Restoring The Femoral Head Centre For Anteverted Femurs. Are Short Stems A Better Alternative To Contemporary Long Stems?

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Disclosures:
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Introduction: The current economic climate and the emergence of new markets for orthopaedic products are driving manufacturers to consider the suitability of devices for the global consumer. Factors such as patient fit, stability, effective load transfer and restoration of native head height and offset are critical to long term femoral implant survival and patient satisfaction. In order to provide a cost effective and appropriate solution for every patient, a need for further understanding of the patient demographic in terms of morphological variation exists. With this information, manufacturers will be able to optimise implant geometry and potentially reduce both implant and instrument inventory, providing the surgeon with the appropriate intraoperative choices necessary to treat their patient cohort.

A demand for the manufacture of bone conserving short stems has arisen primarily from the recognition that conventional long stem prostheses transfer loads distally, resulting in bone loss of the proximal femur. Conservative, short stems have been introduced by many manufacturers in an attempt to better replicate the physiological load distribution in the femur. Benefits in terms of load distribution relative to their long stem counterparts have been reported previously. In addition, short stems also require fewer implant variations (caput-collum-diaphyseal (CCD) angle, offset) as the design principles such as mid-neck resection and lateral loading provide the surgeon with a more versatile operative technique. The sensitivity of femoral loading to mal-positioning of a short-stemmed prosthesis has been reported where minor modifications to stem placement were shown to have little influence on cortical strains. Prior work has also indicated the benefits of a short stem prosthesis in successfully restoring femoral head centre (FHC) for the anticipated range of flare indexes within the target population. That said, evidence supports the promotion of this device as a versatile prosthesis but it has yet to be assessed how this type of device will perform in extreme examples of proximal femoral anteversion evident within the global demographic.

Methods: Project Shield was a Technology Strategy Board (TSB) UK funded consortium involving Corin and a number of technology specialists. The primary objective was to develop novel implantable devices to address undesirable bone remodelling, also known as stress shielding. A portion of this project involved building a statistical model of the adult hip using 178 patient computed tomography (CT) scans from Europe, North America and Australia. A secondary model, built from 30 of the full length North American femoral CT scans, was used to characterise proximal endosteal morphology. For this study manual analysis was performed by a single operator to assess anteversion and complete the characterisation of this secondary dataset. A separate dataset of 76 Japanese CT scans was also characterised by the same operator, following the same landmark definition protocol, in terms of neck shaft or CCD angle, offset and anteversion. Data was compared with that of the 30 full length CT scans as well as work done by another author.

The scans exhibiting the ninetieth percentile of version (extreme anteversion) were segmented using Materialise software and implanted with a contemporary long stem (MetaFix™, Corin) then with a bone conserving short stem (MiniHip™, Corin). The ability of each to restore preoperative FHC was evaluated in CAD (Materialise Mimics) in terms of mediolateral and anteroposterior horizontal and vertical displacement. Results were used to determine whether the MiniHip™ offers any advantage over contemporary long stems in terms of the ability to restore preoperative FHC.

Results: Results of the CT data analysis indicated a tendency for higher anteversion associated with Japanese patients (Table 1). This was evident as none of the ninety percentile was from the US dataset (Figure 1). By simulating the operative approach taken to position both a long stem and short stem it was evident that the proximal anchorage position and mid-neck resection of the short stem allowed good bone fit and achieved a more accurate restoration of FHC for all apparent morphologies (Figures 2 and 3).

Discussion: The analysis showed a tendency for increased anteversion associated with the Japanese dataset. It was previously reported that short stem prostheses are suitable for the restoration of preoperative FHC for a large range of anticipated flare indexes. The mid-neck resection level and proximal anchorage position was shown to be a more versatile alternative to traditional long stem prostheses. With regards to surgical positioning of the long stem device, restrictions imposed by the distal canal and calcar meant that the FHC was limited to the few positions offered by modular head options and stem variants. Such restrictions could be partially corrected clinically using offset modular necks however this type of device is currently under scrutiny due to metal ion release. The short stem, in contrast to this, utilises the mid-neck resection and proximal anchorage location to offer the surgeon the ability to restore FHC more accurately without the inventory necessary for long stem devices.
**Significance:** Results of this study have indicated the suitability of bone conserving short stem devices, provided with a single CCD and offset, for the restoration of FHC for extreme examples of anteverted femurs. Morphological variation can be accommodated for by careful planning of the neck resection and the use of different offset heads.

**Acknowledgments:** The authors acknowledge the support of the TSB in providing funding for project Shield and Imorphics for building the statistical model.

**References:**
Figure 3: Implanted MetaFix™ in patient with 46.5° anteversion with corresponding measurements of the deviation from preoperative FHC.

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<th>Deviation from FHC</th>
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<tr>
<td></td>
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<tr>
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<tr>
<td>-6.0 mm</td>
<td>-5.94</td>
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<tr>
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<tbody>
<tr>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Neutral (0.0 mm)</td>
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<tr>
<td>-6.0 mm</td>
<td>+8.4</td>
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Figure 2: Minipool™ successfully restoring FHC for patient with 45.5° anteverision
Figure 1: Distribution of version angles from Japanese and US datasets

ORS 2014 Annual Meeting
Poster No: 1793