Accuracy and reliability of distal femoral rotation measurements using the transepicondylar axis in total knee arthroplasty: A cadaver study

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ABSTRACT

INTRODUCTION

Knee replacement which also called knee arthroplasty is a common surgical procedure to replace the weight-bearing surfaces of the knee joint to relieve pain and disability of patients. It is the most common procedure for osteoarthritis and also for other knee diseases such as psoriatic arthritis and rheumatoid arthritis. In patients with severe deformity from advanced trauma, rheumatoid arthritis or long-standing osteoarthritis, knee arthroplasty may be more complicated and imposes higher risk. Other major causes of debilitating pain include cartilage defects, meniscus tears, and ligament tears. Debilitating pain from osteoarthritis is much more common in the elderly people.

Knee arthroplasty surgery rate is rising considerably around the world due to the rise of life expectancy and the increase in the elderly population. Reports show that more than 700,000 surgeries have been done in the US only in 2011 which shows a 93% of an increase between 2001 and 2011. Also, it is projected that by 2030, the demand for primary total knee arthroplasty will be increased to 3.48 million cases performed annually in the U.S. This procedure has some risks for patients including loss of motion, instability, fractures, and infection.

Knee replacement surgery can be performed as a partial or a total knee replacement. In general, the surgery consists of replacing the diseased or damaged joint surfaces of the knee with metal and plastic components shaped to allow continued motion of the knee.

A successful Total Knee Arthroplasty (TKA) requires perfect alignment of the femoral and tibial components. To achieve this goal, making correct and accurate femoral and Tibial cuts, is the first step; as the posterior distal femoral cut is considered as one of the most important ones in the femoral region. The exact measurement of rotation in this cut in axial plane is critical, as if not calculated precisely, would lead to misalignment of the components in malrotation position and causes unfavorable postoperative complications such as joint pain, stiffness, flexion instability, patellofemoral instability, earlier implant loosening, increased shear force on the patella, weight overload on the medial compartment inflexion, and ultimately TKA failure. Although, the severity of these
complications is related to the severity of malrotation (up to 3 degrees of malrotation is acceptable with no significant complications, 3 to 5 degrees leads to mildly complicated outcomes, and more than 5 degrees malrotation will cause severe postoperative complications) (21-24).

There are four main methods used in measuring this rotation degree, based on:

1. Posterior condylar axis (PCA)
2. Trans-epicondylar axis (TEA)
3. Whiteside’s line
4. Gap technique (25,26)

Although, the debates continue on determining the method of choice, this study was aimed to assess the accuracy and reliability of using TEA in determining the distal femoral rotation in TKA, which is achieved by comparing the data measured manually based on TEA and the one calculated using CT scan images of distal femoral axial cuts. The results were also compared to the normal distal femoral rotation (3 degrees external rotation) based on PCA. The outlier data, (the outlier considered as 3 and 5 degrees regarding normal distal femoral 3° external rotation) were evaluated as well. To assess the reliability of the measurements in both study groups, kappa index was used. (k>0.7 was defined as valuable). The independent sample t-test was used to compare the DFR data that measured in each group, and the incidence of outliers was calculated using the Fisher's exact test.

METHODS

In this study, 20 cadavers of femoral bones that donated to the department of anatomy of the faculty of medicine, were studied; those with fractures or defects of distal femoral, condylar hypoplasia, or any deformities were excluded. First, the DFR was measured by 8 orthopedic surgeons using “LINK TKA distal femoral jig” (posterior reference) based on TEA. After all of the 20 femoral bones were CT-scanned with 2mm cuts in the axial plan, the next step was to measure the DFR based on PCA and TEA angle, done by 2 orthopedic surgeons and 2 radiologists. To reach accurate results, the distal femoral cut (in CT scan images) with the maximum epicondylar dominance was assessed (by drawing the axis between the most dominant part of the medial epicondyle and the center of lateral epicondyle). The results obtained in 2 groups, were analyzed via both interobserver and intraobserver assessments. Also, the outcome was compared to the normal distal femoral rotation (3 degrees external rotation) based on PCA. The outlier data, (the outlier considered as 3 and 5 degrees regarding normal distal femoral 3° external rotation) were evaluated as well. To assess the reliability of two methods of measurement, Kappa index was calculated 0.64 in manual method and 0.81 in the other groups of study (k>0.7 was considered valuable) The outlier was defined as 3 and 5 degrees regarding normal distal femoral 3° external rotation, and the incidence of the outliers was calculated as follows.

