Sex-based differences in neck selectivity in total hip arthroplasty using a modular femoral neck system

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Abstract

**Background:** Dislocation is a major complication of total hip arthroplasty (THA). The modular femoral neck system has some practical advantages in that it permits adjustment neck version and length, if intraoperative instability is present. Anatomical studies have identified morphological differences in the hip joint between men and women. Although sex-based differences exist in hip morphology, it is unclear whether sex-based differences exist in femoral neck selection when the hip is anatomically reconstructed with THA using a modular femoral neck system. This retrospective study aimed to investigate sex-based differences in femoral neck selectivity in THA using a modular neck system.

**Hypothesis:** We hypothesised that sex-based differences exist in neck selectivity in THA using a modular neck system.

**Patients and Methods:** Between July 2007 and March 2013, 163 THAs using a modular femoral neck system were performed in 149 patients at Teikyo University Chiba Medical Center. Data on the type of modular neck were retrieved from patient records. Fisher’s exact test was used to investigate sex-based differences in femoral neck selectivity in THA using a modular neck system.

**Results:** Neck selectivity did not significantly differ between men and women.

**Discussion:** This retrospective study on THA with a modular femoral neck system revealed no sex-based difference in neck selectivity; however, more than half of the series used varus or version-controlled neck, indicating that a changeable neck may play a role in preventing postoperative dislocation.

Introduction

Dislocation is a major complication of total hip arthroplasty (THA) [1, 2], and recurrent dislocations sometimes require revision surgery [3–5]. To reduce the incidence of dislocation, achieving optimal orientation of the implant placement should be prioritized [6, 7]. Intraoperative assessment of dislocation is a simple method for predicting instability after THA [8]. The modular femoral neck system has some practical advantages in that it permits adjustment neck version and length, if intraoperative instability is present [9].

Anatomical studies have identified morphological differences in the hip joint between men and women. Women tend to have a shorter femoral neck and greater anteversion of the femoral neck [10, 11].

Although sex-based differences exist in hip morphology, it is unclear whether sex-based differences exist in femoral neck selection when the hip is anatomically reconstructed with THA using a modular femoral neck system. We hypothesised that sex-based differences exist in neck selectivity in THA using a modular neck system.

This retrospective study aimed to investigate sex-based differences in femoral neck selectivity in THA using a modular neck system.
Material And Methods

Patient characteristics

Between July 2007 and March 2013, 163 THAs using a modular femoral neck system were performed in 149 patients at Teikyo University Chiba Medical Center. Data on the type of modular neck were retrieved from patient records. The following data were also retrieved from the patient records: patient demographics, such as age, height, weight, body mass index, side of operation, American Society of Anesthesiologists Physical Status (ASA-PS), diseases, and surgical information, such as surgical duration, haemorrhage, surgical approach, femoral stem, bearing, acetabular cup, and femoral head.

Surgical Procedure

All surgeries were performed under general anaesthesia in a clean-air operating room by or under the supervision of the senior author (K.K.). A modified anterolateral approach by Dall [12] or a direct anterior approach [13] was used. The acetabular cup was fixed using a press-fit technique, and additional screw fixation was used for all cups except spiked cups. The femoral stems were selected to correspond to the size of the largest rasp. Intraoperative assessment of dislocation was performed for all patients to avoid dislocation, as well as intraoperative radiography to adjust the leg length and offset. After these assessments, the optimal modular neck was determined. The modular neck system used in the study includes 22 options: straight, varus/valgus, 8° anteverted/retroverted, 15° anteverted/retroverted, anteverted varus, retroverted varus, anteverted valgus, and retroverted valgus, each of which are subclassified into long and short types (Fig. 1).

Statistical analysis

Statistical tests were performed using Fisher’s exact test for categorical variables and two-sample t-test for continuous variables. All p-values were two-sided, and p-values less than 0.05 were considered statistically significant. All statistical analyses were performed with EZR version 1.52 [14], which is a graphical user interface for R version 4.02 (The R Foundation for Statistical Computing, Vienna, Austria). More precisely, it is a modified version of R commander designed to add statistical functions frequently used in biostatistics.

Results

Patient demographics are shown in Table 1. The study included 30 men (30 hips) and 119 women (133 hips). The mean height of men was significantly higher than that in women (164.8 ± 8.8 vs 150.1 ± 6.2 cm, p = 0.01). The mean weight was significantly greater in men than in women (62.7 ± 14.5 vs 54.4 ± 9.2 kg, p = 0.01). The ASA-PS significantly differed between men and women (p = 0.02), and post-hoc analyses revealed that ASA-PS 2 vs 3 was significantly different between men and women (p < 0.01). The disease necessitating surgery differed significantly between men and women (p < 0.01), and post-hoc
revealed that osteoarthritis (OA) vs osteonecrosis of the femoral head and OA vs. fracture were significantly different between men and women ($p < 0.01$, and $p < 0.01$, respectively).

