Bone & Joint

Focus On

Bone graft substitutes in oncology, paediatrics, and hip arthroplasty

After blood, bone is the second most common transplanted tissue with an estimated 2.2 million grafting procedures annually worldwide. Autologous bone graft is considered by many authors to be the gold standard for bone regeneration; however, it can be associated with patient morbidity and significant complication rates, ranging from 8.6% to 20.6%. A limitation of autograft is that it may not provide the quantity of graft required for specific clinical applications. Cadaveric allograft has limitations, including the risk of disease transmission, limited availability, and denaturing of proteins and osteoinductive factors caused by the sterilisation process. There is a growing need for commercially available, clinically effective bone graft substitutes in all subspecialties of orthopaedic surgery. This short review will focus on bone graft substitutes for oncology (benign bone tumours), paediatrics ( unicameral bone cysts), and hip arthroplasty.

Benign tumours of bone and unicameral bone cysts

Bone graft substitutes, either alone or in combination with biological material, have been reported for the treatment of medium to large metaphyseal defects for benign bone tumours and bone cysts. Siegel et al reported on 51 patients with benign bone tumours treated with the combination of beta-tricalcium phosphate and osteoprogenitor cells from bone marrow aspirate. At six months post-operatively, all implanted grafts demonstrated radiological features identical to the surrounding cancellous bone. At one year, all patients were asymptomatic. Trabeculation and resorption rates were similar and were not associated with the size of the lesion.

El-Adl et al reported on 34 patients with benign bone lesions treated with hydroxyapatite/tricalcium phosphate composite bone graft with autogenous bone marrow aspirate. At 19.9 weeks, 70.6% of patients demonstrated substantial healing, 26.5% demonstrated partial healing and there was one local recurrence. A total of 31 patients had no pain, and there were no pathological fractures. The rate of bone healing was directly related to the size of defect after curettage. Shibuya et al reported on 62 patients with benign bone tumours filled with hydroxyapatite and bone graft. At 7.9 years 81% of patients showed ‘effective’ fill of defect. Calcium sulphate can be used safely in benign metaphyseal bone defects, but it has a quicker resorption rate with more inconsistent results.

Faour et al noted that the majority of recent authors have opted for synthetic-based materials alone or in combination with bone marrow aspirate. Biphasic macroporous ceramic bone graft substitutes appear effective in the treatment of benign bone lesions. The addition of osteoprogenitor cells from a bone marrow aspirate may accelerate bone healing. There are no studies demonstrating the superiority of bone graft substitutes over morcellised cadaveric allograft for the filling of benign metaphyseal defects.

Evidence-based guidelines to assist the surgeon in choosing the appropriate graft substitute for a particular clinical application are lacking.

Paediatrics

Although there are many approaches to the treatment of paediatric unicameral bone cysts, recent studies have evaluated disruption of the cyst wall and injection of a bone graft substitute. Thawrani et al reported a healing rate of 85% in 13 benign bone cysts treated with an endothermic calcium phosphate cement injected percutaneously. Mik et al described 55 patients who were treated for unicameral bone cysts with calcium sulphate pellets. At a mean follow-up of 37 months, 80% of patients had a complete or partial response after one treatment, and the remaining 20% required a secondary procedure.

Joeris et al reported on 23 patients treated with percutaneous tricalcium sulphate, with a rate of healing of 96%. Another study reported on 13 patients treated with calcium phosphate pellets, with all defects healing in a mean of 13.4 weeks.

Hou et al reported on several modalities in the treatment of unicameral bone cyst. The highest healing rate (92%) was demonstrated with a multimodal approach including curettage of cyst, ethanol cauterisation, ablation of cyst with an impactor, calcium sulphate pellets, and placement of a screw.

Donaldson and Wright commented that the lack of clear patho-aeiology has impeded the development of simple bone cyst treatment. Although multimodal treatment is an emerging trend, steroid injection of the cyst is the only evidence-based treatment based on a randomised controlled trial.

Revision hip arthroplasty

A major challenge in revision hip surgery is addressing loss of bone stock on either the femoral or acetabular side. Loss of bone stock is often treated with autograft or cadaveric allograft, often with impaction grafting techniques. There is a paucity of long-term literature on bone graft substitutes in revision hip surgery with no randomised controlled studies to guide clinical practice.

Studies generally have small numbers enrolled and are too short to evaluate implant survival. A recent systematic review by Beswick and Blom identified seven studies reporting outcomes for bone graft substitutes as an expander to allograft, and six studies using bone graft substitute exclusively. Calcium phosphate ceramics (including hydroxyapatite and tricalcium phosphate) were utilized in 11 studies and...
glass ceramic in two studies. Studies ranged from six to 72 patients and mean follow-up from 1 to 13 years.

Blom et al reported a prospective cohort study on 43 consecutive patients undergoing acetabular revision using a biphasic porous ceramic bone substitute with 1:1 mixture of bone chips. At mean follow-up of 24 months, there were no revision or implant failures. McNamara et al reported on 50 hips undergoing acetabular reconstruction with porous hydroxyapatite bone substitute and allograft. At a mean follow-up of 60 months, clinical survival was 100% with evidence of incorporation in 60% of hips.

Aulakh et al compared outcomes of morcellized allograft alone and in combinations with solid particulate hydroxyapatite in 65 patients. At 13 years the authors noted similar long-term survival and function. A study of 45 revision acetabular cases using granulate glass ionomer cement with allograft showed loosening of ten components at a mean of 30 months.

Non-gllass ceramic bone graft substitutes show promise as an alternative to or in addition to cadaveric bone graft. The literature does not support the use of glass ceramic bone substitutes at this time for revision hip arthroplasty.

J. M. Werier MD, FRCSC
Division of Orthopaedic Surgery
The Ottawa Hospital and the University of Ottawa
Canada
E-mail: jwerier@ottawahospital.on.ca

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References

J. M. Werier
Division of Orthopaedic Surgery
The Ottawa Hospital and the University of Ottawa
Canada

E-mail: jwerier@ottawahospital.on.ca

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