THE REVISION HIP

Porous metal augments

BIG HOPES FOR BIG HOLES

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The conventional method for reconstructing acetabular bone loss at revision surgery includes using structural bone allograft. The disadvantages of this technique promoted the advent of metallic but biocompatible porous implants to fill bone defects enhancing initial and long-term stability of the acetabular component. This paper presents the indications, surgical technique and the outcome of using porous metal acetabular augments for reconstructing acetabular defects.

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Most acetabular revision operations are currently performed using a hemispherical acetabular component.1 However, when there is a significant amount of segmental and/or contained bone loss such that the initial stability or long-term fixation of the acetabular component cannot be achieved, augmentation is indicated. The conventional method of using either minor (< 50% of the acetabulum) or major (> 50% of the acetabulum) column structural allografts has disadvantages. The risk of disease transmission is low but structural support to the acetabular component and any augment) with the host bone contact, defined as the sum of the contact area of both porous implants (acetabular component and any augment) with the host bone. Since a certain amount of contact of the implant with host bone is considered essential for long term stability of the acetabular component, a porous augment will enhance this stability through increasing the contact area. It is to be noted that the augment-bone contact area is often some distance from the acetabular component proper. This in effect extends the usable bone available to sustain acetabular stability.

Surgical technique

After exposure of the acetabulum through the surgeon’s preferred approach, the old component, surrounding debris and fibrous tissue should be removed, careful not to compromise further the already defective bone stock. After exposing the acetabular floor, gentle reaming at the correct anatomical position should be performed to prepare the bony bed. The final classification of bone defect is best done at this stage. The authors use their own classification based on the percentage of acetabular bone that has been lost (Table I).5

If the circumference of the acetabular rim is intact, any bone loss will be considered contained. In the case of a segmental defect, the authors use the trial acetabulum to classify the defect. The bone defect is quantified based on the percentage of acetabular bone that has been lost (Table I).5

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(i.e. trabecular metal (TM), Zimmer, Warsaw, Indiana) is recommended to ensure sufficient initial stability and potential for subsequent bone ingrowth.

Types III and IV defects are most frequently associated with the use of augments. Enhancing the stability of the cup with structural support either with allograft bone or an augment is usually necessary when facing a defect of > 40%, or when the press-fit of a TM cup cannot be achieved. The potential for bony ingrowth by the host bone is a requirement when planning to use an augment, otherwise non-biological alternatives such as conventional metal cages should be considered.

Selection of the appropriate augment is based on the size of the defect and the geometry of the adjacent pelvic bone. Our experience has been with trabecular metal (TM) augments and the rest of this text will refer to these products.

The augment can be placed in any position or orientation to improve the initial stability of the construct, but there are some common situations. Firstly, a minor or major column defect that is surrounded by an intact rim of acetabular bone within 30 mm of the outer perimeter of the trial acetabular cup, which is the maximum thickness of augments normally available. One or two conventional augments can be used in a ‘wedge’ configuration to fill a similarly shaped defect (Fig. 2). The appropriate diameter of the augment is chosen based on the internal diameter of the segmental defect of the acetabulum, which is usually equal or smaller relative to the trial cup diameter. Our preference is to fix the

<table>
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<tr>
<th>Type</th>
<th>Defect</th>
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<tbody>
<tr>
<td>I</td>
<td>No significant loss of bone stock</td>
</tr>
<tr>
<td>II</td>
<td>Contained loss of bone stock (cavitary)</td>
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<tr>
<td>III</td>
<td>Uncontained loss of bone stock involving &lt; 50% of acetabulum (minor column defect)</td>
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<tr>
<td>IV</td>
<td>Uncontained loss of bone stock involving &gt; 50% of acetabulum (major column defect)</td>
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<tr>
<td>V</td>
<td>Pelvic discontinuity with uncontained loss of bone stock</td>
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augment first, kept in place with the guide of the trial cup. As many screws as possible (at least two) should be inserted to fix the augment before inserting the TM cup.

Secondly, a severe contained medial defect is faced with an intact but thin peripheral rim which would not be sufficiently supportive for a cementless cup. A conventional augment could be inserted into the defect as a foundation in order to provide medial support to the overlying acetabular shell (Fig. 3).

Thirdly, when a minor column defect is present with no bony rim available within 30 mm of the trial cup but with a supportive bony bed, a conventional augment can be used in the opposite way of the ‘wedge’ configuration. The flat surface of the augment is placed medially against the ilium just above the trial cup (Fig. 4), and secured to the bone with three screws. This ‘flying buttress’ configuration is assumed to be supportive to the cup as only a moderate amount of shear force on the augment is expected with a minor column defect. A thicker augment is preferable to obtain as broad a contact as possible with the underlying bone.

Finally, a major column defect is associated with lack of bony rim within 30 mm of the trial cup. We feel that even the strongest conventional augment in ‘flying buttress’ configuration would not have enough host bone contact to resist the powerful shear forces exerted by the uncovered element of the acetabular component. Buttress augments in this situation aim to maximise the bone contact area and stability of the construct as a whole. In case of a straight superior defect, a straight buttress (figure of seven) (Fig. 1) augment is desirable. When the defect is mainly in the anterior or posterior part of the trial acetabular component, an anterior or a posterior column buttress augment is...
preferable (Fig. 1b). The corresponding part of the ilium should be exposed in order to seat the augment. If a gap persists between the flat part of the augment and the ilium, a shim augment can be used (Fig. 5). The abutting surfaces of the shim and the buttress augment are then filled with bone cement. Any remaining contained defects should be filled with particulate bone graft.

