INTRAOPERATIVE MORPHOMETRIC MEASUREMENT OF DISTAL FEMUR DIMENSIONS AND CORRELATION WITH IMPLANT SIZING IN FEMALE TOTAL KNEE ARTHROPLASTY PATIENTS

by

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ABSTRAK

Pengenalan: Pengunaan saiz implan yang berpadanan dan betul merupakan salah satu faktor utama yang menjadi penentu kejayaan pembedahan gantian sendi lutut. Justeru, demi mengelakkan komplikasi pembedahan dan memastikan berjayanya suatu pembedahan gantian lutut, pengunaan saiz implan yang berpadanan dan betul merupakan aspek yang sangat mustahak. Saiz implan yang tidak berpadanan didapati lebih ketara di kalangan jantina perempuan. Kajian ini bertujuan untuk mendapatkan ukuran dimensi hujung tulang paha *(femur)* di bahagian sendi lutut pesakit-pesakit wanita yang menjalani pembedahan gantian sendi lutut di institusi kita dan membandingkannya dengan saiz system implant semasa yang digunakan.

Metodologi: Sejumlah 101 pesakit perempuan (105 sendi lutut) yang menjalani pembedahan gantian sendi lutut telah disampelkan untuk tujuan kajian ini. Sewaktu pembedahan, ukuran dimensi panjang *(anterior posterior length)* di bahagian *"medial"* dan *"lateral condyle*" serta lebar *(mediolateral width)* hujung tulang paha *(femur)* di bahagian sendi lutut selepas potongan pertama *(distal cut)* direkodkan bagi setiap pesakit. Ukuran-ukuran yang telah direkodkan itu dibandingkan dengan ukuran-ukuran dimensi yang diketahui dari pengeluar sistem implan sendi lutut yang digunakan.

Keputusan: Hasil kajian kita mendapati kelebaran*(medio-lateral width)* komponen *"femur"* yang digunakan adalah lebih besar daripada ukuran morfometri pesakit dengan purata 2.11mm (SP 3.94mm). Nilai perbezaan ini adalah signifikan dari segi statistik dengan nilai $p<0.01$. Kita juga mendapati bahawa wujudnya perhubungan positif yang signifikan tapi lemah di antara kedua-dua ukuran panjang *(AP)* dan lebar *(ML). "Aspect ratio"* bagi data morfologi didapati lebih besar untuk sendi lutut yang kecil dan sebaliknya kecil bagi lutut yang besar. Secara amnya, "*aspect ratio"* data morfologi adalah lebih kecil daripada *"aspect ratio"* implan.

Namun, bagi lima saiz pertama, *"aspect ratio"* implan didapati berubah dengan *"trend"* yang hampir sama dengan data morfologi. Akan tetapi, untuk saiz-saiz yang seterusnya, nilai *"aspect ratio"* implan didapati menunjukkan perubahan yang sikit sahaja. Dalam erti kata lain, *"ML overhang"* implan dijangka lebih ketara pada lutut yang lebih besar.

Kesimpulan: Reka bentuk implan perlu dibuat berpadanan dengan data morfologi populasi tempatan. Pihak pengeluar implant seharusnya menghasilkan implan supaya dapat menampung perubahan *ML* yang kecil bagi setiap peningkatan dimensi *AP* serta menyediakan implan yang mempunyai beberapa kelebaran yang berbeza bagi satu dimensi *AP*. Justeru, masalah "*ML overhang"* implan dapat diatasi dengan prostesis yang lebih sesuai dan anatomikal.

ABSTRACT

Introduction: Accurate implant sizing is one of the major determinants in defining the success of total knee arthroplasty. TKA implants currently in used are based on Caucasian knee morphometry which is well documented to be larger than Asian knees. The significant clinical implication of implant mismatch has led researches to greatly delve into this field of study worldwide. With regards to sizing, implant mismatch tends to be more evident in the female population. This study was designed to evaluate the distal femur dimensions of female patients who underwent TKA in our institution and to compare them with the current prosthetic system in use.

Materials and Methods: Total of 101 female patients (105 knees) who underwent TKA were recruited in this study. Intraoperatively, the AP dimensions (medial and lateral condyles) and mediolateral (ML) width were measured. Known dimension of the femoral component of the prosthetic knee system currently in use were compared with the morphological data.

