Morphology Study of the Proximal Femur in Malay Population

Estudio de la Morfología del Fémur Proximal en la Población Malaya

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**SUMMARY:** Clinical practice in our country showed a lack of suitable implants that perfectly match the anthropometry of the local population. However, there have been no reports or comprehensive studies conducted to substantiate this argument. We therefore prospectively studied 120 hips from sixty subjects with an average age of 25±5.18 years old. The average weight and height were 61.48±13.84 kg and 1.65±9.63 m respectively. The exclusion criteria were pregnant woman, those who had injury to the hip joint, and those with implant or prosthesis. Four parameters were measured – the femoral head diameter (FHD), femoral neck length (FNL), femoral neck width (FNW) and collo-diaphyseal angle (CDA). Statistical analysis showed no significant differences between left and right femora but significant differences were found between male and female subjects. The results for the male and female femurs are as follows – FHD: 43.6±3.1 mm and 38.9±2.2 mm; FNL: 91.1±5.7 mm and 81.8±4.3 mm; FNW: 28.9±3.4 mm and 26.0±4.3 mm; CDA: 132.3°±3.4° and 129.9°±4.0°. This data could be used as a guideline to design a more suitable implant for the Malay population which covers most of the South East Asian countries.

**KEY WORDS:** Proximal femur; Morphology; Anatomy.

**INTRODUCTION**

The morphology of proximal femur is an essential parameter in the design and development of implant for total hip replacement (THR). Inappropriate implant design and size could affect outcome of the surgery with reported complications such as stress shielding, micromotion and loosening (Heinert & Parker, 2007; Jiang et al., 2007; Abdul-Kadir et al., 2008). Most of these implants were designed and manufactured from the European and North American region which presumably based on the morphology of their respective population. The use of such implants in other regions such as Malaysia may not be appropriate as the design may not take into consideration the morphology of the local population. As far as the authors are aware, no study has been documented regarding the morphology of proximal femur for the Malay population which can be largely found in the South East Asian countries such as Malaysia, Brunei, Singapore, Indonesia, Thailand and the Philippines.

The use of implants designed based on other populations posed at least two potential major issues. First and foremost is the difference of the anthropometry of the proximal femur between ethnics due to differences in lifestyle, physique, applied force and their distribution. This can be seen from numerous data presented in various studies for the western and eastern population (Hoaglund & Low, 1980; Gnudi et al., 2004; Calis et al., 2004; Igbigbi & Msamati, 2002; Mahaisavariya et al., 2002; De Sousa et al., 2010; Mishra et al., 2009; Caetano et al., 2007; Da Silva et al., 2003). Another issue is implant-morphology mismatch that might cause difficulties during implant placement and could lead to accelerated deterioration of the implant life thus affecting short-term and long-term outcome of the surgery (Reddy et al., 1999; Noble et al., 1988; Kaya et al., 2008; Fang et al., 2010; Ohsawa et al., 1998).

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Due to the importance of anthropometry for the success of hip joint replacement, this study analyses the morphology of the proximal femur for the Malaysian population. The data provided in this study could be used in the design and development of implants suited for local population as well as assisting in decision making during clinical practices.

MATERIAL AND METHOD

This prospective study was performed at Hospital Tengku Ampuan Afzan, Malaysia after receiving approval from hospital ethics committee and the National Medical Research Register (NMRR). Sixty subjects (30 males, 30 females) were recruited for this study, and measurements were taken from 120 hips (left and right). The exclusion criteria were pregnant women, those who experienced previous femoral injury, abnormal body mass index (BMI), wearing implant or prosthesis, or had CT scan previously performed within 6 months prior to the date of recruitment. Gonadal shields were used and no contrast media was administered.

Femoral images were acquired using four row multi slices CT scanner (Somatom, Volume Zoom, Siemens) at 3.0 mm thickness and 12.0 mm table feed per rotation, operated at 120 kV and 90 mAs. Subjects were asked to lay down at supine position with their feet stabilized using a specially designed wood jig to standardize the position of feet during image acquisition.

The following data were collected before the study: patient’s age, gender, weight and height. Four parameters were measured from the CT datasets: femoral head diameter (FHD), femoral neck length (FNL), femoral neck width (FNW) and collo-diaphyseal angle (CDA), as shown in Figure 1. CDA was defined as the angle between femur neck axis (EF) and femoral shaft axis (GH); FNL was the distance between head apex (E) and greater trochanter’s base (F); FHD was the maximum diameter of femur head (AB); and FNW was the minimum diameter of the femoral neck (CD). All measurements were statistically analyzed using SAS software to compare between genders and femoral sides. The goodness-of-fit test (Anderson-Darling method) was used to verify the normality assumption for each group of data. For normally distributed data the Folded F method was used to examine the equality of data variances. The probability value was obtained using t-test either by Pooled method or Satterthwaite method, depending on the equality of variance. If the data was not normally distributed, nonparametric one-way ANOVA was adopted using Wilcoxon scores. The probability value was then determined by Chi-Square values through Kruskal-Wallis test.

