Total hip arthroplasty in severe segmental femoral bone loss situations: Use of a reconstruction modular stem design (JVC IX™)

A. Bertani a,*, M. Helix b, M.L. Louis b, A. Rochwerger b, G. Curvale b

Orthopedic Surgery Department, Laveran Military Teaching Hospital, Boulevard Laveran, 13013 Marseille, France
Orthopedic Surgery Department, Conception Teaching Hospital, 147, boulevard Baille, 13385 Marseille, France

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Summary
Background: Management of extensive proximal femur bone loss secondary to tumor resection or major osteolysis remains controversial. The possible options include a composite allograft/stem prosthesis, a modular type megaprosthesis or a custom-made megaprosthesis. Modularity allows versatility at reconstruction and avoids the delay required manufacturing a custom-made implant.

Hypothesis and type of study: A retrospective radiological and clinical study investigated whether a special reconstruction modular stem design (JVC IX™) would provide medium term success in the treatment of severe proximal femur bone loss.

Material and methods: Between 1995 and 2005, 23 JVC IX™ hip replacements were performed for severe segmental proximal femur bone loss. Etiology was: 13 cases of tumor resection, eight of extensive osteolysis secondary to femoral implant loosening, and two traumatic situations. Follow-up was annual. Functional assessment used the Musculo-Skeletal Tumor Score (MSTS), and implant survival rates underwent Kaplan-Meier analysis, with surgical revision (to replace or remove the implant) as the end point.

Results: All 23 patients (23 hips) were followed up for a mean 5.4 years (±3.7 yrs). Mean MSTS was 16.2 (max. = 30). All stems demonstrated good fixation at radiological assessment, except for one case of probable loosening in contact with a metastatic osteolysis. Four implants had to be revised: two for non-controlled infection, one for tumor extension, and one for stem fatigue fracture. At 10 years’ follow-up, implant survivorship was 81.5% (range: 62% to 100%).

Discussion: Severe proximal femur bone loss is a difficult situation to deal with, offering no ideal treatment option. Modular megaprostheses are salvage procedures. Their results at a mean 5.4 years’ follow-up are encouraging, and appear comparable to the ones obtained with alternative solutions (composite allograft/stem prostheses).

Type of study: Level IV retrospective, therapeutic study.

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* Corresponding author.
E-mail address: antoine_bertani@yahoo.fr (A. Bertani).

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Introduction

Management of extensive proximal segmental femoral bone loss secondary to tumor resection or major osteolysis remains controversial. Historically, the first reconstructions used allograft. Failure rates were high, due to typical allograft complications: infection, bone resorption, fracture and graft non-union [1,2]. The alternative attitude is prosthetic hip replacement, either by composite prosthesis (encased in an allograft) or by megaprosthesis [3,4]. The implant shows better mechanical resistance than with allograft, but the technique runs a risk of secondary loosening [5]. To the best of our knowledge, neither technique (composite or megaprosthesis) has proved preferable in terms of medium-term survivorship. Anract et al. [3] reported 77% 5-year survivorship in 20 composite prostheses and 73% for 20 megaprostheses. Farid et al. [5] reported 86% 10-year survivorship in both 20 composite prostheses and 52 megaprostheses.

Megaprostheses were at first monoblocks, available in a range of sizes, then custom-made, and latterly modular. The present X-ray and clinical study reports results for modular reconstruction megaprostheses (JVC IX™) in a series of 23 cases of severe loss of proximal femoral substance at a maximum 11 years’ follow-up.

Material and methods

Patients

This was a single-center multi-operator retrospective study of the modular JVC IX™ megaprosthesis (Fig. 1). Between January 1995 and January 2005, 23 hip replacements (23 patients) were performed, with none lost to follow-up. At last follow-up, 10 patients (43%) had died, but could be included in the analysis on the basis of their last clinical and X-ray data.

Over the study period, the technique of interest was indicated for femoral reconstruction after proximal femoral extremity resection secondary to tumor or trauma, and for femoral implant replacement due to endocortical osteolysis extending to the femoral stem (stage IV on Vives’ SOFCOT classification [6].

