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Mismatch error among anthropometric dimensions of human knee and implanted knee in knee replacement surgery in India

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Abstract---Background: Many people undergo total knee replacement surgery but many a times the implant sizes fail to match the actual joint size and cause further damage to the bones and muscles. This paper tries to study the difference between the implants used for surgeries and the anthropometric data of patients. Method and Material: Study consists of data of around 150 patients from two private hospitals in, Nagpur, (India). Anthropometric data was compared with the standard implant data for Zimmer and Johnson & Johnson Company. The mismatch error was calculated individually for male and female patients. Results: The result showed that the mismatch error calculated for Zimmer implants were -5.6 for A/P and -3.3 for M/L in female patients; -1.18 for A/P and 4.95 for M/L in male patients. The mismatch error calculated for Johnson & Johnson implants were -3.4 for A/P and -0.4 for M/L in female patients; 1.85 for A/P and 8.18 for M/L in male patients. The total mismatch for Zimmer was -4.4 for females and 1.83 for males and that for Johnson & Johnson was -1.89 for females and 5.01 for males. A mismatch of -19(for females), -15 (for males) was found for Zimmer and that of Johnson & Johnson was found -11(for females), -7(for males). Conclusion: Due to this mismatch patients face many problems post surgery. The study suggests that there is a need of manufacturing customized implants based on the anthropometric data of patients.

Keywords---anthropometric dimension, femoral condyle, implants, knee joint replacement.

Introduction

The science of the 21st century deals with solving of simple to understand but complex problems. One of the most simple to understand but complex problem is the total knee joint replacement and involves the anthropometric discipline of

ergonomics. The concept of total knee replacement came into existence in the late 1950s and the first total knee replacement surgery was performed in the year 1968 and with the advancement in technology and techniques there is improvement in the quality and effectiveness of the implants. Many people undergo the total knee replacement surgery but many a times the implant sizes fail to match the actual joint size and cause further damage to the bones and muscles [2]. The success of the Knee replacement surgery totally depends on the size of the implant and proper placement of the components [5].

Earlier cemented implants were much in demand due to less technological advancement but nowadays cement less implants are more in use due to its effectiveness and durability of the implant after the surgery [1]. But the cementless implants which are currently used in total knee replacement surgery had higher mismatch error for the femoral condyle (femoral component) of the implant. The Mismatch Error is the difference between the human anthropometric dimensions and the implant dimensions for the anterior posterior (A/P) and the mediolateral length (M/L) for the femoral and tibial component. In most of the existing literature it was observed that there is a mismatch between the anthropometric dimensions of the human knee and the implant sizes. In many cases it was found that the implant size was larger than original knee joint size [3][4]. Most of the existing literature has highlighted the difference between the implant dimensions and the human knee sizes. In a study it was observed that the ML dimension had high mismatch and was found more in male patients as compared to female patients due to larger size of the knee [6]. In the similar lines a study identified the aspect ratio (the medial-lateral to anterior-posterior dimensions) for the femoral. The comparison of this ratio between the human knee and implant reflected that smaller implants were more too smaller in size and same was observed for the larger sizes of implant [7]. Another study compared anthropometric dimensions with implant dimensions for four prosthetic systems NexGen (Zimmer), P.F.C. Sigma (Depuy-Johnson & Johnson), Genesis II (Smith & nephew), and Scorpio (Stryker) and found that the mismatch for the femur was higher for the A/P length [8]. A study discussed about the relationship between postoperative overall anatomical knee alignment and the survival of total knee prostheses and found that over 1% of patients suffered from infection and periprosthetic fracture, concluding that the higher coronal, sagittal and rotational misalignments in the femur component due to femoral condyle offset, increases failure rates so the mismatch must be reduced [9]. In two studies it was found that for any given AP femoral dimension the women had narrower ML dimensions as compared to men and this gender difference may serve a reference to implant designers as well as orthopedic surgeons. [10] [11]. In the existing literature it was found that many studies have been done highlighting the mismatch error for the human knee and the implanted knee mostly in Chinese and Thai, Japanese population [12,13,14,15,16]. Fewer studies are carried out for Indian population.

Method and Material

This was real life study and analysis of mismatch between human knee and implanted knee. It involved the study of the three different implant types that is cemented implants, cement less implants and the hybrid implants. From the literature review it was found that the cement less implants had higher

receptivity. Mismatch Error was calculated as the difference between the human knee anthropometric data and the implant dimensions. The data for 150 patients was taken from two private hospitals in Nagpur (India) of different age groups and gender. The information on knee implants such as type of implant, size of the implants was taken from the doctor's record sheet. The major focus was laid on the mismatch in the condylar part of the femur due to its higher complexity. A pilot study was carried out at a private hospital in Nagpur and data for 50 cases was analyzed out of which 30 were female and 20 were male patients. The implant used at hospital was Zimmer and the anthropometric sizes were taken with the help of the patients' scans and reports which were then further compared with implant sizes to estimate the mismatch. To reassure the mismatch error a case study was conducted for about 100 cases at another private hospital in Nagpur and was analyzed out of which 61 were female and 39 were male patients. The implant used at hospital was Johnson & Johnson and the anthropometric sizes were taken with the help of the patients' scans and reports which were then further compared with implant sizes to estimate the mismatch.