Identifying 3 degrees deviation in the manually measured data, 12% of the data was out of the determined range, while in the other group no outlier data were reported; indicating the meaningful difference between two groups of study. (p=0.021)

With a deviation range identified as 5 degrees, no data were detected out of range in any of the two groups.

The rotation rate of the distal femur in two methods (manually and CT scan) is presented in Figure 1.

DISCUSSION

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femoral rotation in TKA, which is achieved by comparing the data measured manually based on TEA and the one calculated using CT scan images of distal femoral axial cuts. The results were also compared to the normal distal femoral rotation (3 degrees external rotation) based on PCA. Our results suggest using CT scan in the patient’s pre-op assessment to obtain the most accurate data due to the unreliability and noticeable risk of error in measuring DFR manually based on TEA. However, Mateziolis et al. (2010), in a review article have reported that based on the studies that have been done so far, we cannot be precise as to which of the four available methods is preferable to determine the rotation of the distal femur.27 Fujii et al. (2011), in another study on the 184 cases of TKA in which the DFR was done using reference line and also epicondylar view X-ray in pre-op planning have shown a statistical difference between 2 groups.28 Patel et al. (2014), in another study have concluded that the int. rot of Posterior condyles relative to the Trans-epicondylar axis which has been suggested 3 degree in previous studies is 2.38±1.6. Also, they reported that this rotation is higher in knees with valgus deformity.29

Vaidya et al. (2013), in their study have reported the malrotation rate of femoral component after surgery using CT-Scan. They concluded that in patients in whom the posterior condylar axis had been used the determining of rotation rate component was being in 2.67±1.1 degree of ext. rot while this was in 5.6±1.4 degree of ext. rot for patients who TEA was used for them. Therefore, the authors concluded that using TEA for determining the distal femoral rotation causes the component to be in excessive ext. rot.30

Franceschini et al. (2016), in a retrospective study, have measured the deviation rate of the component from TEA on the 31 cases of TKA using MRI. They showed that the deviation rate was -3.8±2.9 degree for patients that PCA had been used for them while this was -1.4±1.9 degree for those patients that TEA had been used for them. So, they concluded that using TEA in surgery procedure for the determining of distal femur rotation is preferable.31

In conclusion, the DFR measured manually, not only is less reliable than the one calculated using CT scan images, but also depends on other technical and situational parameters such as the surgeon’s experience and accuracy. Moreover, since identifying the TEA during the operation is more difficult, (specifically in identifying the medial epicondyle regarding the exposure limits and the presence of soft tissue in the field), the real risk of error is estimated to be even more than what is reported in the present study; while these limits are not expected to be biasing the data which is calculated using CT scan images. Besides the unreliability of manually measuring the DFR, the risk of error and the severity of the following malrotation are also significantly increased. Thus, this study suggests using CT scan in TKA pre-op assessments to obtain the accurate DFR measurement in a normal knee (with no deformities or defects of distal femoral), in order to achieve the most desirable outcomes.

CONCLUSION

Since manually measuring the DFR based on the TEA, in a normal knee (with no distal femoral deformities or defects), is noticeably surgeon-dependent, and regarding the unreliability and the significant risk of error in this method, this study suggests using CT scan images in measuring the DFR based on the TEA.

It is also implied that in cases where a pre-op CT scan is not accessible, (and in a normal knee with the characteristics explained above) using the normal distal femoral rotation (3°external rotation) regarding to PCA, instead of using the TEA to determine the DFR, is more likely to lead to more acceptable outcomes.

CONFLICT OF INTEREST

Not declared.

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