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>Total</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of hips (no. of patients)</td>
<td>30 (30)</td>
<td>133 (119)</td>
<td>163 (149)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>62.9 ± 11.6</td>
<td>66.4 ± 9.4</td>
<td>65.7 ± 9.8</td>
<td>0.082*</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.8 ± 8.8</td>
<td>150.1 ± 6.2</td>
<td>152.8 ± 8.8</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>62.7 ± 14.5</td>
<td>54.4 ± 9.2</td>
<td>55.9 ± 10.8</td>
<td>&lt; 0.01*</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>22.9 ± 3.7</td>
<td>24.1 ± 3.7</td>
<td>23.9 ± 3.7</td>
<td>0.109*</td>
</tr>
<tr>
<td>Side (left/right)</td>
<td>16/14</td>
<td>51/82</td>
<td>67/96</td>
<td>0.153**</td>
</tr>
<tr>
<td>ASA-PS (1/2/3/4)</td>
<td>3/20/7/0</td>
<td>19/106/8/0</td>
<td>22/126/15/0</td>
<td>0.02**</td>
</tr>
<tr>
<td>Disease (OA/ONFH/FX)</td>
<td>14/10/6</td>
<td>123/9/1</td>
<td>137/19/7</td>
<td>&lt; 0.01**</td>
</tr>
</tbody>
</table>

BMI; body mass index, ASA-PS; American Society of Anesthesiologists Physical Status, OA; osteoarthritis, ONFH; osteonecrosis of femoral head, FX; fracture

Surgical Information

Details of the surgical information are shown in Table 2. Surgical time and bleeding in one patient were not recorded.
<table>
<thead>
<tr>
<th></th>
<th>Men (30)</th>
<th>Women (133)</th>
<th>Total (163)</th>
<th>(p) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical time</td>
<td>124.0 ± 27.4 (n = 29)</td>
<td>123.9 ± 28.0</td>
<td>123.9 ± 27.7</td>
<td>0.978*</td>
</tr>
<tr>
<td>Bleeding</td>
<td>462.4 ± 317.7 (n = 29)</td>
<td>483.4 ± 314.6</td>
<td>479.7 ± 313.3</td>
<td>0.746*</td>
</tr>
<tr>
<td>Surgical approach</td>
<td>30/0</td>
<td>119/14</td>
<td>149/14</td>
<td>0.07**</td>
</tr>
<tr>
<td>Acetabular cup</td>
<td>15</td>
<td>107</td>
<td>122</td>
<td>&lt; 0.01**</td>
</tr>
<tr>
<td>Trilogy</td>
<td>7</td>
<td>6</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Conserve (spiked)</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Trabecular</td>
<td>2</td>
<td>9</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Trident</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Conserve (non-spiked)</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Continuum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing</td>
<td>21/9</td>
<td>125/8</td>
<td>146/17</td>
<td>&lt; 0.01**</td>
</tr>
<tr>
<td>Femoral head</td>
<td>26</td>
<td>115</td>
<td>141</td>
<td>1**</td>
</tr>
<tr>
<td>CoCr</td>
<td>4</td>
<td>18</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Ceramic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Femoral stem</td>
<td>30</td>
<td>128</td>
<td>158</td>
<td>0.585**</td>
</tr>
<tr>
<td>Profemur Z</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Profemur TL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MAL, modified anterolateral; DA, direct anterior; MoP, metal on polyethylene; MoM, metal on metal; CoCr, cobalt-chrome.

* Two-sample \(t\)-test, ** Fisher’s exact test

Six types of uncemented acetabular cups were used: Trilogy (Zimmer Biomet, Warsaw, IN, USA) was used for 122 hips, Conserve Plus (MicroPort Orthopedics, Memphis, TN, USA) for 17 hips, Trabecular (Zimmer...
Biomet, Warsaw, IN, USA) for 12 hips, Trident (Stryker Orthopaedics, Kalamazoo, MI, USA) for 11 hips, and continuum cup (Zimmer Biomet, Warsaw, IN, USA) was used for one hip. The use of acetabular cups differed significantly between men and women \((p < 0.01)\), and post-hoc tests showed that Trilogy vs. Conserve (spiked) was significantly different between men and women \((p < 0.01)\). Metals on polyethylene bearing were used for 146 hips and metal on metal bearing for 17 hips, with a significant difference between men and women \((p < 0.01)\). Two uncemented femoral stems were used: Profemur Z (MicroPort Orthopedics, Memphis, TN, USA) and Profemur TL (MicroPort Orthopedics, Memphis, TN, USA). The use of femoral stems did not significantly differ between the men and women \((p = 0.585)\).

**Neck Selectivity**

The details of neck selectivity are shown in Figs. 2 and 3.