Results: The average femoral component overhang was 2.11mm (SD 3.94mm). There was significant difference between the mean ML width of the resected femur and the femoral component ($p<0.01$). Analysis also revealed a significant positive and weak relationship between both, AP (medial and lateral) and ML dimension. The aspect ratio for the morphological data showed a larger ratio for smaller knees and inversely a smaller ratio for larger knees. Although the aspect ratio of the morphological data were generally smaller than the implant aspect ratio, the trend of change in the aspect ratios of the initial five sizes of implant were seen to follow the morphological data. However, the larger implant sizes showed little change in its aspect ratio. In other words, the implant ML overhang is expected to be more pronounced in the larger knees.

Conclusion: Implants should be designed based on the morphological data of the local population. Implant manufactures should tailor them to accommodate a smaller change in ML width for an increment in the AP length and provide several ML widths for one AP length to obtain a better fitting prosthesis hence curbing the problem of ML overhang.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Total knee arthroplasty (TKA) defines a major breakthrough in orthopaedic management of degenerative joint disease that is considered to be highly successful. By restoring the joint function and alleviating pain this surgery has become readily accepted by patients today as compared to the time of initial introduction.

Majority of patients undergoing this surgery are from the female gender as reported in various studies performed locally and abroad(Chin *et al.*, 2011; Dhillon *et al.*, 1993; Eil *et al.*, 2016; Ewe *et al.*, 2009; Zulkifly *et al.*, 2011). Furthermore, female knees is of particular interest due to their higher prevalence of knee arthritis with severe debilitating symptoms and functional impairment(Conley *et al.*, 2007).

One of the major crucial factors to the success of total knee arthroplasty (TKA) is correct sizing. Thus, to avoid complications and maximize the outcome of the surgery, proper implant sizing is of utmost importance(Hitt *et al.*, 2003). Implant manufacturers have designed variety of sizes of prosthesis that could accommodate both genders be it unisex or gender specific implants. However, those designs were made according to Caucasian morphometric data. Studies have shown that asian femurs are narrower than the whites(Chin *et al.*, 2011; Urabe *et al.*, 2008; Vaidya *et al.*, 2000; Yue *et al.*, 2011). It is also well documented that females had a narrower distal femur(Chin *et al.*, 2002; Chin *et al.*, 2011; Ewe *et al.*, 2009; Lonner *et al.*, 2008) and morphologically, knees of Asian females significantly differ from their Caucasian counterparts(Urabe *et al.*, 2008; Yue *et al.*, 2011). With regards to sizing, implant mismatch tends to be more evident in the female population(Cheng *et al.*, 2009; Ewe *et al.*, 2009; Hitt *et al.*, 2003; Vaidya *et al.*, 2000). In our centre, Hospital Universiti Sains Malaysia, majority of patients undergoing TKA are females accounting to about 86%(Eil *et al.*, 2016). Thus, the question of implant mismatch in our population is of great value.

Implant mismatch be it in the medio-lateral dimension or antero-posterior dimension, is of great clinical impact to the outcome of TKA. Medio-lateral overhang or oversizing could result in soft tissue irritation and affect balancing efforts(Hitt *et al.*, 2003). On the other hand, undersizing could leave the exposed cancellous bone which may be a source of immediate postoperative bleeding(Hitt *et al.*, 2003). A precise antero-posterior (AP) dimension is important to maintain flexion-extension gap(Thilak and George, 2016) whereas anterior notching predisposes to periprosthetic fractures(Lonner *et al.*, 2008).

Globally, there are many morphological studies ranging from cadaveric studies to radio-imaging studies using Computed Tomography (CT) or Magnetic Resonance (MR) imaging of normal patients not requiring surgery(Cheng *et al.*, 2009; Hidayat *et al.*, 2015; Seedhom *et al.*, 1972; Yue *et al.*, 2011). The present study is designed to obtain morphological data intraoperatively on osteoarthritic knees that are usually deformed and differ from normal knees.

Previous studies have reported anatomical variations of male and female knees(Chin *et al.*, 2002; Chin *et al.*, 2011; Ewe *et al.*, 2009; Lonner *et al.*, 2008) and some comparing that of Asian distal femur dimensions to that of Caucasian(Urabe *et al.*, 2008; Yue *et al.*, 2011). Chin KR et al(Chin *et al.*, 2002) published an article in 2002 on intraoperative distal femur dimensions of both male and female gender undergoing TKA. Their study revealed that female arthritic knees had a narrower medio-lateral (ML) dimension and a significantly greater aspect ratio than males.