Results

The result showed that the mismatch error calculated for Zimmer implants were -5.6 for A/P and -3.3 for M/L in female patients; -1.18 for A/P and 4.95 for M/L in male patients. The mismatch error calculated for Johnson & Johnson implants were -3.4 for A/P and -0.4 for M/L in female patients; 1.85 for A/P and 8.18 for M/L in male patients. The entire implant mismatch for Zimmer was -4.4 for females and 1.83 for males and that for Johnson & Johnson was -1.89 for females and 5.01 for males. The femoral condyle was responsible for more errors and a mismatch of -19(for females), -15 (for males) was found for Zimmer and that of Johnson & Johnson was found -11(for females), -7(for males). The results depict that higher mismatch is seen along femoral condyle and is more in female patients which is 73% for pilot study and 67% for the case study, (Table 1), (Figure 1), (Table 2), (Figure 2).

Conclusion

On the basis of the literature review, data collection and its analysis it can be concluded that the implant size selection for the total knee replacement plays very important role in the patient's lives, as mismatch error results in the deterioration of the knee joint after the surgery and will not promote growth of new bones. Also at higher mismatch errors patients have to undergo surgery again and this results in weakening knee joint and affects the lifestyle of the patient. The minimization of the mismatch would result in higher success rate of the total knee replacement surgery as it will improve the life of the joint and also improve patient's lifestyle with meager changes. Also this study would act as an aid for designers to make more customized knee implants and communication gap between the surgeons and designers will improve. The result of this study compares favorably with published literature.

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Table 1: Mismatch Error results from pilot study

Parameters	Female patients	Male Patients
(Femoral Condyle) A/P	-19	-15
(Femoral Condyle) M/L	-7.76	2.45
(Tibial Plateau) A/P	-1.1	2.25
(Tibial Plateau) M/L	-4.27	2.2
	3.27	9.2
	2.2	10.2

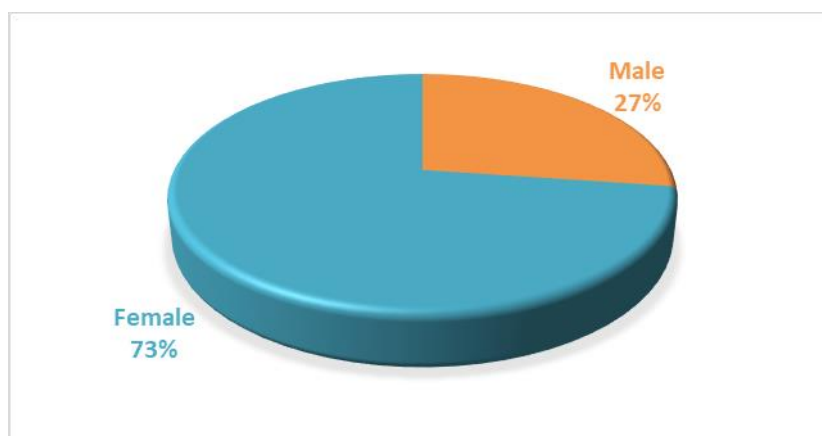


Figure 1: Mismatch for femoral condyle (Pilot study)

Table 2: Mismatch Error results from case study

Parameters	Female patients	Male Patients
(Femoral Condyle) A/P	-11	-7
(Femoral Condyle) M/L	1	11
(Tibial Plateau) A/P	-3	3
(Tibial Plateau) M/L	-5	3
	3.84	9.54
	2.84	10.54

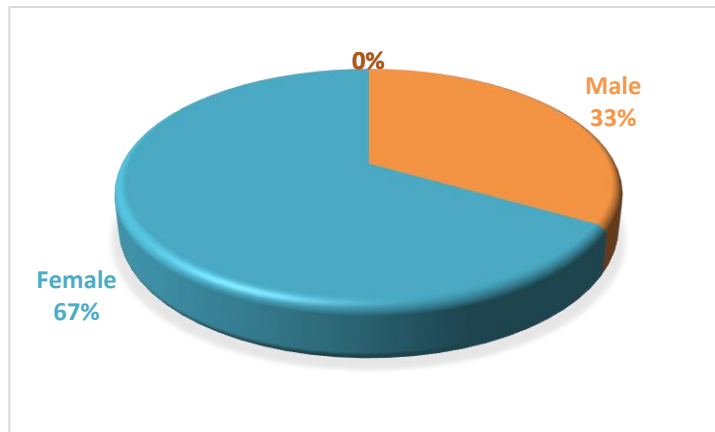


Figure 2 : Mismatch for femoral condyle (Case Study)