The use of more than one augment in a single reconstruction may be required, especially when a major column defect is to be addressed using ‘wedge’ rather than ‘buttress’ augments; they can be placed in wedge configuration, either side by side or at opposing poles of the acetabulum, based on the location of the bone defect. The selected augment frequently is not a perfect match to the defect and some adjustments will be necessary. Minor mismatches could be addressed by burring the bony bed to accommodate the augment. Major discrepancies, however are usually corrected by removing the corresponding portion of the augment using a rongeur. We routinely pack some morsellised bone graft into the windows of the augment to encourage bone remodeling.

The augment will not provide full support for the cup and metal debris may be released through fretting if they are not cemented. The ‘effective host bone contact’ concept is valid only if there is a reasonable unity of the construct comprised of the porous cup and the porous augment. The mechanical validity of this combined construct remains to be verified, but as most of the forces between cup and augment are compressive, the authors feel the cement is capable of accommodating these forces. We have modified the
original technique recommended by the manufacturer, including the application of bone cement to the interface of cup and augment at the time of insertion of the TM cup. A small amount of cement is placed between the cup and the augment while cementing the liner to the revision shell. A revision TM shell is preferable when using an augment, as the surgeon has some flexibility in positioning a revision cup as minor mal-positions can be compensated for by adjusting the position of the liner within the shell. Extra screw holes can also be drilled through the shell material to the best available host bone. This type of porous tantalum revision cup possesses a lower modulus of elasticity that is biomechanically advantageous.

The porous acetabular component is fixed with a minimum of three screws. It is beneficial to have some screws inserted superiorly and postero-superiorly into the pelvic columns, and an additional ischial screw to provide stability for the cup in as many planes as possible. If the best bone available to fix the screws is out of alignment with the manufacturer’s provided screw holes, new holes can be made with a metal burr when using a revision TM shell. However, in these circumstances, some metal debris will inevitably be released and, the long term consequence is as yet unknown. Occasionally it is possible to strengthen the construct further by aligning one screw hole of the cup with the augment window so that a screw can go across both components into the host bone.

Porous augments have been used in combination with alternative acetabular components to ultra-porous cementless shells. Recently, good results were reported for impaction grafting as well as application of combined cemented cups and porous augments. The authors have frequently used TM augments in association with cup-cage constructs and conventional cages, and the use of porous augments can also be justified in some primary hip replacements. One common indication is when there is a significant segmental defect in acetabulum in an elderly patient, especially in the absence of a usable femoral head for autograft.

Post-operatively, the patients are advised to restrict weight bearing for eight to 12 weeks based on the stability of fixation and the amount of bone loss (less for the wedge configuration and more for other configurations). Patients are followed regularly and radiographs are evaluated regarding signs of cup or augment loosening, including the appearance of lucent lines around the implants, changes in position of the components and progressive metal debris shedding; a sign of friction between a loose cup and a stable augment. Valid radiological criteria for augment loosening remains to be defined.

Outcomes

The use of porous augments in acetabular revision has been rewarding in short and mid-term follow-up. In the five series reported so far, 154 augments (147 conventional and seven buttress augments) were used in 149 hips. We excluded the reports on the mixed results of acetabular reconstructions with and without augments. The mean follow up of these studies have ranged from 32 to 64.5 months and a total of seven aseptic failures were reported. Most recently, Abolghasemian et al reported on the first 34 revisions performed with the use of TM cups and augments in our institution. At a mean follow-up of 64.5 months, there were three aseptic and one septic loosening. There were no aseptic failures in cases with minor column defects treated by augments in either ‘wedge’ or ‘flying buttress’ configuration, and only one of the 14 cases with major column defects developed aseptic loosening.

This is a better outcome compared with conventional methods used to treat acetabular bone loss with the use of structural bone allograft, where mid-term failure rates of around 20% and 50% have been reported for minor and major column allografting techniques respectively. The other two aseptic failures were in patients with pelvic discontinuity. No substantial distraction had been applied to the discontinuity sites, and the authors concluded that using a TM cup and augment for treating pelvic discontinuity was not recommended. However, studies from elsewhere showed promising results regarding use of a TM cup with and without augment for pelvic discontinuity if applied with 6 mm to 8 mm of distraction.

Future perspectives

Our knowledge of augments and their proficiency in acetabular revision is limited by several factors. There is no long term study yet available and what we have is mostly on the use of conventional augments with no distinction being made between the different configurations, and there is very little data on results of restrictors and buttress augments. Augment-cage and augment-cup-cage composites although being used in some centres, have not been evaluated yet. Biomechanical studies will be of help to assess the strength of cement in unifying the cup and augment, the possibility of fatigue failure of augments under the compressive forces exerted by the adjacent cup, and the distinctive biomechanical features of different augment shapes and configurations.

Some concerns remain unresolved regarding the use of porous augments. They do not restore bone stock and may cause even more bone loss if they have to be removed during revision surgery. The metal debris released at the time of creating new screw holes through the porous shells, or those created by fretting between the augment and a loose cup might cause local and systemic adverse reactions. Consequently, we still tend to use bone allograft in young patients with high probability for another revision. However, considering the versatility they offer to the surgeon and the favourable short- and mid-term outcomes reported so far for TM augments, their use will become more frequent in the immediate future until we know more about their long-term performance.

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.
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References