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Incidence and Impact of Component Size Asymmetry in Bilateral Total Knee Arthroplasty: A Prospective Study

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Abstract: ***This study investigates the incidence of component size asymmetry in patients undergoing bilateral total knee arthroplasty TKA. A prospective analysis was conducted on 100 patients treated at HOSMAT Hospital, Bangalore, between April and September 2022. The study found that 31% of patients exhibited asymmetry in component sizes, with 17% having femoral asymmetry, 19% tibial asymmetry, and 4% patellar asymmetry. The findings suggest that orthopedic surgeons should carefully assess the sizes of knee components independently for each knee to ensure optimal postoperative outcomes, avoiding errors that could arise from assuming bilateral symmetry.***

Keywords: total knee arthroplasty, component size asymmetry, bilateral TKA, orthopedic surgery, functional outcome

1. Introduction

Numerous studies identify the asymmetry in the anatomy of knee joints that occur naturally in the population[1-5], particularly in the females[6].

Total knee arthroplasty is a surgical procedure indicated mainly for relieving the pain associated with osteoarthritis which is refractory to non-operative treatments[7]. Other indications include other inflammatory arthritis and some cases of osteonecrosis[7]. Studies show that total knee arthroplasty is a cost effective procedure that not only relieves pain but also improves the quality of life[8-10]. It is also known that single staged (simultaneous) bilateral total knee arthroplasties are more cost-effective than two-staged bilateral total knee arthroplasties[11] however there is paucity of evidence to support superiority of either of the two procedures[16]. Advancing patient age, underlying disease and obesity negatively affect the outcome of the prosthetic joint[7]. Components in articular cavity, depending on their size and material can cause foreign body reaction thus resulting in asymmetrical recovery between limbs following surgery[12, 13]. Thus asymmetry of component size is a major risk factor for incongruent recovery between the two limbs following TKA[13]. A femoral component of the incorrect size can lead to a flexion extension gap mismatch for example a femoral component of small size may lead to flexion instability whereas, component of a large size may reduce the flexion space leading to the postoperative loss of flexion and over stuffing.

Although bilateral arthritis is frequently symmetric in appearance and deformity, component sizes during bilateral TKA should not be assumed the same. Improper component sizing may adversely affect functional results including range of motion and stability. An improper sizing of the femoral component can lead to a flexion-extension gap mismatch. A large-sized femoral component can lead to the loss of the flexion space causing postoperative loss of flexion and overstuffing of the patellofemoral joint. Whereas, an undersized femoral component leads to flexion instability[3]. Also, improper sizing of patella causes patellar maltracking, which may result in poor functional outcomes.[4] An oversized properly rotated tibial components has shown to cause overhang, tissue irritation or overstuffing of the joint space and associated compromise of range of motion. Whereas, smaller tibial component may compromise alignment, potentially leading to component subsidence and loosening due to compromised cortical support.[3, 4, 5]

We did prospective analysis of femoral, tibial and patellar component asymmetry in sequential bilateral total knee arthroplasty, assuming hypothesis that component sizes in bilateral knee arthroplasty may or may not be same. Theoretically, the femoral component size affects the flexion gap, stability, range of motion (ROM) and functional outcome after surgery. If the selected component is too small, the result could be flexion instability and pain, recurrent effusion, cam jump and dislocation in a posterior-stabilised prosthesis, and premature loosening of the component itself [3]. Conversely, too large of a fem-oral component can limit the ROM, create a painful and stiff knee, lead to anterior knee pain with patellar over-stuff, and result in a poor functional outcome [4, 5]. In the mediolateral (ML) plane, too small of a component creates an under hang which may result in subsiding of the component, increased bleeding from the raw surface, and, finally, osteolysis [6] whilst too large of a femoral component enhances component overhang and may increase knee pain [5, 7].