In a study published by Loner JH et al(Lonner *et al.*, 2008) in 2008 on anthropomorphic differences of the distal femur in both men and women, the mean aspect ratio (ratio between the AP and ML dimension) was larger for women than for men, 0.84 versus 0.81 respectively. The mean AP dimension and ML dimension at the level of transepicondylar axis(TEA) in

males were signigfcantly higher compared to their female counterparts. The authors also stated that sexual dimorphism is evident when comparing both the genders, with regards to the dimensions of the distal femur as well as its morphology and shape.

Urabe et al(Urabe *et al.*, 2008) in a study to compare the morphology of the distal femur between Caucasian and Japanese women using lateral radiographs of the knee concluded that both, the size of the femur and the anterior and posterior condyles are significantly larger in Caucasian than Japanese women.

In 2009, Yue et al(Yue *et al.*, 2011) performed a study on racial differences of knee geometry comparing that of 40 subject from Shanghai, China and 36 subjects from Massachusetts, USA using 3-dimensional knee blocks constructed with Computed Tomography (CT) or Magnetic Resonance (MR) imaging. The study showed that the dimensions of Chinese knees were generally smaller than white knees. In addition, Chinese females had a significantly narrower distal femur than white females.

An intraoperative morphometric study of gender differences in the distal femur was conducted by Chin PL et al(Chin *et al.*, 2011) at the Singapore General Hospital. This study further ascertains that men has a significantly smaller aspect ratio than women. The authors also noted that there is also variaton within each gender. They concluded that females have narrower femur morphology than men and that Asian population in general have smaller and narrower distal femur morphology than the whites.

Worlwide,there have been many studies carried out pertaining to gender differences of distal femur morphology and correlating them with currently used TKA prosthesis. Hitt et al(Hitt *et al.*, 2003) conducted a multi-centric study on a large group of patients undergoing primary TKA. Apart from comparing the dimensions between men and women, the authors did assess the differences between the component medio-lateral and femoral medio-lateral. The

results of the study showed that component overhang was significant among women for all the analysed designs. However, a significant association between the component size and the amount of overhang was noted in one of the designs.

In an anthropometric computed tomography scan study conducted by Vaidya et al(Vaidya *et al.*, 2000), it was noted that a statistically significant number of Indian patients had measurements lower than smallest implant size available. This was more significant among the female subjects accounting to about 60.4%. Cheng at al(Cheng *et al.*, 2009) in 2009 found that two out of five conventional femoral components used in China had large values in ML dimension for all range of the AP which was more evident among the females. Several other studies(Ha and Na, 2012; Ho *et al.*, 2006; Wanitcharoenporn *et al.*, 2014) in this Asian region showed similar results that the currently used prosthesis were not suitable for our poulation with some showing ML under coverage or ML overhang.

In Malaysia, Ewe et al(Ewe *et al.*, 2009) conducted a cross sectional study at Hospital Kuala Lumpur to investigate the use of computer navigation system for in vivo measurement of AP and ML dimensions is patients undergoing primary TKA and comparing the measurements to currently available prosthesis. In this study of 69 patients(80 knees), the mean AP length and ML width of females were significantly smaller than males. The authors also revealed that the femoral components for women tend to be too large for a given AP length, resulting in over-hang which was more obvious in larger knees. The risk of implant overhang and its associated complications are significant in the Malaysian population in view of their knee measurement results were comparatively smaller than Caucasians as well as other Asian sub-population

The purpose of this study is to evaluate the distal femur dimensions of female patients undergoing TKA in our institution and to compare them with the current prosthetic system. At

present, we are using a prosthetic system which is fairly new (since 2015) to our institution for our TKA patients. This implant has been around in Europe for the past fifteen years, however, being new to our region, we would want to analyze the suitability of this current implant system in our population. The results of this study could provide a guide to implant manufacturers in order to tailor implants which suit the morphometric measurements of Malaysian population especially female patients hence maximizing the outcome of TKA and reducing its complications.