The 23 patients had a mean age of 65 ± 17.2 years, with a gender ratio of 0.3 (i.e., 5 male, 18 female). Indications for surgery comprised 13 tumor resections (56%), eight femoral revisions for severe osteolysis (35%), and two cases of trauma (9%). The 13 proximal femur tumors comprised four high-grade chondrosarcomas, four breast adenocarcinoma metastases, two osteosarcomas (including 1 in a context of fibrous dysplasia), one Ewing sarcoma, one plasmocytoma, and one epidermal amygdala cancer metastasis. The eight femoral revisions comprised seven cases of recurrent (n > 2) loosening and one Vancouver B3 periprosthetic fracture [7]. The two trauma cases were of complex trochanteric fracture in elderly osteoporotic patients with history of neoplasia, suggestive of pathological fracture.

Materials

The JVC IX™ stem is a femoral stem with collar, of constant length, giving a 200 mm anchorage in the distal femur. It is sealed using methyl methacrylate.

A modular diaphyseal or metaphyseal component was fitted to the femoral stem. Apart from the 30 mm metaphyseal component, which has a fixed neck, the other metaphyseal parts were adapted to a modular neck. The modular metaphyseal-epiphyseal component, corresponding to the resection level, had a mean height of 107 ± 45.2 mm.

A bipolar arthroplasty was fitted in nine cases (39%), and an acetabular implant in 14 (61%): seven uncemented fixed cups, four cups sealed into a reinforcement ring, and three dual mobility cups. Femoral head diameter was systematically 28 mm.

Surgical technique and postoperative course

All implants were made after parenteral injection of antibiotics. The approach was systematically anterolateral, with part of the greater trochanter fixed to the prosthesis shoulder by steel wire in ten cases (45%), and gluteal reinsertion in the other 13 (55%).

Postoperatively, contact weight bearing was allowed with limited active abduction for the first three weeks, to enable soft tissue healing.

Table 1  Clinical results.

<table>
<thead>
<tr>
<th></th>
<th>Group I: Tumor</th>
<th>Group II: Femoral revision</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSTS</td>
<td>17.5</td>
<td>13.8</td>
<td>16.2</td>
</tr>
<tr>
<td>SD: 9.2</td>
<td></td>
<td>SD: 6.8</td>
<td>SD: 8.6</td>
</tr>
<tr>
<td>Abductor test</td>
<td>3</td>
<td>2.6</td>
<td>2.9</td>
</tr>
<tr>
<td>SD: 1.1</td>
<td></td>
<td>SD: 1.1</td>
<td>SD: 1.1</td>
</tr>
</tbody>
</table>

MSTS: musculo-skeletal tumor score [8].

Assessment

On follow-up, patients were assessed annually on Enneking et al.’s Musculo-Skeletal Tumor Society score (MSTS), a lower-limb assessment adapted to tumor resection [8], and in terms of abductor counter-resistance force in lateral decubitus (max = 5). The MSTS provides a functional score on six items, scored 0 to 5 each (i.e., max = 30): pain, walking ability, gait handicap or limp, walking aids, overall function and emotional acceptance. Results were considered excellent for MSTS > 20, satisfactory for 10–20, and insufficient for MSTS < 10.

The X-ray analysis was carried out on the last images with the original implant fitted. We examined the presence and spread of radiolucency on frontal and lateral views. X-ray diagnoses of loosening were divided into three categories, following Harris et al. [9]: certain (obvious implant migration), probable (circumferential radiolucency without implant migration) and possible (radiolucency on at least 50% of the implant periphery).

Statistical analysis

Hips requiring revision and those in which the implant remained in place were compared to explore reasons for failure in terms of general examination findings, etiology, extensive radiolucency, resection height, and greater trochanteric vs. gluteal implant shoulder fixation. Results were also compared between groups I and II.

Comparison used $\chi^2$ or Fisher’s exact tests for qualitative variables according to application conditions, and the Mann-Whitney non-parametric test for quantitative variables. Survivorship was plotted following Kaplan-Meier, with a 95% confidence interval. Revision for implant replacement was considered as terminating implant survival.

Results

Clinical results

At a mean 5.4 ± 3.7 years’ FU, 19 implants (83%) were still in place. Mean abductor force was 3 ± 1.1, and mean MSTS 16.2 ± 8.6 (see Table 1).

On MSTS, results were excellent in seven hips, satisfactory in 10, and insufficient in six. All seven excellent results were in group I, and three had had greater trochanter or trochanter medallion reinsertion. Three of the six patients with insufficient results died with the implant in place; there were three implant infections after tumor resection, two iterative revisions in elderly patients (mean age, 75 years) with initially satisfactory results gradually deteriorating due to general deterioration in health status, and one complex trochanteric fracture in an elderly patient who died due to general complications three months postsurgery.