An overview of previously published work shows that 7–9.2% of patients who had undergone a bilateral TKA had an asymmetrical femoral component (AFC) [8–10]. Asymmetrical incidences for anterior referenced femoral component were significantly higher than those using the posterior referencing system. This may be because of the irreproducibility of the flexion gap which will possibly create variability in femoral component sizing [9]. Many

factors can influence AFC size selection, including asymmetrical patient anatomy between the left and right knees, the ligament laxity or tightness, the thickness of distal femoral cut which affects the extension gap, errors in distal femoral cutting angle, and the potential variability of the different anatomical landmarks used to measure (between surgeons) over the anterior surface of distal femur [11]. Overall, though, we consider that there is a lack of data on exactly why specific AFC sizes are chosen for patients using posterior referencing bilateral TKA.

2. Aim and Objectives

To study the incidence of component size asymmetry in BILATERAL TOTAL KNEE REPLACEMENT.

3. Review of Literature

Brown and Diduch in a review of 268 consecutive patients undergoing bilateral total knee arthroplasty (TKA) was performed to determine whether component size asymmetry exists in patients undergoing bilateral TKAs. Component sizes were selected based on preoperative radiographic templating and intraoperative sizing measurements irrespective of the component sizes chosen for the other knee. All radiographs were evaluated according to described criteria. Component sizes used for the femur, tibia, and patella were compared between the right and left knees. Of the 268 bilateral TKAs, 18 (6.7%) femoral components varied in size between right and left knees. There were no statistical differences for patellar or tibial component size asymmetry or knee function pre-or postoperatively. Brown and Diduch reported asymmetry rates for femoral (6.7%), tibial (1.1%), and patellar components (0.3%) in a review of 268 patients who underwent either simultaneous or staged bilateral TKA [2].

Capeci et al. Component size asymmetry and knee scores were determined in a review of 253 patients undergoing simultaneous or same-day, bilateral total knee arthroplasty (TKA). Asymmetry in component sizes was found in 22 (8.7%) pairs of femoral components, 17 (6.7%) pairs of tibial components, and 13 (5.1%) pairs of patellar components reported the asymmetry rates of 8.7%, 6.7%, and 5.1% for femoral, tibial, and patellar components, respectively in a review of 253 patients who underwent simultaneous bilateral TKA [4], R Sivaram et al in their study of 123 patients, femoral and tibial component size variations were present in 42 patients (34.1%) and 30 patients (24.4%) respectively. The variation was evident in both posterior substituting (PS) and cruciate retaining (CR) designs. The femoral components had a higher variation in size between the sides for both PS and CR designs than the tibial components for both designs

In Mootha et al. [6]. the study, they found a higher incidence of 9.3% for the femoral component and 8.6% for the tibial component compared to Capeci et al.

Mohan babu et al in their study, out of 200 cases, found asymmetry rate of 6% in femoral components and 13% asymmetry in tibial components.

A study of 289 bilateral TKAs by Reddy shows femoral and tibial component asymmetry to be 9.2% and 8.7% respectively[22]. Incidence of femoral component asymmetry was found to be 9.2% and tibial component asymmetry to be 8.7%. Of 289 cases, TKA 178 were done in a single day (group A), while 111 were done at 2 to 3 day intervals (group B).[22]

Another study found out the incidence of asymmetric femoral components to be under 10% while reporting the risk factors and outcomes of bilateral total knee arthroplasties.[23]

Mubasshir et al in study of 100 patients 20% were found to have component size asymmetry with 12% in the femoral component only, 2% in tibial component only, 3% in patellar component only, 2% having asymmetry in both femoral and tibial components and 1% having asymmetry in both femoral and patellar components

4. Material and Methods

Study Area
The Department of arthroplasty, Hosmat hospital, Bangalore.

Study Population
Patients coming to out patient department of Orthopedics in our hospital and diagnosed with bilateral osteoarthritis of knee clinically and confirmed radiologically with normal clinical examination for ligaments.

Study Design
A Prospective, Observational Study.

Study Duration
5 months; From 15 April to 14 September 2022

Sampling Methods
Consecutive type of non-probability sampling was followed. A total of 100 eligible subjects who came to our hospital during the study duration were included in the study after applying inclusion and exclusion criteria.