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CHAPTER 2

OBJECTIVES OF THE STUDY

2.1 OBJECTIVES

2.1 GENERAL OBJECTIVES

To determine the distal femur dimensions in female total knee arthroplasty patients and to correlate them with implant sizing

2.2 SPECIFIC OBJECTIVES

2.2.1

To determine the mean of the following distal femur dimensions of our female TKA patients

- Anteroposterior(AP) length
- Mediolateral(ML) width
- Aspect ratio (AP/ML)

2.2.2

To determine the correlation between AP dimension and ML dimension of the study subjects

2.2.3

To compare the mean difference of the ML dimension between the measured distal femur with currently used TKA prosthesis

CHAPTER 3

MANUSCRIPT

INTRAOPERATIVE MORPHOMETRIC MEASUREMENT OF DISTAL FEMUR DIMENSIONS AND CORRELATION WITH IMPLANT SIZING IN FEMALE TOTAL KNEE ARTHROPLASTY PATIENTS

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3.1 ABSTRACT

Introduction: Accurate implant sizing is one of the major determinants in defining the success of total knee arthroplasty. TKA implants currently in used are based on Caucasian knee morphometry which is well documented to be larger than Asian knees. The significant clinical implication of implant mismatch has led researches to greatly delve into this field of study worldwide. With regards to sizing, implant mismatch tends to be more evident in the female population. This study was designed to evaluate the distal femur dimensions of female patients who underwent TKA in our institution and to compare them with the current prosthetic system in use.

Materials and Methods: Total of 101 female patients (105 knees) who underwent TKA were recruited in this study. Intraoperatively, the AP dimensions (medial and lateral condyles) and mediolateral (ML) width were measured. Known dimension of the femoral component of the prosthetic knee system currently in use were compared with the morphological data.

Results: The average femoral component overhang was 2.11mm (SD 3.94mm). There was significant difference between the mean ML width of the resected femur and the femoral component ($p<0.01$). Analysis also revealed a significant positive and weak relationship between both, AP (medial and lateral) and ML dimension. The aspect ratio for the morphological data showed a larger ratio for smaller knees and inversely a smaller ratio for larger knees. Although the aspect ratio of the morphological data were generally smaller than the implant aspect ratio, the trend of change in the aspect ratios of the initial five sizes of implant were seen to follow the morphological data. However, the larger implant sizes showed little change in its aspect ratio. In other words, the implant ML overhang is expected to be more pronounced in the larger knees.

Conclusion: Implants should be designed based on the morphological data of the local population. Implant manufactures should tailor them to accommodate a smaller change in ML width for an increment in the AP length and provide several ML widths for one AP length to obtain a better fitting prosthesis hence curbing the problem of ML overhang.

Keywords: *Morphometric measurement, female Malaysian knees, Total knee arthroplasty, Knee joint prostheses, Knee dimensions*

3.2 INTRODUCTION

One of the major crucial factors to the success of total knee arthroplasty (TKA) is correct sizing. Thus, to avoid complications and maximize the outcome of the surgery, proper implant sizing is of utmost importance(1).

Implant mismatch be it in the medio-lateral dimension or antero-posterior dimension, is of a great clinical impact to the outcome of TKA. Medio-lateral overhang or oversizing could result in soft tissue irritation and affect balancing efforts(1). On the other hand, undersizing could leave the exposed cancellous bone which may be a source of immediate postoperative bleeding(1). A precise antero-posterior (AP) dimension is important to maintain flexion-extension gap(2) whereas anterior notching predisposes to periprosthetic fractures(3).

The currently used TKA implants worldwide are based on morphometric measurements obtained from Caucasian population. However, studies have shown that asian femurs are narrower than the whites(4-7). It is also well documented that females had a narrower distal femur(3, 4, 8, 9) and morphologically, knees of Asian females significantly differ from their Caucasian counterparts(5, 7). With regards to sizing, implant mismatch tends to be more evident in the female population(1, 6, 9, 10). In our centre, Hospital Universiti Sains Malaysia, majority of patients undergoing TKA are females accounting to about 86%(11). Thus, the question of implant mismatch in our population is of great value.

Globally, there are many morphological studies ranging from cadaveric studies to radio-imaging studies using Computed Tomography (CT) or Magnetic Resonance (MR) imaging of normal patients not requiring surgery(7, 10, 12, 13). The present study is designed to obtain a morphological data intraoperatively on osteoarthritic knees that are usually deformed and differ from normal knees.

