Association of intra-operative metaphyseal fractures with prosthesis size during hemiarthroplasty of the hip

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ABSTRACT

Purpose. To study the possible causes of intra-operative metaphyseal fractures in elderly patients undergoing hemiarthroplasty for displaced intracapsular femoral neck fracture.

Methods. 36 men and 228 women aged 61 to 89 years with 273 displaced femoral neck fractures underwent hemiarthroplasty using a hydroxyapatite ceramic-coated Furlong bipolar prosthesis. Anteroposterior and lateral radiographs were taken immediately after surgery to evaluate the presence and type of any intra-operative fractures (classified according to the Vancouver system) and their effect on stem stability or osseointegration. Pain and clinical outcomes were evaluated using a visual analogue scale and the Harris Hip Score.

Results. Regarding the 273 surgeries for displaced femoral neck fracture, 28 (10%) were associated with intra-operative metaphyseal fracture (21 Vancouver type AL and 7 type AG). There was a correlation between intra-operative metaphyseal fractures and stem size. A size-9 stem was used in 64 surgeries without any fracture. A size-10 stem was used in 129 surgeries in which 11 (9%) sustained fractures, and a size-12 stem was used in 80 surgeries in which 17 (21%) sustained fractures. Postoperatively, 25 cases developed hip-related problems (thigh pain=14 and periprosthetic fractures=8) after 3 to 18 months. No patient whose metaphyseal fracture was fixed had hip problems.

Conclusion. In elderly women with compromised bone quality, extra care is needed to achieve better fitting so as to avoid iatrogenic metaphyseal fractures. Under-sizing or cementing of the prosthesis is recommended when encountering difficulties.

Key words: complications; hip prosthesis

INTRODUCTION

In the elderly, the choice of surgical treatment for displaced intracapsular femoral neck fractures, known as ‘unsolved fractures’, is controversial. The options include internal fixation, hemiarthroplasty, and total hip arthroplasty (THA).

The prostheses used for hemiarthroplasty are either press fit or cemented, unipolar or bipolar. The hydroxyapatite ceramic (HAC)-coated hemi-
arthroplasty, first introduced in 1983, facilitates a biological bond between the host bone and implant, and has other advantages. These include shorter operating time, less blood loss, lower mortality (even in patients with pre-existing cardiovascular disease), and easy conversion to a THA if required.

We aimed to determine the possible causes of intra-operative metaphyseal fractures in elderly patients with displaced intracapsular femoral neck fractures, who underwent HAC-coated bipolar hemiarthroplasty, and the effect of such fractures on morbidity.

MATERIALS AND METHODS

Between November 2001 and November 2004, 36 men and 228 women aged 61 to 89 years with 273 displaced femoral neck fractures underwent hemiarthroplasty using a HAC-coated Furlong bipolar prosthesis (Joint Replacement Instrumentation, London, UK) via an anterolateral approach.

Each patient’s age, gender, operated side, American Society of Anesthesiologists grading, operating surgeon, surgical approach, head size, and stem diameter were analysed to explore possible associations with fracture. Their duration of hospital stay, mobility status, complications, and additional procedures they underwent were also analysed to explore any effects on clinical outcomes. Postoperative management was the same for all patients.

Anteroposterior and lateral radiographs were taken immediately after surgery and at final follow-up to evaluate the presence and type of any intra-operative fracture (classified according to the Vancouver system) and its effect on stem stability or osseointegration. Subsidence of the stem was determined by measuring the vertical distance from the medial shoulder of the prosthesis to the superior tip of the greater trochanter (or to the tip of the lesser trochanter). Varus or valgus migration was determined by measuring the angle made by the intersection of a line through the mid-stem of the prosthesis and a line through the mid-shaft of the femur as seen on the anteroposterior radiograph.

Pain and clinical outcomes were evaluated using a visual analogue scale and the Harris Hip Score (excellent=90–100, good=80–89, fair=70–79, and poor <70), respectively. The mobility status (ambulation without assistance, with assistance of one or 2 sticks, with assistance of a frame or walker, and ability to ascend and descend stairs) was also assessed. The differences between means were compared using the t-test. The differences between proportions were compared using Fisher’s exact test. Logistic regression models were used to investigate the association between the fracture and control groups, type of surgeon and stem size. All tests were 2-sided with a p value of <0.05 regarded as statistically significant.

RESULTS

There was no significant difference in age, gender, operated side, or co-morbidity between the 2 groups (Table 1). Of the 273 surgeries for displaced femoral neck fracture, 28 (10.3%) were associated with intra-operative metaphyseal fracture (21 Vancouver type AL and 7 type AG, Figs 1–3), the remaining 245 sustained no fracture (control group). 22 of the metaphyseal fractures were not fixed intra-operatively and resulted in a mean of 7 (range, 4–13) mm of femoral subsidence and thigh pain. The remaining 6 were fixed; only one resulted in a subsidence of 5 mm. Four cases had no metaphyseal fracture but revealed subsidence (mean, 3 mm; range, 2–6 mm), with no thigh pain. Eight cases had varus and 12 had valgus migration of the femoral stem. The mean diaphyseal canal fill was 92% (standard deviation [SD], 6%; range, 73–100%).