Inclusion Criteria
a) Where prostheses of the same model and manufacturer were used in both the knees,
b) Who had data regarding the implant details available,
c) Who had a minimal follow-up of 6 months
d) Whose preoperative and follow-up knee society scores [sup] [6] were available.

Exclusion Criteria:
a) Those where arthroplasty was done at different admissions for each knee

b) Those who had any postoperative complication in either of the knees such as deep vein thrombosis and infection, which might affect the final outcome
c) Those lost to follow-up

We conducted a prospective analysis of 100 patients presenting to the orthopedic department of HOSMAT Hospital between April 2022 and October 2022. During this period, a total of 100 bilateral TKAs were done either in a single staged procedure (both knees operated under a single anesthesia simultaneously) or as a two staged procedure at an interval of 5 days (single hospital admission). We included only those cases (a) where implant of the same type and manufacturer was used in both knees, (b) who did not develop any postoperative complications and (c) had a follow up for one year. Cases excluded were (a) those whose knees were operated separately under separate hospital admissions, (b) those who developed any postoperative complication in the knees, (c) those lost to follow-up.

We had collected their data prospectively as a part of a planned study but analyzed the data retrospectively.

All patients were preoperatively evaluated by taking their complete history, clinical examination, routine investigations and anteroposterior and lateral X-rays. We conducted the two staged procedure for patients older than 70 years or for those whose comorbid conditions did not allow a single day procedure. Component asymmetry was first assessed preoperatively under direct vision.

All patients were administered prophylactic antibiotics (cefuroxime) before the skin incision and then after every 8 hours for 24 hours. The same surgical team performed all the operations.89 cases were operated as a single staged procedure whereas 11 were operated as a two staged procedure (5 day interval). A median incision was given at the knee to expose the capsule.

Medialparapatellar approach is a standard app-roach which was used on all patients. Femur was prepared first by drilling the entry point of the femoral step reamer 1 cm above the insertion of posterior cruciate ligament. After inserting the intramedullary drill guide, the distal femoral cut was carried out after measuring the valgus angle at right angles to the mechanical axis from the posterior anterior radiograph view of standing leg. Anterior cruciate and posterior cruciate liga-ments were removed. The tibia was approached in an extramedullary guided fashion, and proxi-mal tibial cut was made. Ligaments were balanced to make a rectangular extension gap which was checked with a spacer block. After measuring lower extremity alignment, stability of the knee was tested in fully extended position. We chose the anterior referencing system for the anteroposterior femoral cut. After completing the AP cut, we checked the balancing of the flexion gap using a spacer lock in full flexion. After this femoral, patellar and tibial component sizes were determined after final cutting by using the implant size which was closest to the respective component.

The pneumatic tourniquet was applied to both sides at 300 mmHg from the beginning of the incision to the end of the procedure and then released following the end of procedure. Hemo-stasis was secured. The component sizes were measured perioperatively after their removal and final cutting. Patients received epidural analgesia during post-operative 48 hours. All patients were

routinely administered with Paracetamol 1gm I/V three times a day during hospitalization and diclofenac 50mg thrice daily following discharge for relieving postoperative pain. Anticoagulant therapy Low molecular weight Heparin was started 24 hours after operation and was continued for 5 days thereafter.

5. Results

Our primary finding was the incidence of component size asymmetry in a subset of population. In our study 31% were found to have component size asymmetry with 8% in the femoral component only, 10% only in tibial com-ponent only, 4% in patellar component only, 9% having asymmetry in both femoral and tibial components and 1% having asymmetry in both femoral and patellar components. Overall, 17% of the patients had femoral component asymmetry, 19% had tibial component and 4% had patellar component asymmetry.

There were total 10 males and 21 females with component asymmetry in our study.

Figure 1: Incidence of components asymmetry in 100 cases of bilateral TKR

Symmetry	Asymmetry
69	31

Among our 100 patients, who underwent sequential bilateral total knee arthroplasty, 19 were males and 81 were females. Mean age of patients was 65.36 (50-75yrs).