This study was designed to evaluate the distal femur dimensions of female patients who underwent TKA in our institution and to compare them with the currently used prosthetic system. The authors believe the results of this study could provide a guide to implant manufacturers to tailor better fitting prosthesis which suit the morphometric measurements of the Malaysian population especially in female patients hence optimizing the outcome of TKA and reducing its complications.

3.3 MATERIALS AND METHODS

This is a single centre observational cross-sectional study with all procedures performed by two experienced arthroplasty surgeons. This study was approved by the Human Ethical Committee of the School of Medical Sciences, Universiti Sains Malaysia. A total of 101 female patients (105 knees) who underwent primary total knee arthroplasty for osteoarthritis at the arthroplasty unit of Hospital Universiti Sains Malaysia were randomly included in this study in accordance to the study inclusion and exclusion criteria. This study was conducted from June 2016 until December 2017.

Patients with congenital or acquired deformities of the knee or with history of disease/trauma involving the knee, gross deformities of the knee of more than 15 degrees valgus/varus or severe fixed flexion deformity more than 20 degrees were excluded from this study. Patients with substantial bone loss and/or degeneration requiring augmentation or presence of anterior notching or severe flexion gap laxity after distal femoral cut were also excluded.

All TKAs were performed by one of the two senior arthroplasty surgeons at our institution. After removal of osteophytes, the distal femoral cuts were performed prior to making measurements in millimeters using a sterile caliper. All measurements were taken by the surgeon and his assistant together to reduce random error. Measurement of the distal femur after the cut is considered a reasonable approach as it would be easier to place a ruler on the cut surfaces and minimizing tilting of the tool that would potentially occur on an uncut distal femur(3). The distal cut was made nine mm from medial joint line to be able to fit the femoral component which was currently being used in our center**.** The anterior cut was performed using

an anterior referencing cutting guide to ensure the cut was flush with the femoral shaft in order to avoid anterior notching.

The dimensions measured from the resected distal femur (Figure 1) were the anteroposterior dimensions of the medial (APM) and lateral femoral condyles (APL) and the mediolateral (ML) width. The APM and APL were taken as the distance of a line parallel to Whiteside's line from the anterior cut to the posterior femoral condyle. ML width was measured as the distance between the medial and lateral cortex at the transepicondylar axis. After appropriate sizing and bone cuts, the implant size which closely approximated the anteroposterior dimension of the resected femur were then implanted. Morphological data of the distal femur were recorded into the study proforma. Aspect ratio which measures the shape of the distal femur (AP/ML) is calculated separately for both the medial and lateral femoral condyles. Data about the anteroposterior (AP) and mediolateral (ML) dimensions of the present femoral components used were obtained from the respective implant manufacturer.

The data were analyzed using SPSS version 24. The dimensions are summarized as the mean and standard deviation. Correlation between AP and ML dimensions of the patient's femur were determined using Pearson correlation. As the implant size were determined by the close approximation of AP dimension of the resected femur, thus the difference of the mean ML dimension between the implant and patient's knee were determined. The differences between the component ML and femoral ML were assessed using paired t-test with a confidence interval set at 95% and a p value of less than 0.05 were regarded as statistically significant.

3.4 RESULTS

There were total of 101 patients included in this study with a mean age of 64.3 years old. Four patients had bilateral total knee arthroplasty making it up to a total of 105 knees taken into this study. The ethnic distribution of the patients was predominantly Malay accounting to 97% of the total followed by Chinese (2%) and Indian (1%).

The mean AP medial (APM) of the resected femur was 66.02 mm (SD: 3.53) while the mean AP lateral (APL) was 68.08 mm (SD: 3.44). The mean mediolateral (ML) width of the measured femur was 59.71 mm (SD: 4.42). The calculated mean aspect ratio as determined by ratio of ML to APM and APL were 0.91 and 0.88, respectively. A summary of the intraoperative data of the resected distal femurs is shown in Table 1.

The relationship of AP medial and AP lateral with ML dimension as demonstrated in Table 2 shows a significant positive and weak linear relationship between AP medial and ML ($r=0.475$; $p<0.001$) and a similar relationship between AP lateral and ML as well ($r=0.521$; $p<0.001$)(14). From this, we can deduce that with increasing AP length, the ML width increases but with a smaller magnitude. When comparing AP medial and lateral, the correlation between AP lateral and ML was slightly better.