RESULTS

The four measured parameters for the proximal femur of the Malay population are shown in Table 1. The mean age, weight and height of subjects were 25.0±5.2 years old, 61.5±13.8 kg and 1.65±9.63 m respectively. Statistical analysis showed no significant differences between left and right femora for all parameters. However, significant differences were found between male and female subjects.
DISCUSSION

Implants for the replacement of diseased hip joint were mostly developed by European and American manufacturers, presumably using the morphology of their respective population. These implants come in different sizes to suit the various sizes of their population. However, due to the relatively small build size of our population, local surgeons have a fewer choice of size available to them. The search for a perfect match seemed to be more challenging and may require some ingenuity from the surgeon. There were cases where the chosen implant did not exactly fit the morphology of the femur from a particular population (Koval, 2007; Gadegone & Salphale, 2007). Other than the relatively larger size of implants, other parameters such as the collo-diaphyseal angle, neck length and width were also reported to be different (Lv et al., 2011; Sivanathan et al., 2003). This implant-bone mismatch could result in an unnecessary removal of bone stock in order to fit a particular implant. Analysis of the morphology from the local population is therefore essential as it provides crucial information required to design a more suitable size and shape of implant.

There are several literatures comparing morphology between different populations. Mahaisavariya et al. compared the morphometry of proximal femur between Siamese and Caucasian populations and reported a wider CDA for the Siamese. On the contrary, Hoaglund & Low observed smaller FNW and CDA for Hong Kong Chinese population when compared with their western counterpart. This information is important especially when dealing with femoral neck fracture where the use of larger diameter screw may eventually cause avascular necrosis of the femoral head. A 20 mm femoral neck screw usually requires 2.5 mm margin cranially and caudally of FNW during placement of screw and pin (Chiu et al., 2009). Our study shows that the Malay population has an average FNW value of 28.9 mm and 26.0 mm for male and female respectively which would be sufficiently safe for the 20 mm femoral neck screw. (Heinert & Parker; Jiang et al.).

The information on proximal femoral morphology presented in this study could be used as a guideline to design a more suitable implant for the Malay population which covers most South East Asian countries. The design of hip implant has evolved drastically as lessons were learnt from the many and various post surgical complications. However, some of the problems still exist such as osteolysis which is caused by wear debris, poor bone remodeling due to altered physiological loading and aseptic loosening due to insufficient primary and secondary stability. There are several reported works where morphological data were used as reference for the design and analysis of femoral stem (Bargar, 1989; Stulberg et al., 1989; McCarthy et al., 1997; Abdul-Kadir et al.). These implants were specifically designed according to the morphology of the bone for accurate representation in an idealized situation. As there were numerous implant options available to surgeons, information presented in this report could also be used as guidelines for clinicians in making a more informed decisions. Gözte et al. (2002) proved the importance of a suitably matched

Table I. Four measured parameters from the proximal femur of the Malay population.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sex</th>
<th>Mean</th>
<th>Range</th>
<th>p</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collo-diapysial angle (*)</td>
<td>Male</td>
<td>132.33±3.44</td>
<td>124.96 – 138.89</td>
<td>&lt;0.0005</td>
<td>0.3136</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>129.87±3.95</td>
<td>121.10 - 137.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Femoral Head Diameter (mm)</td>
<td>Male</td>
<td>43.62±3.05</td>
<td>36.90 - 50.34</td>
<td>&lt;0.0001</td>
<td>0.7158</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>38.85±2.17</td>
<td>33.01 – 43.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Femoral Neck Width (mm)</td>
<td>Male</td>
<td>28.88±3.38</td>
<td>18.46 – 35.73</td>
<td>&lt;0.0001</td>
<td>0.0885</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>25.95±4.31</td>
<td>21.79 – 51.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Femoral Neck Length (mm)</td>
<td>Male</td>
<td>91.08±5.65</td>
<td>78.70 – 104.88</td>
<td>&lt;0.0001</td>
<td>0.9088</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>81.78±4.33</td>
<td>73.61 – 93.24</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Statistical analysis of means between sexes.
** Statistical analysis of means between femoral sides.
implant for successful surgery through a custom made femoral stem, Adapativa. The implant had an interface motion of less than 150 μm with lower dynamic micromotions and rotation behavior at the proximal region.

The collo-diaphyseal angle (CDA) is an important parameter especially in surgeries involving the dynamic hip screw (DHS) and dynamic condylar screw (DCS). In general, trochanteric two fragment fractures normally require a DHS with a CDA of 135°. However this value may not be suitable for the Malay population as the average CDA values are 132° and 130° for male and female respectively. Lv et al. reported that a proximal femoral nail with antirotation specifically for Asian population has a mediolateral angle of 5°, diameter of 16.5 mm, blade length range from 75 to 120 mm in steps of 5 mm and CDA values of 125° and 130° which is within the range of our study. Sivanathan et al. reported that the usage of small stem Exeter for total hip arthroplasty with an offset of 30 to 35.5 mm suitable for Asian populations demonstrated promising results at 2.5 years follow-up.

In conclusion, we would like to emphasize the importance of proximal femoral measurement especially the collo-diaphyseal angle, femoral neck length and width which is particularly different from other populations. As far as the authors are aware, this is the first reported study on the morphology of the proximal femur for the Malay population, aimed at giving information to engineers and clinicians alike in the development of implants and practice related to the hip joint.

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