Incidence of infection with the use of non-irradiated morcellised allograft bone washed at the time of revision arthroplasty of the hip

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Implantation of allograft bone is an integral part of revision surgery of the hip. One major concern with its use is the risk of transmission of infective agents. There are a number of methods of processing allograft bone in order to reduce this risk. One method requires washing the tissue using pulsed irrigation immediately before implantation. We report the incidence of deep bacterial infection in 138 patients (144 revision hip arthroplasties) who had undergone implantation of allograft bone. The bone used was fresh-frozen, non-irradiated and pulse-washed with normal saline before implantation. The deep infection rate at a minimum follow-up of one year was 0.7%. This method of processing appears to be associated with a very low risk of allograft-related bacterial infection.

Allograft bone is commonly used in revision arthroplasty of the hip to restore bone stock. Clear guidelines for its retrieval and storage in the United Kingdom are laid down by the British Association of Tissue Banking, although no specific recommendations exist for its processing. There is a wide variation between orthopaedic surgeons in how the allograft is prepared before use.

Major concerns are the risk of disease transmission from the donor and contamination at retrieval or during processing. A number of techniques have been used by bone banks in order to reduce these risks. These include freeze-drying with or without gamma-irradiation, gamma-irradiation alone, exposure to ethylene oxide and various methods of washing. Any processing of bone within a bank requires subsequent irradiation, a procedure which may affect the material properties of the tissue. However, it is not clear whether this alters the outcome, either in relation to infection or the durability of the construct. Robinson et al suggested that the use of irradiated bone may have been responsible for their poor results of femoral impaction grafting.

We believe that thorough washing of the bone immediately before implantation reduces the risk of bacterial cross-contamination and avoids the necessity for irradiation. We describe the results of a retrospective study of the incidence of infection with the use of non-irradiated, morcellised allograft bone washed at the time of surgery in revision arthroplasty of the hip.

Patients and Methods
Between 1995 and 2002, we performed 144 revision hip arthroplasties with impaction bone grafting in 138 patients. There were 62 men and 76 women with a mean age at time of surgery of 67 years (27 to 85). The reasons for revision were aseptic loosening of both components (56 hips), aseptic loosening of the acetabular component (43 hips), aseptic loosening of the femoral component (27 hips) while the remaining 18 procedures were undertaken for either recurrent dislocation or periprosthetic fracture associated with aseptic loosening. The acetabulum alone was grafted in 99 hips, the femur alone in 23, and both in 22. Six patients also had allograft strut augmentation. The diagnosis at the time of the primary hip arthroplasty was osteoarthritis in 129 patients (93%), inflammatory arthritis in five (4%) and failure of previous fixation of a fracture in four (3%). The index arthroplasty was the first revision in 139 (97%) hips. Revision arthroplasties performed for infection were excluded from this series.

The allograft bone was provided by the Leicester Bone Bank. Morcellised bone was retrieved from primary arthroplasties of the hip and strut bone from cadaver donors. The bone was stored according to the guidelines laid down by the British Association of Tissue Banking. The method used to assess bacterial contamination at the time of retrieval has been described previously. The Leicester Bone Bank irradiates any femoral head which is deemed to
be contaminated according to this methodology prior to its use. However, in this case series none of the femoral heads used had a positive microbiological culture at retrieval.

The allograft femoral heads were thawed in the operating theatre at room temperature for one hour before use. Bacterial swabs were taken and the bone was then milled after removal of any residual soft tissue and sclerotic subchondral bone. Preparation was undertaken with a pneumatic mill (Lere Mill; DePuy Ltd, Leeds, UK) producing bone chips between 2 and 5 mm in size. The chips were then placed in a standard metal sieve and irrigated with normal saline delivered as pulsed lavage at a pressure of 7 bar (Micro Aire 4740; Wright CremaScoli Ortho Ltd, Chester, UK). No antibiotics were used in the irrigation solution. For the first part of the series involving most of the hips, we used saline at room temperature. Latterly, the saline was warmed to 60°C in order to provide more rapid cleansing as the fatty marrow melted. The bone chips were washed until all visible blood and marrow products had been removed.

The technique of impaction grafting was as described by Gie et al,7 but modified for use with the Charnley-Elite Plus instrumentation and prostheses (DePuy Ltd, Leeds, UK). For the acetabular side the impacted bone was used either with a support cage and a cemented component, or a cementless component alone.

All patients received prophylactic antibiotic cover with a third generation cephalosporin administered on induction of anaesthesia, with two further post-operative doses.

After discharge from hospital, the patients were followed up at six weeks, six months and one year post-operatively, and annually thereafter. A radiograph was taken on each occasion, apart from the six-week follow-up. At each visit, evidence of infection was actively sought. This involved obtaining a history of pain, inspection of the wound and annually thereafter. A radiograph was taken on each occasion, apart from the six-week follow-up. At each visit, evidence of infection was actively sought. This involved obtaining a history of pain, inspection of the wound and seeking radiographic changes such as a periosteal reaction, new bone formation or endosteal irregularity. Any suspicion of infection prompted the measurement of the inflammatory markers (C-reactive protein and plasma viscosity). We only included patients with a minimum follow-up of one year since we felt that any deep infection, as a result of allograft transmission or contamination, would have been evident either clinically or radiographically by then.