In terms of ML mismatch, there was significant difference between the mean ML width of the resected femur with that of the component($p<0.01$). The average component overhang was 2.11mm (Table 3). ML dimension of the femoral component increases in close approximation with the morphological data. Despite that, for a given AP length, the ML dimension of the femoral component tend to be wider. By extrapolation of the best fit line for the morphological data, the disparity between them is expected to be more pronounced in the larger knees (Figure 2).

The calculated mean aspect ratio of the morphological data as determined by ratio of ML to APM and APL were 0.91 and 0.88, respectively. The aspect ratio for the morphological data showed a larger ratio for smaller knees and inversely a smaller ratio for larger knees. Regardless, the best fit line for the aspect ratio of the morphological data was seen to be generally smaller than the implant aspect ratio. Despite the discrepancy, the initial five sizes of the implant did show changes in its aspect ratio which tends to follow the trend of the morphological data. However, the larger implant sizes show little change in its aspect ratio, hence widening the margin of difference (Figure 3). Thus, the implant ML overhang is expected to be more prominent in the larger knees.

3.5 DISCUSSION

Issues on implant sizing which match the morphology of distal femur has always been a great field of research. Worldwide, various studies have been conducted to analyse the morphology of the distal femur and correlating them with the TKA prosthesis in use. Of note, various study designs ranging from studies involving plain radiographs to CT or MR imaging, cadaveric as well as intraoperative measurements have been identified in our wide literature search(1, 2, 6, 7, 9, 10, 15, 16). We believe that intraoperative measurements of knees are more reliable, practical and representative of the actual morphology of the native femur.

Component overhang in our population was notably more prominent in the larger knees. This finding is consistent with the description by Hitt et al(1) in their female population. As compared to their study, ours revealed a smaller magnitude of implant overhang (2.1mm vs 4.9mm), Although smaller, this ML mismatch of the implant with the morphological data has proven to be statistically significant ($p<0.01$). As in our population of study, the femoral components used were predominantly from the lower half of the available sizes. Thus, we could get away with lower magnitude of implant overhang. If we were to encounter larger knees, we expect to deal with a wider margin of overhang and its associated complications.

The aspect ratio of the morphological data in our study were generally smaller than the aspect ratio of the implant currently in use for any given AP dimension. Nevertheless, the initial five sizes of the implant did show changes in its aspect ratio which tends to follow the morphological data. However, the larger implant sizes showed little change in its aspect ratio. This is contrary to the findings in several other studies(1, 9, 16) which showed little changes in all the implant sizes of the various designs evaluated. Although our morphological aspect ratio follows the implant aspect ratio quite closely, we still have significant ML overhang in our study.

Many studies have shown that Asian femurs are narrower than the whites(4-7). The knees of our population are seen to be even narrower than the Thais(17) and Koreans(15). As we compare our results with a Korean study(15) which used a similar method of measurement, it was noted that our population had a narrower distal femur as reflected by the smaller aspect ratio seen in our study. Thus, in general, for any given implant size, our population is at a greater risk of ML overhang. This justifies the need for specifically tailored implant design with a smaller ML width for a given AP length to suit the morphology of our population.

The weak positive relationship between the AP length and ML width as demonstrated in our study population signifies that the ML dimension increases in a smaller magnitude as the AP increases. Thus, implant sizes should be tailored to accommodate a smaller change in ML for an increment in the AP to get a better fitting prosthesis hence curbing the problem of ML overhang. The variation in the morphology of our population and its difference from other population should be considered for a specific implant design. One author suggested that implant component should be designed with several medial-lateral widths for one anterior-posterior length to obtain a better anatomical fit as it was founded that patients with approximately equal AP dimension may have a different ML width(16).

We believe that, implants should be designed based on the morphological data of the local population. As revealed in our study that the currently used implant is broader than our morphological data, it poses risk of soft tissue irritation and may affect balancing(1). Further research in this field with regards to evaluating the long term outcome of patients with implant overhang should be undertaken in near future to determine its impact to our population.

3.6 CONCLUSION

We conclude that the currently used implant is suboptimal in its sizing for our population as depicted by the disparity in the aspect ratio and ML length for given AP dimension, notably in the larger sizes. The results of this study could provide a guide to implant manufacturers to tailor implants which suit the morphometric measurements of Malaysian population especially in female patients hence maximizing the outcome of TKA and reducing its complications.

3.7 REFERENCES

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