The shape and size of femoral components in revision total hip arthroplasty among Chinese patients

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ABSTRACT

Purpose. 39 sets of preoperative hip X-rays were studied to find out whether Chinese patients need revision femoral components with a different shape and size from western patients.

Methods. From July 1998 to June 2001, the pre-revision X-rays of 39 revision total hip replacements among 38 Chinese patients (21 men and 17 women) were studied. The component size that produced the best distal canal-filling in the anteroposterior X-ray was determined by using templates of 200-mm femoral components used commonly for Caucasian patients.

Results. The diameter of the component needed was 13.5 mm or less in 54% of cases, compared with only 17% for Caucasian patients as reported in the literature (p<0.01). When lateral templates of the corresponding size were put over the lateral X-rays, the anterior cortex of the 200-mm straight stem was shown to have thinned by 2.0 mm or more in 36% of hips; for 200-mm bowed stem, there was thinning of the anterior cortex by 2.0 mm or more in only 5% of hips (p<0.01).

Conclusion. Chinese patients are likely to need smaller femoral components than Caucasian patients, and may benefit from bowed-stem components in femoral revision.

Key words: arthroplasty, replacement, hip; Chinese

INTRODUCTION

After failure of total hip arthroplasty, the proximal femur is compromised either mechanically (i.e. the bone support is weak) or biologically (i.e. the bone may not be viable). It is often not possible to use a cemented femoral component or a proximally porous-coated femoral component. However, the use of an extensively porous-coated femoral component can offer durable and reliable diaphyseal fixation. The re-revision rates for aseptic loosening of such femoral components...
range from 0% to 6% after an average follow-up of 4 to 13 years.\textsuperscript{1–8}

For extensively porous-coated femoral components to work, it is important to have 4 to 6 cm of ‘scratch fit’ or good canal fill in the diaphysis, so that the porous-coated part of the stem can be in close contact with good quality cortical bone. Moreland and Bernstein\textsuperscript{6} reviewed 175 femoral revisions with such components. They found that bone ingrowth occurred in 83% of cases: 88% for components with complete canal fill but only 71% for components with incomplete fill. Krishnamurthy et al.\textsuperscript{3} reported Paprosky’s minimal 5-year results (mean, 8.3 years) of 297 femoral revisions. Bone ingrowth was achieved in 82% of patients and 16% had stable fibrous fixation; only about 2% had unstable fixation. The unstable femoral components were attributed to the use of undersized femoral components.

Insertion of an extensively porous-coated femoral component that is long and straight into the medullary canal of a Chinese patient may not be straightforward. Femora in Chinese individuals have a narrower isthmus and a more pronounced anteroposterior (AP) bowing than femora in Caucasians.\textsuperscript{7} Because the more pronounced AP bowing may be further aggravated by the remodelling changes to the loosened femoral component, insertion of a straight femoral component carries a risk of perforation to the anterior cortex distally (Figs. 1 and 2).

In this study, we examined the pre-revision X-rays of 38 Chinese patients, with the aim of finding out how commonly small or bowed femoral components are needed for femoral revision in this group.

**Figure 1** A 66-year-old woman with loosening of a cemented Charnley femoral component, with extensive osteolysis over several zones (left). The femur was bowed, and the distal anterior cortex was thin and osteoporotic (right).

**Figure 2** A 200-mm straight-stem femoral component was used to bypass the proximal deficiency (left) of the same patient. The distal anterior cortex was probably violated (right).
MATERIALS AND METHODS

The pre-revision X-rays of all revision total hip replacements performed by 7 joint replacement surgeons from 4 institutions, namely, Kwong Wah Hospital, Pamela Youde Nethersole Eastern Hospital, Queen Mary Hospital, and United Christian Hospital, from July 1998 to June 2001 were screened. Cases in which hemiarthroplasty or bipolar hip replacement were converted to total hip replacement procedures were excluded. To be included, both AP and lateral X-rays had to be available, in which about 30 cm of the proximal femur had to be visible. Because of the retrospective nature of the study, the distance of the beam to the table was not standardised, but it was about 100 cm in most cases.

The pre-revision X-rays of 39 revision total hip replacements among 38 patients (21 men and 17 women) were suitable for this study. The mean age at the time of the revision was 63.1 years (standard deviation [SD], 14.2 years; range, 32–83 years). The failed femoral components were cemented in 33 hips and cementless in 6 hips. The reasons for revision were aseptic loosening in 33 hips, deep sepsis in 5 hips, and recurrent instability in one hip; 31 hips were first-time revisions, 7 were re-revisions, and one was a third revision.