X-ray results

At last follow-up, there was one case of possible loosening associated with metastatic osteolysis (breast adenocarcinoma) at the distal third of the stem (group I), but no certain loosening in the other 22 cases. Nineteen patients (82%) showed stress-shielding osteolysis under cemented stem collars during the first year (Fig. 2); all these osteolysis were asymptomatic and non-evolutive.

Complications

Nine patients experienced at least one complication (see Table 2); the morbidity rate was 43.5%:

- four patients showed implant instability. Acetabular revision was performed in three patients in group II (2 antidislocation crescents and 1 dual mobility cup) and orthopedic treatment for one patient in group I. No recurrence of instability was observed in these cases, although
one patient in group II contracted a deep infection requiring implant replacement;

- deep infection was found in three patients. One (group I) was managed medically (antibiotherapy only) due to severely degraded general health status and died 1 month after initiation of treatment. The other two (group I and group II) were managed by implant removal and replacement;
- one Vancouver C periprosthetic fracture (group II) was consolidated by osteosynthesis;
- one patient (group I) experienced femoral stem fracture, requiring implant replacement;
- tumor recurred in two cases (group I): one periprosthetic fracture in a context of tumor recurrence in the distal quarter of the femur, with possible stem loosening, was managed by osteosynthesis; and the other fracture, managed by femoral implant revision, failed to consolidate and the patient died three years later;
- finally, one patient (group I) suffered early postoperative stroke and died within the year.

Reoperation with femoral implant replacement

Four implants (17%) were replaced during the mean 5.4 ± 3.7 years’ follow-up. In two cases, this was due to infection, as noted above (see Table 3) (Fig. 3):

- one deep infection occurred early after acetabular revision and was managed by 1-step implant removal and replacement. At 4 years’ FU, there was no recurrence of infection;
- one deep infection (group I) occurred late (at 4 years) secondary to dental abscess and was treated by iterative lavage and adapted antibiotherapy. Evolution was adverse, with non-controlled and badly supported infection. Disarticulation was performed 10.7 years post-surgery;

Figure 3 Example of a stem breakage. Neither mechanic nor metallurgic failure were identified.
one patient underwent revision for recurrence of tumor on the remaining femur, due to non-respect of the resection margins. Total femur implantation was performed on a total knee replacement. A subsequent infection was managed by iterative lavage and adapted antibiotic therapy. At 2 years’ FU, a chronic fistula required long-course antibiotic therapy.

• one patient (group I) experienced implant fracture 2.6 years postoperatively, at the junction between diaphyseal and metaphyseal reconstruction components. The implant was replaced, without further complications.

Only one of these four cases (the implant fracture) showed a satisfactory result for the revision, while the others were considered insufficient.

Statistical analysis

At 6 years’ FU, overall survivorship was 81.5% (62% to 100%). No significant impact on survivorship was found for any revision risk factors in terms of general examination findings, etiology, resection height, trochanteric reinsertion or complications.

Tumoral resection showed a non-significant trend ($p = 0.2$) towards giving better functional results than revision for femoral loosening. There were no significant differences in functional result according to abductor fixation technique.

Discussion

Surgical technique and material

In severe proximal femur bone-loss, surgical options are between composite prostheses or megaprostheses (modular or custom-made). Using allograft around the implant has the theoretical advantage of reconstituting bone capital, improving femoral anchorage (thereby reducing the incidence of femoral loosening), and achieving biological reinsertion of the abductor apparatus – which should in principle provide a better functional result [3,5].

The advantages of megaprostheses lie in their ready availability and easier implantation technique, and the avoidance of using human-derivative material. Megaprostheses were initially monoblocks; although these came in a range of sizes, adaptation to the exact bone-loss was suboptimal. Custom-made megaprostheses were then developed, but involved a manufacturing delay. More recently, modular megaprostheses appeared, providing a certain flexibility in resection (adjustment, freedom of choice, adaptability) thanks to peroperative modular assembly [2].

The choice of megaprostheses for complex pertrochanteric fractures is debatable, but here the aspect resembled metastatic fracture, and they were managed as such even though subsequent anatomopathological analysis proved negative. We agree with Wedin and Bauer [10] that implanting is less risky than osteosynthesis for proximal femur metastatic locations.

Figure 4 In this tumor case, partial conservation of the great trochanter enabled an excellent clinical and functional result.