A size-9 stem was used in 63 surgeries, in which no intra-operative metaphyseal fracture was encountered. A size-10 stem was used in 130 surgeries in 11 (9%) of which fractures ensued. A size-12 stem was used in 80 surgeries, in 17 (21%) of which fractures occurred. The increase in proportion of fractures was
significant as the stem increased from 9 to 12 ($\chi^2=17.97$, $p<0.001$). The size-12 stem with a head size of ≥50 mm was involved in 4 greater trochanter fractures. Overall, the grade of surgeon appeared to have no influence on the chance of sustaining metaphyseal fractures ($\chi^2=2.71$, $p=0.439$, Table 2); further analysis by logistic regression also showed that there was no significant association between the grade of surgeon and metaphyseal fracture (Wald test=1.13, $p=0.777$).

The mean duration of hospital stays for patients with and without metaphyseal fracture were 20 (SD, 11; range, 4–54) and 19 (SD, 11; range, 2–92) days, respectively. The patients with the calcar fracture fixed stayed for 19 (SD, 9; range, 8–33) days.

Postoperatively, 25 cases developed hip-related problems (thigh pain=14, periprosthetic fractures=8, and others=3) after 3 to 18 months. Five of the 14 cases with thigh pain had intra-operative metaphyseal fractures (3 type AL and 2 type AG). Of the 8 cases with periprosthetic fractures, 4 were type A and 2 each were types B and C. One patient with a type B periprosthetic fracture did not have an intra-operative metaphyseal fracture fixed. No patient whose metaphyseal fracture was fixed had hip problems. One patient developed deep wound infection and underwent a Girdlestone arthroplasty. Two cases required revision surgery, one each for acetabular erosion and sinking of the prosthesis due to the unfixed metaphyseal fracture.

In 142 surviving cases (15 in the fracture and 127 in control groups) followed up for a mean of 25 (range, 14–48) months, the mean Harris Hip Scores were 74 and 84, respectively (Table 3). Intra-

**Table 2**

Association of the grade of surgeon with metaphyseal fractures when using a size-12 stem

<table>
<thead>
<tr>
<th>Surgeons†</th>
<th>No. of surgery</th>
<th>Size-12 stem used No. (%)</th>
<th>Metaphyseal fractures No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultants</td>
<td>58</td>
<td>27 (47)</td>
<td>6 (22)</td>
</tr>
<tr>
<td>Middle grades</td>
<td>113</td>
<td>36 (32)</td>
<td>8 (22)</td>
</tr>
<tr>
<td>HST grades</td>
<td>82</td>
<td>17 (21)</td>
<td>3 (18)</td>
</tr>
<tr>
<td>BST grades</td>
<td>20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>273</td>
<td>80 (29)</td>
<td>17 (21)</td>
</tr>
</tbody>
</table>

* $p=0.439$, Fisher’s exact test
† HST denotes higher surgical training, and BST basic surgical training

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**Figure 1** (a) An intra-operative calcar fracture (arrow) without fixation results in subsidence of the femoral stem and hip pain. (b) Revision is performed.

**Figure 2** An intra-operative metaphyseal fracture is fixed with cables but the stem size is compromised (73% fill).

**Figure 3** A missed intra-operative metaphyseal fracture leads to Vancouver type-B periprosthetic fracture (arrow) caused by subsidence and loosening of the stem.
operative metaphyseal fractures appeared to affect postoperative mobility (Table 4).

**DISCUSSION**

Uncemented, non-HAC-coated prostheses are associated with significantly more thigh pain, poor function, and dependence on walking aids because of stem loosening. The cemented hemiarthroplasty provides immediate stability and early mobility to ensue better postoperative outcomes. But this technique is associated with a greater risk of fat embolism, hypotension, and cardiac arrest. Intra-operative fractures could be caused by intrinsic or extrinsic risk factors. Intrinsic risk factors cannot be controlled, but extrinsic risk factors can be improved or changed. Intrinsic factors include poor bone stock, advanced age, female gender, abnormal femoral geometry, biomechanical factors, patient compliance, and thinning of the femoral cortex with a smaller proximal canal/neck flare. Extrinsic factors include the use of a straight rather than bowed or so-called anatomic stem, stem diameter, the surgical approach, and under-reaming instead of line-to-line reaming for implantation of bowed stems.

Intra-operative metaphyseal fractures can be divided into hairline cracks, fissures, and fractures. Hairline cracks are barely perceptible breaks in continuity, with no evident gaping at any point during prosthesis implantation. During cementation, the cracks are not filled with cement. In fact, clinically they are detectable only in the calcar area. Fissures are cracks that most commonly arise in the calcar or shaft area during rasping of the medullary canal. They gape open when the prosthesis is inserted. Spontaneous healing can be expected to take place in patients with uncemented prosthesis but is hazardous with cemented implants, as the cement penetrates into fissures and can permanently prevent the self-repair mechanisms of remodelling. Fractures are complete breaks in continuity.

In our study using HAC-coated Furlong bipolar hemiarthroplasty for the treatment of displaced intracapsular femoral neck fractures, an excessive stem diameter was a major risk factor for intra-operative metaphyseal fractures. The diameter sizes available during the study period were 9, 10, 12, 14, and 16 mm. In elderly women with compromised bone quality, the jump from 10 to 12 mm appeared too big. Moreover, over-reaming was not preferred, as this decreased the chances of bonding between bone and the HAC coating of the prosthesis. Therefore, extra care is needed to achieve a better fitting in the compromised bone so as to avoid iatrogenic metaphyseal fractures. Under-sizing or cementing of the prosthesis is recommended when difficulties are encountered.

After this study, a size-11 stem was introduced. During the past 8 months, an additional 10 patients have used a size-11 stem and 4 patients have used a size-12 stem for hemiarthroplasty, none of whom had intra-operative metaphyseal fractures.

**ACKNOWLEDGEMENT**

We thank Tracey Young from University of Sheffield for her statistical advice.
REFERENCES