The templates of the Solution femoral components (DePuy, Leeds, UK) were used to guide the measurement of the canal widths and cortical thicknesses in the diaphysis, and to determine the sizes of the femoral components, the distal canal fill, and the possibility of erosion or perforation of the anterior cortex distally. The Solution femoral components come in 3 stem lengths: 152 mm (6-inch), 200 mm (8-inch), and 254 mm (10-inch). The 200-mm femoral components were used in this study because this size is most commonly used to bypass the proximal deficiency, and both straight-stem and bowed-stem templates are available. The smallest available 200-mm components are 10.5 mm in diameter for the straight stem and 13.5 mm in diameter for the bowed stem (the size increment is 1.5 mm).

Firstly, we determined if a 200-mm component was to be inserted, the canal widths and cortical thickness at the level of the distal limit of the porous-coated surface. We identified the tip of the greater trochanter in the AP X-ray. The template of 200-mm stem was then put over the film such that the centre of the hip ball was at the same level as the tip of the greater trochanter. A transverse line that depicted the distal limit of the porocoat was then drawn over the X-ray. The process was repeated with the lateral X-ray. The thicknesses of the medial and lateral cortices and the mediolateral (ML) canal width were measured in the AP X-ray. The thickness of the anterior cortex and AP canal width were measured in the lateral X-ray.

Secondly, we explored whether the distal anterior cortex could be jeopardised with the use of 200-mm straight femoral component, and whether a 200-mm bowed femoral component would be helpful. The AP X-ray was first templated, and the size of the 200-mm femoral component that would give the best distal fill was selected. The lateral X-ray was then evaluated with the straight-stem and bowed-stem lateral templates of the corresponding size. It was important that the template was placed in a standardised manner, so that the femoral component was just touching the endosteum of the anterior cortex proximally, and was just touching the endosteum of the posterior cortex in the middle segment. Special attention was given to the distal part of the femoral component in relation to the anterior cortex. Any erosion or even perforation of the anterior cortex was carefully quantified.

Thirdly, we assessed the effect of sizing the femoral component by reversing the templating sequence. The lateral X-ray was first evaluated with the 200-mm straight-stem and bowed-stem lateral templates. The sizes of the femoral component that could theoretically be inserted without jeopardising the distal anterior cortex were determined. The corresponding sizes of AP 200-mm templates were then put over the AP X-ray. The proportion of the canal fill was then determined at the level of the distal limit of the porocoat, and at 5 cm proximal to it. The sizes determined by the lateral templating were also compared with the size of the femoral component that gave the best distal canal filling in the AP X-ray.

The ruler on the 120% magnified template was used for the measurements of the cortical thicknesses and canal widths. There was no adjustment for variation in the X-ray magnification of the different sets of X-rays. The surgeons first measured and templated the X-rays from their own hospitals. Each set was then cross-checked by a surgeon from a different hospital. If there was any disagreement, the X-rays were measured and templated again by a surgeon from another hospital and so on, until consensus was reached.

The data were analysed with Statistical Package for the Social Sciences (Windows version 10.0.1; SPSS Inc., Chicago, United States), using Pearson correlation, chi-square tests, and two-tailed t tests. Statistical significance was assumed if p value was less than 0.05.
RESULTS

Dimensions at the distal limit of the porocoat

At the level of the distal limit of the porocoat, the anterior cortex was 3.7 mm thick (SD, 1.4 mm; range, 1–8 mm), the medial cortex was 5.2 mm thick (SD, 2.5 mm; range, 1–14 mm), and the lateral cortex was 4.9 mm thick (SD, 1.8 mm; range, 1.0–8.5 mm). The anterior cortex was significantly thinner than the medial and lateral cortices at this level (p<0.001), which was clinically relevant, because the distal tip of the femoral component might jeopardise the cortex in this direction.

At the level of the distal limit of the porocoat, the ML canal width in the AP X-ray averaged 14.9 mm (SD, 2.9 mm; range, 10–22 mm), and the AP canal width in the lateral X-ray averaged 15.6 mm (SD, 2.7 mm; range, 10.0–23.5 mm). There was a strong correlation between the 2 canal widths ($r=0.66$). For male patients, the medullary canal distally was oval at this level, with a mean AP canal width of 15.4 mm and a mean ML canal width of 14.1 mm. For female patients, the medullary canal distally had similar dimensions, with a mean AP canal width of 15.4 mm and a mean ML canal width of 15.6 mm.

Component sizes determined from X-rays

The distribution of the component sizes that gave the best distal canal fill in the AP X-rays is shown in Fig. 3. Small femoral components ($\leq 13.5$ mm) were needed in 21 (54%) hips: 11 of 17 (65%) hips in females and 10 of 22 (46%) hips in males. The difference was not significant (p=0.32).

The effects of straight and bowed stems on the distal anterior cortex

After the component size was determined from the AP X-ray, the lateral templates of the corresponding size were put over the lateral X-ray. Because there were no 10.5- and 12.0-mm templates for the bowed-stem femoral components, bowed stem measurements could not be made for 10 hips.

For straight-stem femoral components, the distal anterior cortex was thinned out by an average of 1.1 mm (SD, 2.9 mm; range, -3–15 mm). If a bowed-stem femoral component was used, the distal stem tip was still 0.7 mm (SD, 2.2 mm; range, -7–4 mm) away from the endosteum of the anterior cortex.

