REVISION ARTHROPLASTY USING AN ANTI-PROTRUSIO CAGE FOR MASSIVE ACETABULAR BONE DEFICIENCY

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Revision hip arthroplasty in patients with massive acetabular bone deficiency has generally given poor long-term results. We report the use of an ‘anti-protrusio cage’, secured to the ischium and ilium, which bridges areas of acetabular bone loss, provides support for the acetabular socket, and allows pelvic bone grafting in an environment protected from excessive stress.

Forty-two failed hip arthroplasties with massive acetabular bone loss were revised with the Burch-Schneider anti-protrusio cage and evaluated after two to 11 years (mean five years). There was failure due to sepsis in five hips (12%) and aseptic loosening in five (12%); the remaining 32 hips (76%) showed no evidence of acetabular component failure or loosening.

Severe deficiency of pelvic bone stock is a major problem in the increasing number of patients who require revision of a failed hip arthroplasty. This loss of bone stock results from earlier bone removal to accommodate a prosthesis and cement, lysis caused by wear particles and, most importantly, by motion between the original socket and the pelvis. Loss of acetabular bone makes it difficult to place the new component in a biomechanically optimal location and on bone of sufficient strength and quality to provide long-term secure fixation.

Under the system of D’Antonio et al (1989) for classifying acetabular bone deficiencies, most hips for revision have mild or moderate deficiency which may be segmental (type I), cavity (type II), or combined (type III). Satisfactory reconstruction of these hips is usually possible with standard acetabular components (Young, Hastings and Schatzker 1985; Harris, Krushell and Galante 1988; Hedley, Gruen and Ruoff 1988; Müller and Jaberg 1990), with or without small to moderate bone grafts (Harris, Crothers and Oh 1977; Gross et al 1985; Trancik et al 1986; Oakeshott et al 1987; McGann, Welch and Picetti 1988; D’Antonio et al 1989). A few failed hip arthroplasties, however, have massive deficiency of bone stock, usually of type III, and cannot be treated satisfactorily by these methods.

The management of massive loss of bone stock has been by a variety of methods. These have included resection arthroplasty (Jasty and Harris 1990) and reconstruction by filling the bone defect with a large amount of acrylic cement (Salvati, Bullough and Wilson 1975; Jasty and Harris 1988; Eftekhar and Nercessian 1989). More recently, the use of bipolar prostheses, custom prostheses, massive bulk allografts (Harris et al 1977; Oakeshott et al 1987) and uncemented acetabular components has been proposed, but each has inherent disadvantages. Bipolar prostheses used with acetabular bone grafts may be subject to high rates of migration (Wilson et al 1989; Brien et al 1990). Custom-made prostheses should theoretically fit well to the host bone, but do not always match the defects found at surgery. Massive bulk allografts provide structural support which can heal to host bone, but their long-term durability remains uncertain (Jasty and Harris 1990). Uncemented acetabular components may allow biological fixation of the prosthesis to native bone, but even extra-large hemispherical components may fail to bridge a large superior to inferior defect. Small, superiorly-placed uncemented components may cause leg-length discrepancy and increase the risk of dislocation. The long-term results of these new techniques are not yet known.

At our centre massive pelvic bone loss has been managed since 1975 by using an ‘anti-protrusio cage’ (APC: Protek AG, Berne, Switzerland; Fig. 1). The APC is larger than the ‘protrusio shell’ of Oh and Harris (1982) or the ‘acetabular reinforcement ring’ (Müller 1981;
Müller and Jaberg 1990), which are useful for smaller defects or poor acetabular bone quality. Several designs of APC have been used at different centres (Kerboul 1975; Gross et al 1985; Schneider 1989); the APC that we have used was designed by Burch in 1974 and subsequently modified by Schneider. It is made of rough-blasted titanium, with a superior flange resting against the ilium, and an inferior flange which is driven into the ischium. Further fixation is provided by multiple bone screws (Fig. 2). The polyethylene inner socket is fixed to the APC by acrylic cement.

The APC provides a large contact area between the implant and remaining pelvic bone, distributing joint forces over a large area, and theoretically decreasing the likelihood of implant migration (Oh and Harris 1982). It also allows the treatment of bone deficiency by morsellised or bulk bone grafts placed deep to it and thus protected from forces which might contribute to graft failure.

Reports of the successful use of the APC (Gross et al 1985; Young et al 1985; Schneider 1989) and a similar device designed by Kerboul (Hedde et al 1986; Postel and Courpied 1986; Postel 1989) have appeared in the literature. To our knowledge, however, a comprehensive study of the longer-term performance of these devices has not been published. Our aim was to evaluate the results of using the APC to manage massive acetabular bone deficiency in revision hip arthroplasty.

**PATIENTS AND METHODS**

The APC has been used by the senior author in all revision arthroplasties with massive acetabular bone deficiencies since 1975, and the Maurice E. Müller Documentation Centre (Berne, Switzerland) provided a data base of 42 such cases with a minimum two-year follow-up. Until 1982, acrylic cement had been used to fill bone deficiency beneath the APC; subsequently, such deficiencies have been filled by morsellised bone grafts. Clinical records up to the latest follow-up and serial radiographs were examined.

