Femoral stem impaction grafting: extending the role of cement

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Femoral revision after cemented total hip replacement (THR) might include technical difficulties, following essential cement removal, which might lead to further loss of bone and consequently inadequate fixation of the subsequent revision stem.

Femoral impaction allografting has been widely used in revision surgery for the acetabulum, and subsequently for the femur. In combination with a primary cemented stem, impaction grafting allows for femoral bone restoration through incorporation and remodelling of the impacted morsellized bone graft by the host skeleton. Cavitary bone defects affecting meta-physis and diaphysis leading to a wide femoral shaft, are ideal indications for this technique. Cancellous allograft bone chips of 1 mm to 2 mm size are used, and tapered into the canal with rods of increasing diameters. To impact the bone chips into the femoral canal a prosthesis dummy of the same dimensions of the definitive cemented stem is driven into the femur to ensure that the chips are very firmly impacted. Finally, a standard stem is cemented into the neo-medullary canal using bone cement.

To date several studies have shown favourable results with this technique, with some excellent long-term results reported in independent clinical centres worldwide.

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Although the overall number of primary cemented total hip replacement (THR) procedures has fallen over the last few years in most countries, there will be a residual burden of revising cemented THR in future years, especially within the European area. In the United States of America, revision THR is projected to increase by 137% from 2005 to 2030, including uncemented as well as cemented implants.

The major goals in revision THR (RTHR) are to create a stable construct, preserve host bone, augment deficient host bone, provide a foundation for future surgery, and create a biomechanically restored hip. However, femoral revision after cemented THR is likely to include some technical difficulties, based on the need to remove the cement with consequent loss of bone, inadequate fixation, cortical perforation or even fractures.

Impaction allografting has been widely used in RTHR since it was first described for the acetabulum and subsequently for the femur. Femoral impaction grafting, in combination with a primary cemented stem, permits femoral bone restoration due to incorporation and remodelling of the impacted morsellized bone graft by the host skeleton. It was first performed and described in Exeter, England in 1987, using a cemented tapered polished stem in combination with morsilized fresh frozen bone allografts. The technique was refined by the development of specialised instruments, which have been supplemented by the Nijmegen group from Holland. To date, several studies have shown favourable results using this technique, with excellent long-term results in independent clinical centres worldwide.

Cavitary bone defects affecting the metaphysis and diaphysis, which lead to a wide or so called ‘drain pipe’ femoral canals are ideal indications for this technique, especially in young patients who are prepared to comply with the subsequent rehabilitation process (Fig. 1). Impaction grafting can also be used where there has been load transfer of a previous long cementless, distally fixated stem, to provide proximal fixation.

Generally, the technique creates a new endosteal surface to host the cemented stem by reconstruction of the cavitary defects with impacted morsilized bone graft. This construct achieves primary stability and restores the bone stock. It has been shown that fresh frozen allografts show superior mechanical stability than freeze-dried allografts and incorporation of these grafts has been described to be as high as 89%.
Surgical technique
After removal of all previous cement and debridement of intramedullary soft tissue, a distal, appropriately sized, centralising cement plug is inserted into the femoral canal. Allograft bone chips from fresh-frozen femoral heads are introduced into the femoral canal using tapered rods of increasing diameters. To impact the allograft bone chips into the femoral canal, a prosthesis dummy mimicking the dimensions of the definitive cemented stem is driven into the proximal femur over a central wire (Fig. 2). The authors currently prefer to create bone chips of 1 mm to 2 mm size using a mill. Larger size pieces, as for instance produced by hand, might prevent adequate filling of small gaps causing fractures due to higher local stresses during the impaction process. It is important to remove the osseous fat from the grafts before impaction, to allow adequate cement penetration and therefore prolonged hot water irrigation of the graft prior to implantation.

It is also important that the morsilised bone chips are very firmly impacted. This risks fracturing the residual femoral shaft, thus when the shaft is clearly weak or defective, the proximal femur should be reinforced proximally with wire mesh, cerclage wires and/or plates to withstand
the forces when the graft is impacted.\textsuperscript{6} The impaction should be repeated until any gap between the dummy prosthesis and the cortical bone is filled (Figs 3 and 4).

Finally, a standard femoral stem is cemented into the neo-medullary canal using low viscosity bone cement. The cement mantle is important as it acts as the distributor of force between the stem and the bone graft, and seals the stem. Cementing of the final original shaft has to be carried out very gently, with slow insertion of the implant, creating a cement mantle of at least 2 mm, which is associated with a favourable results.\textsuperscript{8}

Rehabilitation
Immediate mobilisation is recommended, however post-operative care usually includes touch down weight bearing for six to eight weeks, followed by four to six weeks of gradually increased weight bearing, with a total of 12 weeks on crutches. An alternative physiotherapy pathway has been reported, ranging from partial weight bearing for six weeks followed by weight bearing for another six weeks, as tolerated.\textsuperscript{9}

Contraindications
Contraindications include extended femoral bone loss, or when the amount of total graft is extensive, a history of previous periprosthetic joint infection or noncompliance of the patient, which is essential especially during the partial weight bearing phase.\textsuperscript{9}

Complications
These include mainly intra-operative femoral fractures due to the force required to impact the allograft bone. Subsidence of tapered polished implants might be related to cold flow within the cement mantle, however this could also be related to cement mantle fractures, leading to early failure. The incidence of the most common complications related to femoral impaction bone grafting is reported as 5% to 12% for peri-prosthetic fracture, 3% to 4% for hip dislocation and 0% to 2.5% for peri-prosthetic joint infection.\textsuperscript{8}

Outcomes
Survivorship with an defined endpoint as any femoral revision after ten year follow up, has been reported by the Exeter group at over 90%. Reported survivorship for revision defined as aseptic loosening, is above 98%.\textsuperscript{9,10} Over the last years, various other authors and institutions have reported similar excellent survivorships above 90% after ten years.\textsuperscript{8,10} In addition, a long term follow up by the Swedish arthroplasty registry in more than 1180 patients, reported a cumulative survival rate of 94% after 15 years.\textsuperscript{19}

Conclusion
Impaction grafting might technically be more challenging and time consuming than cementless fixation techniques, however it enables a reliable restoration of bone stock, especially after a cemented primary fixation, which might become particularly important if further revision is required.

References

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