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Does Computer Navigation Offer Superiority in Restoring Posterior Condylar Offset Ratio (PCOR) Than A Conventionally Done Total Knee Arthroplasty – A Cross Sectional Analytical Study?

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Abstract

Purpose: The restoration of knee anatomy is one of the key factors for a successful and long-lasting Total Knee Arthroplasty (TKA). The study is conducted with an objective to assess whether the use of navigation software is superior in recreating posterior condylar offset ratio to pre- operative anatomical state than a conventionally done TKA.

Materials and methods: The pre- and post-operative radiographic assessment of two hundred patients were evaluated retrospectively. The data of one hundred non-navigated TKA surgeries were obtained from the hospital when navigation software was not available and data of one hundred navigated TKA surgeries were obtained after the navigation system was installed in the hospital.

Results: The mean PCOR pre- and post-operative values for the navigated TKA were found to be 0.45 ± 0.14 and 0.46 ± 0.1 and for the non-navigated TKA were 0.45 ± 0.14 and 0.47 ± 0.13, respectively. There is a statistically significant difference in pre- and post-operation mean PCOR in non-navigated TKA (mean difference (0.02) (P=0.0001) and navigated TKA (Mean difference (0.01) (P= 0.0367), using paired T-test, implying that the PCOR after non navigated and navigated surgery is different and statistically significant when compared with pre-operative state. Further analysis revealed that the reduction of mean difference (0.01) in Navigated TKA, using t-test, is also statistically significant (P= 0.0196) implying that navigation system helped to lower the post-operative mean difference in PCOR significantly. The pre-operative mean PCOR values of both navigated and non-navigated group were not different (P=0.4552) but the post-operative mean PCOR values were different and significant (P=0.0193). This shows that the pre-operative PCOR values of both groups were comparable but post-operative PCOR values of both groups were significantly different.

Conclusion: TKA done using navigation software is found to be superior in recreating the posterior condyle offset ratio when compared to the conventional TKA.

Keywords: Computer navigation system, minimally invasive surgery, Posterior condylar offset ratio (PCOR), Range of flexion (ROF), Total knee arthroplasty (TKA).

Introduction

Total Knee Arthroplasty (TKA) is considered as a treatment of choice in the management of severe knee osteoarthritis. According to the Indian Society of Hip and Knee Surgeons (ISHKS) preliminary report, during the period of 2006 to 2012 around 34478 total knee arthroplasties and 3604 total hip arthroplasties had been performed and this number increased to 70,000 joint replacement surgeries in the year of 2017.[1]

The major concern amongst the clinicians and patients is to achieve a nearly normal range of flexion (ROF) after TKA. Surgeons are paying more attention to reconstruct the anatomical structure thereby restoring the functional capacity of the knee leading to improved quality of life of the patient after TKA.[2] The degree of flexion after total knee replacement has been studied by many authors and suggested that the pre-operative flexion and accurately corrected posterior condylar offset (PCO) are the major factors which determine the ROF after surgery. The restoration of PCO during TKA is a crucial step to achieve flexion stability, a maximum range of motion, improve knee kinematics, and to prevent impingement and complications arising due to differences in the size of distal femur.[3–5]

Bellemans et al. postulated that for every 1 mm of PCO reduction there was a loss of 6.1 degrees of flexion and for more than 3 mm reduction a significant loss of 29.7-degree flexion. So, they proposed a mechanism of retaining the PCO which allow maximal knee flexion after TKA.[6] Johal et al observed that there was considerable variability in the posterior condylar offset of different population hence they introduced a dimensionless parameter as posterior condyle offset ratio (PCOR) which was significantly correlated with ROF.[7]

PCOR is defined as the quotient of the distance between the posterior condylar boarder and the tangent to the posterior cortex of the femoral diaphysis, and the distance between the posterior condylar border and the tangent to the anterior cortex of the femoral diaphysis. The PCOR assessed radiographically has the advantage of easy execution which provide excellent intra and inter-observer reproducibility. PCOR estimation is independent of gender, population, referencing system, and x-ray magnification. As dimensionless, PCOR eliminates the complications due to differences in the size of the femur which occurs among the patients. Sometimes, PCOR in plain radiograph underestimates the condylar asymmetry and external rotation of component which may distort anteroposterior (AP) length.[4]

The use of computer navigation in TKA surgery has recently been famous amongst orthopedic surgeons. The computer navigation enables the surgeon to measure and assess knee kinematics during surgery, allowing real-time documentation of knee behavior from extension to flexion which eventually improves surgical precision and patient outcome.[8] While balancing the flexion gap the rotation of the femoral cutting jig along with component upsizing or downsizing will lead to variation in the PCOR. Navigation offers stepwise planning and monitoring of surgical procedure results in precise positioning of implants which reduces post-operative malalignment.[9] No comparison study had been conducted till now between the correction of PCOR using navigation software method and non-navigated conventional method in TKA. Hence, the current study was carried out with the aim to determine whether computer navigation is superior in recreating PCOR

when compared with the conventional method in total knee arthroplasty.