Neck selectivity did not significantly differ between men and women. Further analyses were conducted to identify the risk factors affecting neck selectivity. In the univariate analysis, there was one risk factor for anteverted neck and varus neck use (Tables 3 and 4). However, no significant risk factors affecting neck selectivity were identified in multivariate analysis.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Anteverted neck</th>
<th>Others</th>
<th>Total</th>
<th>(p) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>OA/ONFH/FX</td>
<td>0/2/0</td>
<td>137/17/7</td>
<td>137/19/7</td>
<td>0.0246*</td>
</tr>
</tbody>
</table>

* OA; osteoarthritis, ONFH; osteonecrosis of femoral head, FX; fracture

<table>
<thead>
<tr>
<th>Bearing</th>
<th>Varus</th>
<th>Others</th>
<th>Total</th>
<th>(p) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MoP/MoM</td>
<td>48/12</td>
<td>98/5</td>
<td>146/17</td>
<td>&lt;0.01*</td>
</tr>
</tbody>
</table>

* MoP; metal on polyethylene, MoM; metal on metal

**Discussion**
This retrospective study examined THAs with the modular femoral neck system and found no significant sex-based differences in neck selectivity, contrary to our hypothesis. Previous studies have included multiple surgeons or multiple methodologies, making it difficult to make direct comparisons. However, to our knowledge, this study was the first to report the results of THA performed by a single surgeon using a single method and concept.

Traina et al. reported the results of modular neck THAs in Italy, and the short neck was used in 73.7% of the women and 51.5% of the men, whereas the long neck was used in 26.3% of the women and 48.5% of the men ($p = 0.0001$) [15]. Gofton et al. also reported from Canada that the majority of short femoral necks were implanted in women (57.2%, 426 of 745) compared to those implanted in men (42.8%, 319 of 745), whereas the majority of long femoral necks were implanted in men (64.1%, 41 of 64) compared to those implanted in women (35.9%, 23 of 64) ($p < 0.01$) [9]. However, in our study, the use of long or short femoral neck was not significantly different between men and women; namely, short femoral neck was used in 63.3% (19 of 30) of the men and 76.7% (102 of 133) of the women, whereas long femoral neck was used in 36.7% (11 of 30) of the men and 23.3% (31 of 133) of the women ($p = 0.165$). This difference in results might have been due to differences in the body size of the patients. The participants’ mean heights were 164.8 ± 8.8 (men) and 150.1 ± 6.2 (women) in our study, whereas the mean height of the study of Traina et al. was 172.2 ± 6.7 (men) and 161.7 ± 6.5 (women) [15]. The Profemur system (MicroPort Orthopedics, Memphis, TN, USA) was designed for use by Westerners; therefore, a long femoral neck might not have been necessary for small Japanese men.

Traina et al. reported that a version-controlled neck was selected in 27.8% of women and 21.6% of men ($p = 0.0001$) [15]. Meanwhile, Gofton et al. reported no significant difference in neck selectivity as a sex-based function [9]. Similar to the results of Gofton et al., our study revealed no sex-based differences in neck selectivity.

Although no sex-based difference was observed in neck selectivity in this study, varus neck or version-controlled neck was selected in more than half of the patients (84/163). The results demonstrated that the changeable femoral neck system plays a role in avoiding dislocation after THA. Optimal implant positioning is important for reducing the risk of dislocation [1, 2], and several devices are used to achieve optimal implant positioning, including navigation and portable navigation [16–18]. However, dislocation is multifactorial and cannot be completely prevented even when optimal implant positions are obtained. Furthermore, in cases of strong bone deformity, malalignment of the cup and femoral stem must be allowed to obtain a firm fixation, which may result in a significant deviation from the optimal position to prevent dislocation. For these reasons, modular neck system THA is effective in preventing dislocation because the neck can be selected to prevent dislocation regardless of the position of the acetabular cup and femoral stem.

This study had several limitations. First, it was a retrospective study, which might have resulted in various biases. Second, the sample size was relatively small. Third, no postoperative image evaluation was
performed to determine whether THA resulted in anatomical reconstruction of the hip. Further studies are needed to clarify this issue.

In conclusion, this retrospective study on THA with a modular femoral neck system revealed no sex-based difference in neck selectivity; however, more than half of the series used varus or version-controlled neck, indicating that a changeable neck may play a role in preventing postoperative dislocation.

**Declarations**

Ethics approval and consent to participate: All methods were carried out in accordance with relevant guidelines and regulations. The study was approved by the Institutional Review Board (Teikyo University, IRB No.22-148). The requirement for informed consent for participation was waived by the Institutional Review Board (Teikyo University, IRB No.22-148).

Consent for publication: Not Applicable

Availability of data and materials: The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests: None

Funding: None

Authors’ contributions: T.S. wrote the main manuscript text and Y.M. and Y.Y. prepared figures. K.K. performed critical revision.

Acknowledgements: None

**References**


Figures

Figure 1

Types of modular femoral necks used (MicroPort Orthopedics, Memphis, TN, USA)

(a) straight, (b) varus/valgus, (c) antverted/retroverted (8°), (d) antverted/retroverted (15°), and (e, f) the combination of varus/valgus and antverted/retroverted.
Figure 2

Distribution of modular femoral necks in men and women
Figure 3

Modular femoral distribution

AV, anteverted varus; RV, retroverted varus.