Results

There were no patients lost to follow-up although seven died from unrelated causes within one year of operation. The mean period of follow-up was four years (1 to 8) with a mean of 1.7 femoral heads (1 to 5) used per procedure. Four (2.9%) patients developed a superficial wound infection in the early post-operative period; all were successfully treated with a standard course of systemic antibiotics.

The culture swabs from grafts at the time of implantation were not available for 14 patients (10%). Of the 124 swabs available from patients at the time of implantation, 107 (86%) were negative and 17 (14%) were positive. The organisms which were grown are shown in Table I. The majority of positive swabs grew organisms of low pathogenicity with only three growing organisms of high pathogenicity. None of the patients with a positive swab at the time of implantation developed a deep infection.

Only one (0.7%) patient developed a deep infection with methicillin-resistant Staphylococcus aureus (MRSA) after acetabular grafting. This patient had undergone a secondary evacuation of a haematoma following primary hip arthroplasty. The infection was identified from the bacteriological specimens obtained at the time of excision arthroplasty. The source of infection was unclear. All swabs from the graft implanted at the time of surgery were negative. At the time of this operation the treating hospital did not operate an MRSA screening policy, so it is likely this was a hospital-acquired infection.

Discussion

The number of reported incidents of disease transmission after the implantation of allograft bone has been low, given the large number of grafts implanted worldwide.5,9 The American Association of Tissue Banks10 and the British Association of Tissue Banking1 have laid down strict guidelines to ensure continued good practice. However, it is important that bone banks and surgeons continue to work together to further reduce the risks of using allograft, particularly with the emergence of previously unknown viruses and other infective agents such as prion-related proteins.

Debate continues as to how best to process allograft bone before use. Ideally, this should render the tissue safe from disease transmission but without compromise to its structural integrity. Irradiation reduces the risk of bacterial transmission and is also known to inactivate the HIV virus at a relatively high dose.11,12 Both freeze-drying13 and irradiation,3,4 either alone or in combination, have been shown to affect the structural integrity of bone, although the clinical relevance of this is not proven. Chemical methods, such as the use of ethylene oxide, preserve integrity but may have toxic effects both for product handlers and recipients.14 Reducing the risk of viral transmission still depends on effective serological testing of the donor.

Mechanical methods, aimed at removing the blood and marrow content of the bone, have been shown to reduce the bacterial contamination.15 Additionally, the removal of fat and marrow fluid produces a stronger, compacted graft which is more resistant to shear.16 However, because of the risk of contamination of the graft at the time of processing within a bone bank, it is necessary to irradiate the tissue sec-

### Table I. Positive culture swabs at the time of graft implantation

<table>
<thead>
<tr>
<th>Micro-Organism</th>
<th>Number of times cultured</th>
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<tbody>
<tr>
<td>Staphylococcus epidermidis</td>
<td>2</td>
</tr>
<tr>
<td>Faecal streptococcus</td>
<td>12</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>2</td>
</tr>
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Number of times cultured
ondarily. In order to avoid this we employed a thorough mechanical cleansing of the bone at the time of implantation. Schreurs et al\textsuperscript{17} and Pekkarinen et al,\textsuperscript{18} using impacted bone in revision hip arthroplasty, found infection rates of 3.3\% and 4.4\%, respectively. However, their handling of the bone immediately before implantation was not described. Using unwashed non-irradiated bone, the Exeter group had an infection rate of 2.2\% in a series of 226 femoral impaction grafts.\textsuperscript{19} Sutherland et al\textsuperscript{2} reported a 12.2\% rate of infection in a group of patients receiving non-irradiated bone from their bone bank.

The recent report of the transmission of variant Creutzfeld-Jakob disease through blood transfusion from a donor who subsequently developed the disease indicates that transmission between humans is possible.\textsuperscript{20} There are no current guidelines for the processing of allograft bone to reduce the risk of transmission of variant Creutzfeld-Jakob disease. Although the variant Creutzfeld-Jakob disease infectivity of bone matrix itself is unknown, it is likely that any transmission would occur through the blood and marrow products within the bone. Consequently, removal of these should reduce the risk of developing the disease. This is currently being investigated in laboratory studies. It is unclear whether the risk of transmission of variant Creutzfeld-Jakob disease from bone can be reduced by other methods of processing in current use. Prion proteins, for example, are only marginally affected by high doses of radiation.\textsuperscript{21}

Despite these concerns, our rate of bacterial infection of less than 1\% would indicate that mechanical washing of allograft bone at the time of implantation is effective in reducing the risk of bacterial infection while simultaneously maintaining the structural integrity of the allograft material.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