Methods

The current cross-sectional analytical study was conducted in MEITRA hospital, Calicut, where data of a total of 200 patients were collected and evaluated. One hundred non-navigated patients' data were obtained from records during the year 2016-2017 when the navigation system was not available in the hospital. The data of one hundred patients with navigated TKA were obtained during the year of 2017-2018 when the navigation equipment (Knee 3 Motion – Brain Lab) was installed in the hospital. The surgical consent was obtained from all patients undergoing TKA and to maintain uniformity, all procedures were carried out by the same surgeon using same Depuy implants.

The patients with stage 4 osteoarthritis undergoing primary TKA were included in the study and the patients undergoing revision TKA, use of augments, and whose true lateral X-rays were unavailable, were excluded from the study. A non-navigated group of 100 patients had 74 females and 26 males. Fifty patients underwent right TKA while 50 patients had left TKA in which 32 patients had bilateral TKA. In the navigated group of 100 patients, there were 71 females and 29 males where 52 patients underwent right knee TKA and 48 patients had left knee TKA in which 26 patients had bilateral TKA.

Pre- and post-operative true lateral X-ray of 200 patients were evaluated by 3 individuals to check reproducibility and PCOR was measured for all patients using PACS software (Electronic picture archiving and communication system software) three times by the same observer and the average of the 9 values were used for data analysis to reduce the inter and intra-observer error.

Radiographic assessment methods:

True lateral X-ray were taken pre- and post-operatively for the patients undergoing TKA. By true lateral Xray of the knee the author refers to those lateral radiographs of the knee where there is superimposition of the femoral condyles showing the patello-femoral joint and joint spaces between the femoral condyles and the tibia. The PCOR is calculated by drawing three tangents. One each to the anterior cortex of the femur (a), posterior cortex of the femur (b) and one to the posterior condylar border (c). The distance between the (a) to (c) is measures as (ac) and the distance between (b) and (c) were measured as (bc). The PCOR was calculated as bc/ac (Figure 1).

In the navigated surgery after the initial registration, planning of the surgery was done using the software and specific pre-determined cuts were selected to recreate the posterior condyle of the individual knee with the aim of getting a well aligned perfectly balanced knee (Figure 2).

Statistical analysis

SPSS v15 software was used for statistical analysis of the data and Paired t-test were used for comparing mean and to find the statistical significance.

Results

The study results show that the mean age of the non-navigated group was 63.92±7.2 years and that of the navigated group was 64.8±8.4 years respectively. The mean PCOR pre- and post-operative values for the navigated TKA were found to be 0.45 ± 0.14 and 0.46 ± 0.1 and for the non-navigated TKA were 0.45 ± 0.14 and 0.47 ± 0.13, respectively. (Table 1).

Table 1: Demographic characteristics and pre- and post-operative mean posterior condylar offset ratio values of navigated and non-navigated total knee arthroplasty knees. (PCOR: Posterior condylar offset ratio, TKA: Total Knee Arthroplasty)

Characteristics	Navigated Tkr	Non-Navigated Tkr
N-sample size	100	100
Male	71	74
Female	29	26
Mean age	64.8±8.4	63.92±7.2
Right knee	52	50
Left knee	48	50
Bilateral	26	32

The interclass correlation coefficient was 0.75 for an individual observer and 0.93 for three different observer's measurements that indicate no bias in the calculation i.e., no inter and intra-observer error was found.

The pre-operative mean PCOR values of both navigated and non-navigated group were not different (P=0.45519) but the post-operative mean PCOR values were different and significant (P=0.01934). This shows that the pre-operative PCOR values of both groups were comparable but post-operative PCOR values of both groups were significantly different.