Functional results

This was a heterogeneous series, and the results are hard to compare. There was a trend towards better functional results in the tumor resection group as compared to the femoral revision group, the former comprising younger patients without history of surgery.

In the tumor resection group, results were satisfactory (mean MST5, 17.5), but still lower than those of Menendez et al. [11], who reported a mean MST5 score of 22 at a mean 18 months’ FU for 96 modular megaprostheses, with the same etiology but excluding revision cases. The present results in the femoral revision group were poor, with a mean MST5 score of 13.8. Even so, we consider a large modular femoral stem as a salvage solution in case of iterative revision. Parvizi et al. [12] recommend using this type of implant in this indication only in elderly patients with a low level of functional demand.

Functionally, the various abductor muscle reinsertion techniques did not provide significantly different results. However, the three excellent results obtained with reinsertion of the greater trochanter or a trochanteric medallion (Fig. 4) lead us to consider this as an important point in improving MST5 score and abduction force. Indeed, the continuity of the abductor apparatus ensured by biological fixation of the muscles onto an allograft can account for the trend towards better functional results found with compound prostheses compared to megaprostheses [3,5]. Even so, neither Anract et al. [3] nor Farid et al. [5] reported significant differences between these two reconstruction groups, and one technique cannot be asserted to be better than the other from a functional point of view.

Dislocation

In the femoral revision group, the dislocation rate was 37.5% and instability was the main reason for revision, and is
indeed the most frequent complication following megaprosthetic reconstruction in non-tumoral etiologies [12], with dislocation rates ranging from 16% to 22% depending on the series [13,14]. To limit this risk, Parvizi et al. [12] recommend using a retention cup and postoperative bracing to immobilize the hip in abduction in case of iterative femoral revision. In our opinion, dual mobility cups could limit this complication, although to the best of our knowledge there have been no studies assessing this implant association in iterative revision.

In the tumor resection group, there was one episode of dislocation (dislocation rate = 7%). These results are comparable to those of Kabukcuoglu et al. [15], who reported an 11% dislocation rate in 54 megaprostheses for primitive tumor, with fixed-cup acetabular reconstruction. Tumor resection seems to involve a greater risk of instability than does iterative revision. Even so, we recommend using a large head (bipolar or intermediate reinforcement cup or dual mobility cup). Bipolar prostheses may be reserved to patients with short life expectancy, with dual mobility cups indicated in other cases. In young active patients, there is an issue of friction couple wear; the risk of implant instability then has to be set against that of accelerated wear with a dual mobility cup.

Infection

The overall infection rate in the present series was very high (12.5%) and comparable in groups I and II. In femoral revision, Haentjens et al. [13] had a similar infection rate of 16%. In tumor resection, infection rates vary from 3% to 13% according to the series [16,17,18], well below the 30% rate reported with allograft reconstruction [19]. There is little in the way of specific action to reduce this risk. Very controversially, Malawer and Chou [17] recommend systematic probabilistic antibiotherapy during postoperative immunosuppression in femoral revision.

Implant survivorship

At 10 years' follow-up overall survivorship was 81.5%, and 100% at 2 years. These results are comparable to those of Farid et al. [5], who reported identical 86% 10-year survivorship for both types of implant (20 composite prostheses and 32 megaprostheses). Menedez et al. [11] reported 82% 10-year survivorship for 96 modular megaprostheses.

In the present series, there were no cases of aseptic loosening. This may be due to advances in surgical techniques, or to implant design. If, however, the implants systematically survived longer than their bearers, it is to be borne in mind that this was probably due to the high rate of mortality in the first 3 years following implantation.

The rate of loosening may therefore rise over longer follow-up, especially as some implants were in young and active patients. In some studies the failure rate associated with loosening was 10% to 16% [16,20]; but they, like the present study, were biased by the heterogeneity of their recruitment, precluding satisfactory assessment of failure due to mechanical causes. In the present series, there was one case of implant fracture, with no mechanical or metalurgic explanation.

Conclusions

Severe proximal femoral bone-loss creates a difficult situation with no ideal treatment option. While the distal anchorage is the real weak point in reconstruction prostheses, the present study uncovered no sure loosening of the femoral stem at a mean 5.4-years' follow-up. Modularity optimized adaptation to the precise bone-loss, whatever the context (tumor or revision surgery). Modular megaprostheses represent a salvage solution, with encouraging medium-term results. They seem ideally indicated for extensive proximal femoral bone-loss in patients with limited life expectancy.

Conflict of interest

None.

References


