured (B) relative to the tangent of the posterior cortex of the femur.

Results

Lateral Radiographic measurements were tabulated (Table 1). The mean joint line measured was 16 mm (Range 14 to 18) with 3.0 as standard deviation and the mean PCO was 25mm (Range 19 to 31) with a standard deviation of 3.0. The KSS score had a mean of 85 (range 80 to 90) indicating excellent score with standard deviation of 2.0.

Table 1: The mean, standard deviation (SD), and range for all radiographic measurements.

Radiographic measurement	Mean (mm)	Standard Deviation	Range
Joint line	16	3.0	14 to 18
PCO	25	3.0	19 to 31
KSS score	85	2.0	80 to 90

Joint line ratio was 95% Confidence interval (CI) and the ratio for PCO was also 95% CI. There was a significant difference in the measured joint line between genders (Table 2). However, there was no significant difference in the ratios for joint line or PCO. In this series the KSS score was not affected by the alteration of joint line and PCO in both genders. KSS scores in this series showed excellent results.

Table 2: Radiographic measurements and ratios for genders.

	Male (n=120)	Female (n=90)	Difference	95% CI	P value
Joint line	16.8 (4.5)	14.7(4.8)	3.6	0.1 to 7.1	<0.001
PCO	28.7(3.1)	22.4(2.8)	1.8	0.4 to 0.8	<0.001
KSS score	86	82	-	-	<0.001

Discussion

The current study showed a modified reliable method of measuring joint line and PCO with the usage of simple lateral radiographs of the knee joint correlating both with the clinical outcomes as measured by KSS. Inability to restore the native joint line and PCO will show negative effects on clinical outcome and the same fact is well documented in literature. There was significant correlation between the posterior femoral line with the perpendicular line drawing from the tibial tuberosity with the joint line and PCO. Using this ratio both PCO and joint line could be predicted with in 3mm and 2mm respectively. There was no significant interobserver and intraobserver difference with reproducibility of this method up to less than 2mm (*P value* <0.001).

The same can be used to post-operative primary and revision TKR to assess the native joint line and PCO and KSS score outcome can be measures and compared accordingly. There are few limiting factors in this study, such as small cohort study of 210 lateral knee radiographs with wide range of age variability, with slight magnification in radiographs altering the measurements, with Indian ethnicity taken into consideration. The population in this study was mainly of Indian origin and this needs further documentation and study with other populations across the globe. Overcoming the limiting factors in this study with small cohort with variable ages and ethnicity consistent reproducibility of our methodology is near accurate with small interobserver and intraobserver difference, which can be relayed upon in reproducing the joint line and PCO with KSS score correlation. Wang *et al.* [16] had demonstrated similar study stating variations of joint line and PCO in different ethnic groups showing increased PCO in Chinese population when compared to Western population. The similar cannot be compared in children and adolescent groups who may not require revision TKR.

The current study has similar comparative PCO results to that of Johal *et al.* [14], which can show overall equivalent results with Western population. Latest study by Wang *et al.* [16] showed increased PCO in Chinese population when compared to Western population and also minor variations in male and female gender. Bellemans *et al.* [10] extensively studied about the KSS score and joint line level using a cohort of 200 post primary TKR lateral radiographs and correlated with magnification coefficient and found elevation of joint line to mean of 1.6 mm but with no difference in gender groups. In all the studies, the variables did not change much according to the population assessed. This study used digital picture lateral radiographs with Insta RIS PACS software to measure the parameters which is becoming more popular in medical science when compared to other study series. This digital radiograph has better clarity and contrast can be adjusted for better visual acumen and thereby reducing the chance of poor-quality pictures. The standardisation of this method offers a simple and easy way to calculate the joint line and PCO which can overcome the magnification coefficient.

Reproduction of the original joint line and PCO in primary and revision TKR is important to get excellent KSS score. Porteous *et al.* [6] and Partington *et al.* [8] studies state that joint line elevation of greater than 6mm has led to decreased

functional outcome with average KSS score. In this case series, the current method of measuring native joint line and PCO offered less than 4mm variability, which is reliable and easy to reproduce without any error in magnification coefficient. This can be incorporated for planning of preoperative calculations of complex degenerated TKR surgeries. Thus, restoring near native joint line and PCO to provide mid flexion stability with excellent KSS score and clinical outcome. The increase in PCO has increased range of movement by with less stability by Malviya *et al.* [9, 10, 11], using the current measuring method, which is independent of magnification coefficient, we can reproduce similar excellent results. Thus, this is a multifactorial picture in which many factors will affect the outcome of TKR, of which joint line reproduction with in 4mm and PCO with in 5mm play a major role.

Conclusion

Using the current measuring method related to standard fixed bony land marks (Posterior femoral line, posterior femoral condyle and tibial tuberosity) which are unaffected even post-surgery the restoration of native joint line and PCO is reliable and reproducible. This can also be used as preoperative tool to enable surgeon to plan surgery accordingly in selection of inventory prediction of component sizes. Further research is required in various ethnic groups in large cohort studies to standardise the measurement protocols to improve the functional and radiological outcomes.

Conflict of interests

The authors have no benefits in any form, did not receive any grant or financial aid relating to this study.

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