Figure 2: Sex distribution in components size asymmetry

Chart 1: Component of knee with frequency of incidence of asymmetry

Component of knee	Incidence of asymmetry
Femoral component only	8
Tibial component only	10
Patellar component only	4
Both femoral and tibial components	9

Chart 1: Incidence of component asymmetry by type of implant used

Implant	No. of cases	Femoral asymmetry	Tibial asymmetry	Patellar asymmetry
Depuy	82	7	10	2
Maxx	9	2	2	1
Stryker	7	1	2	1
Zimmer	2			

6. Discussion

As mentioned earlier, many studies can be found describing the normal variations in anatomy of the knee joint17 however very few studies have described the incidence of component size asymmetry in patients undergoing bilateral total knee arthroplasties. Its significance can be analyzed by the fact that altered alignment of the mechanical axis of the knee joint can be brought about by the incomplete seating of either of the components of the knee joint during arthroplasty which undermines the primary goal of doing a total knee arthroplasty which is restoration of knee joint movement besides relieving pain18. Furthermore, unbalanced soft tissues resulting from improper placement of the asymmetric components may cause higher strains in the surrounding tissues producing pain as a consequence19, hence component sizing is very important before bilateral total knee arthroplasty. Brown and Diduch reported asymmetry rates for femoral, tibial, and patellar components as 6.7%, 1.1% and 0.3% respectively20.

In another review21 of 253 patients under-going simultaneous bilateral TKA, the rates of asymmetry were 8.7%, 6.7%, and 5.1% for femoral, tibial and patellar components respectively, which was comparatively higher than the previous study.

A study of 289 bilateral TKAs by Reddy shows femoral and tibial component asymmetry to be 9.2% and 8.7% respectively22.

Another study found out the incidence of asymmetric femoral components to be under 10% while reporting the risk factors and outcomes of bilateral total knee arthroplasties23. The same study also showed that the size of the asymmetric femoral component was not determined by its preoperative anatomy, but instead it was deter-mined by the flexion of the component.

Our primary finding was the incidence of component size asymmetry in a subset of population. In our study 31% were found to have component size asymmetry with 8% in the femoral component only, 10% only in tibial com-ponent only, 4% in patellar component only, 9% having asymmetry in both femoral and tibial components and 1% having asymmetry in both femoral and patellar components. Overall, 17% of the patients had femoral component asymmetry, 19% had tibial component and 4% had patellar component asymmetry. Our study reports an increased incidence of tibial component asymmetry as compared to previous studies and this might be of use to guide surgeons to select the appropriate sized components for each knee separately in future 24.

The femoral component asymmetry had occurred in 17 of 100 patients and all were found to be of one size difference. Right side was bigger than left in 9 cases. Total incidence of femoral component asymmetry was 17%.

The tibial component asymmetry had occurred in 19 of 100 patients and all were found to be of one size difference. Right side was bigger than left in 10 cases. Total incidence of tibial component asymmetry was 19%.

The patellar component asymmetry had occurred in 4 of 100 patients and all were found to be of one size difference. Total incidence of both component asymmetry was 9%.

The strengths of our study include a prospective study design and both the surgeons who performed the bilateral total knee arthroplasties in this study measured the individual component size for each knee independently hence effectively portraying the difference in bony anatomy between the two knees that existed in some patients. Limitations of our study include a relatively small sample size which might have failed to represent the total population of patients undergoing bilateral total knee arthroplasties effectively. We did not analyze the data regarding risk factors of this asymmetry or the possible outcomes of this asymmetry on the function of the knee joint. The variables responsible for inter limb asymmetry have been analyzed in a previous study like gender, old age, increased levels of anxiety, diagnostic differences, high BMI, and asymmetry of component sizes, 13 however, our study aimed only in identifying the relatively high incidence of component size asymmetry which is one of the risk factors for inter limb asymmetry.

7. Conclusion

We conclude that the incidence of asymmetry of component sizes between the two knees of the patients undergoing bilateral total knee arthroplasties is very high, in our study being 31%. Hence orthopeaedic surgeons must keep this difference in mind before inserting the implant of the appropriate size after measuring the component sizes of each knee separately rather than using the measurements of one knee for the other erroneously. This might improve functional out-comes for patients undergoing this procedure.

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