Because the mean thickness of the anterior cortex was only 3.7 mm, a further thinning of 2 mm or more would be undesirable. For straight stem femoral components, thinning of the anterior cortex by 2 mm or more would occur in 36% of hips. For bowed-stem femoral components, only 5% of hips would be so affected. The difference was statistically significant (p<0.01).

The stem tip of straight-stem femoral components perforated through the anterior cortex in 4 (10%) hips. In contrast, the stem tip of a bowed-stem femoral component perforated through the anterior cortex in only one (3%) hip.

Canal filling after lateral templating

By putting a straight-stem lateral template over the lateral X-ray, the component size that best fitted the medullary canal without jeopardising the anterior cortex was determined. Compared with the component sizes determined by the AP templating, a femoral component that was 2 sizes smaller was needed in 3 hips, one that was one size smaller in 13 hips, a same-size component in 14 hips, and one that was one size bigger in 9 hips. Thus, 16 (41%) hips were downsized from the AP X-ray so as to not jeopardise the distal anterior cortex. In these 16 hips, the average canal fill in the AP radiographs was 86% at the level of the distal limit of the porocoat and 85% at the level 5 mm proximal to that.

By putting a bowed-stem lateral template over the lateral X-ray, the component size that best fitted the medullary canal without jeopardising the anterior cortex was determined. Compared with the component sizes determined by the AP templating, a femoral component that was one size smaller was needed in 6 hips, a same-size component in 11 hips, and one that was one size bigger in 12 hips. Thus, 6 (21%) hips were downsized from the AP X-ray so as...
not to jeopardise the distal anterior cortex. In these 6 hips, the average canal fill in the AP radiographs was 95% at the level of the distal limit of the porocoat and 80% at the level 5 mm proximal to that.

The difference in the number of hips that had to be downsized between straight-stem and bowed-stem femoral components did not reach statistical significance (p>0.1). However, while it was at most one size smaller for the bowed-stem femoral component, it could be 2 sizes smaller for the straight-stem femoral component.

DISCUSSION

Most revision cementless femoral components are straight, hence there is no need to have left and right components thereby reducing the inventory. A bowed-stem femoral component is considered necessary only if it is exceedingly long. For the Solution system, 254-mm femoral components are bowed. Both straight and bowed stems are available for the 200-mm Solution femoral components. However, the bowed 200-mm Solution femoral components are said to be rarely needed, and are reserved for patients with unusual femora only.

In this study, the 200-mm bowed-stem femoral components benefited more than 30% of Chinese patients by eliminating the chance of jeopardising the distal anterior cortex (Fig. 4). If one is not careful enough and inserts a straight, long stem into a bowed femur, it is possible to perforate the cortex distally (Figs. 1 and 2). If the latter occurs, there is a risk of postoperative fracture, because the tip of the femoral component stops at the same level as the cortical defect. One could argue that the risk of distal perforation could be minimised by performing templating in the lateral X-ray. However, we found that about 40% of the straight-stem femoral components would then be downsized, which led to suboptimal canal filling in the AP X-ray. The latter was the most important factor to achieve bone ingrowth. With a bowed-stem femoral component, the chance of downsizing was halved.

Moreland and Bernstein\(^6\) reviewed 175 femoral revisions with extensively porous-coated cementless stems. The mean patient age at revision was 62.4 years; 17% of femoral components were 13.5 mm or smaller in diameter, and 13% were 18 mm or larger. Krishnamurthy et al.\(^3\) reported Paprosky’s minimal 5-year results of 297 femoral revisions. The mean patient age was 59.6 years; 17% of femoral components were 13.5 mm or smaller in diameter, and 22% were 18 mm or larger. Our finding that more than half of the Chinese patients required a femoral component that was 13.5 mm or smaller in diameter indicates that Chinese patients are likely to need small components. One should bear in mind that the patients in our series differed from those in the 2 western series. Firstly, this study was a radiological templating exercise and not actual surgery. Secondly, the number of hips was much less. The age at revision, on the other hand, was comparable, and the templates we used were those of the revision femoral components being implanted in the 2 western series.

When a surgeon plans to use extensively porous-coated femoral components in revision total hip replacement, it is important to know the size and to find out whether the femoral canal is compatible with the use of a straight stem. To the best of our knowledge,
very few revision hip systems have bowed femoral components with moderate stem length. For the Solution femoral component, a bowed stem version is available for 200-mm femoral components. However, 10.5-mm and 12-mm diameter bowed-stem femoral components are not available in the Solution system. Perhaps such sizes are rarely needed in western countries, which are the system’s most important markets.

We hope that the manufacturers will reconsider the situation and provide their best support to surgeons performing joint replacements among Chinese patients so that the specific needs of these patients can be met.

REFERENCES