In non- navigated TKA the difference in pre- and post-operation mean PCOR (0.02) were statistically significant (P=0.00001), using paired T-test, implying that there is a significant change in the PCOR after non navigated surgery. Likewise, the difference in pre- and post-operative mean PCOR for navigated TKA were also statistically significant (P=0.03671) implying that there is a significant difference in PCOR post operatively even with navigated TKA when compared with pre-operative state. This shows that TKA surgery has resulted in a significant change in the PCOR post -operation compared with the pre-operation state. (Table 2).

Table 2: Comparison of P values of pre- and post-operative of navigated and non-navigated total knee arthroplasty knees. (*statistically significant ($p<0.05$); statistically not significant ($p>0.05$), PCOR: Posterior condylar offset ratio, TKA: Total Knee Arthroplasty.)

Characteristics	Navigated Tkr	Non Navigated Tkr	P Value (Navigated Vs Non-Navigated)
Mean Pre-operative PCOR	0.45 ± 0.14	0.45 ± 0.14	0.45519
Mean Post-operative PCOR	0.46 ± 0.10	0.47 ± 0.13	0.00193
p value* (pre vs post)	0.03671	0.00001	

Further analysis using t-test revealed that in post-operative navigated TKA there is a reduction in mean PCOR by 0.01 when compared with post-operation non-navigated TKA which is statistically significant (P=0.01961). This implies that the navigation system helped to significantly lower the difference in mean PCOR when compared with non-navigated knees.

Discussion

The Posterior condylar offset ratio is an important factor for achieving maximal knee flexion, balanced flexion stability and anatomical recreation of the normal knee

kinematics. It been postulated that for every 1 mm reduction in the PCO, there is a loss of 6.1 degrees of flexion which means pre- and post-PCOR is significantly correlated with maximum flexion.[6] In the case of an anterior referencing system to measure the femoral size, a fixed amount of bone is resected from the anterior and the remaining from the posterior as per the size of the jig selected. If the femoral size comes in between numbers, we tend to upsize or downsize causing more or less resection of the posterior condyle thereby changing the posterior condylar offset ratio. Downsizing with anterior referencing leads to decreased PCO and therefore reduces the maximum flexion due to early impingement.[4] The conventional jig offers only a fixed external rotation of 3, 5 or 7 degrees to balance the flexion gap which also changes the posterior condylar offset. The correction of PCO is an important aspect to retain femoral natural anatomy and joint stability.[6,7,10] Even though the posterior referencing technique is considered better than anterior referencing in terms of simulating condylar anatomy and the restoration of PCOR in TKA, many studies comparing anterior and posterior referencing techniques failed to demonstrate a statistically significant difference.

With the computer navigation, the thickness of the posterior condyle resection can be measured and adjusted to recreate the implant thickness by adjusting the position (flexion-extension and anterior-posterior shift) of the AP cutting block even before any cuts are made using the planning software provided with navigation. Moreover, the femoral external rotation can be adjusted for 0.5 degrees to get an equal flexion-extension gap thereby reducing additional posterior condylar resection which is inevitable with the conventional techniques.

There is ample of literature evidence reporting the benefits of computer navigation in TKA. The use of navigation systems lowers the rate of post-operative cardiac and neurological complications, enhance the accuracy of sagittal femoral component placement,[9] improves the implant alignment[14], and reduces post-operative complications.[10] There are many literatures available debating the use of navigation system in TKA.[13] Kamat et al and Molfetta et al, both studies corroborated that there was no statistical difference found between navigated and non-navigated knees up to five years, however, they revealed the navigated TKA group had a high proportion of accurately aligned knees and regular use of navigation system helped the surgeons to gain experience and improve their skill in precise component orientation.[13]

There are conflicting shreds of evidence available either supporting[8,9,,11,12,] or confronting[13] the use of navigation in TKA. Nevertheless, the use of computer navigation in TKA has been widely accepted by orthopaedic surgeons due to its ease of execution, reproducibility, and better restoration of knee kinematics. In the current study, we found that the pre- and post-operative mean PCOR values of the navigated TKA group to be significantly different, but the difference is lower and statistically significant than the mean PCOR of conventional TKA. This implies that the navigation software helps in more accurate recreation of the PCOR. The clinical significance of this claim needs to be further analysed by additional functional outcome studies.

Conclusion

The study shows that there is a significant difference in the PCOR post operation with both navigation software assisted and conventional TKA but the difference is significantly lower in navigation assisted TKA. Hence we conclude that the recreation of PCOR using navigation software assisted technique is significantly superior to the conventional methods.

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