The 42 anti-protrusio cages were placed in 27 women and eight men. Three patients had bilateral APCs, one patient had a second bilateral operation, and one had a repeated unilateral implantation. The average age at operation was 61 years in women and 64 years in men. There were 21 right and 21 left hips. The average follow-up was 5.0 years (2 to 11). For hips without bone grafts the average follow-up was 6.3 years; for those with bone grafts 3.5 years. The failed hip arthroplasties were considered to be infected in five cases and aseptic in 37. Thirty hips had had one previous hip arthroplasty, seven had had two, and five had previously had more than two arthroplasties.

Bone deficiency was classified as combined cavitary and segmental (type III) in all patients. A medial segmental defect was present in 36 hips and was greater than 2 cm in 30. The failed acetabular component was completely within the pelvis in four of these cases.

Revision arthroplasty was performed in a vertical laminar flow operating room. The acetabular component only was revised in 13 cases; both components were revised in 29. A trans-trochanteric approach was used in 41 of the 42 cases. The morsellised or wafer-shaped bone grafts used in 20 patients after 1982 were of allograft only in 17 hips, autograft only in one, and a combination of allograft and autograft in two. Bone allografts were obtained from femoral heads stored at $-32^\circ$. Prophy-
lactic antibiotics were used in 22 cases and antibiotic-impregnated cement in 27. The estimated blood loss averaged 2100 ml and the average operating time was three hours ten minutes.

**Surgical technique.** The failed acetabular component is exposed and removed, then all cement and the underlying soft-tissue 'membrane' are cleared. The severity of bone loss is assessed and only when there is massive bone deficiency is the decision made to reconstruct with an APC. The outer wall of the ilium is exposed for several centimetres above the bone defect, and the residual bone surfaces are roughened with a burr, reamers, or an osteotome. Morsellised or wafer-shaped pieces of bone graft are then packed into bone defects, leaving room for the APC. The large or small size is selected for the left or right side.

The APC is then placed by driving its inferior flange into the inferior acetabulum so that it lodges in the substance of the ischium, at a point already determined by a slot cut with an osteotome into the ischium from the inferior acetabulum. If necessary, the inferior flange may be bent slightly to improve its seating. Care is taken not to damage the sciatic nerve. The superior flange of the APC is placed against the lateral ilium and a number of titanium, fully-threaded 6.5 mm cancellous bone screws are placed through the appropriate holes in the APC into the roof of the acetabulum and into the ilium. Any residual spaces deep to the APC are packed with bone graft through the remaining holes. A polyethylene socket, of 50 mm outside diameter for the large APC, and 44 mm hips (12%). One of these was known to be infected; one-stage revision was tried using an APC and gentamicin-impregnated cement. Three of the other four failures due to sepsis were in the early part of the series in patients who did not receive peri-operative prophylactic antibiotics.

Failure due to aseptic loosening occurred in five patients (12%). The diagnosis of APC loosening was based on breakage, bending or loosening of screws.
securing the APC to the pelvis, change in position of the implant, or the development of a continuous cement-bone radiolucency greater than 2 mm in width. In one of the five patients loosening was at the interface between the socket and the APC; in the other four it was at the APC–bone interface. In three of these four patients the APC had been too high or too horizontal, so that the inferior flange did not engage the ischium.

The effect of using acetabular bone grafts in the more recent cases was studied. There was failure in six of 20 hips with bone graft and four of 22 hips with cement only and no bone graft. In the 16 bone-grafted hips with surviving cages the bone graft appeared to be healing or incorporating in 12, as shown by radiographic remodelling and a more homogeneous trabecular appearance. In the other four the radio-opaque APC prevented adequate assessment of the bone graft. No case showed significant graft resorption, apart from remodelling of the medial surface.

Pre-operative and postoperative hip scores according to Merle D’Aubigné (1954) were estimated for 30 hips with surviving APCs and three hips which had not yet required revision but were classified as loose because of broken anchoring screws. The pain scores averaged 3.2 pre-operatively and 4.8 postoperatively. Of the eight patients with postoperative pain scores of 3.0 or less, four had loose femoral components and two had ununited greater trochanters. The average walking scores had improved from 4.4 to 5.0, and the motion scores from 4.2 to 5.1.

Operative complications included one laceration of the femoral artery, which required repair, and two partial palsies of the sciatic nerve. Postoperative complications included one case each of hip dislocation, wound haematoma requiring operative evacuation, wound infection, aspiration pneumonia, skin decubitus ulcer, and transfusion-induced hepatitis. The patient with a wound infection developed deep infection and is one of the failures of the series.

DISCUSSION

At an average of five years after implantation, the 24% failure rate was due equally to septic and aseptic causes. Most of the patients with surviving prostheses had substantial pain relief and improved walking capacity and range of hip motion.

Two studies of devices similar to the APC have been reported. Hedde et al (1986) reviewed 65 hips at one to seven years (mean 30 months) after revision. Of the 18 with massive acetabular deficiency, most had been treated by bone grafts and the anti-protrusio device of Kerboul. The clinical result was good in 13 patients, fair in five, and poor in none; no patient had radiographic evidence of component failure. Fuchs et al (1988) reviewed 68 hips after acetabular reinforcement rings or metallic shells had been used for secondary reconstruction. Combined (type III) bone deficiencies were present in 81% and bone grafting was used in 94%. At a two- to five-year follow-up, there was radiographic evidence of aseptic loosening in only 3% and no revisions had been required. Neither study used the same device consistently or had a long mean follow-up, but the satisfactory results corroborate our findings.

Several series of revision arthroplasties by other methods are available for comparison. Jasty and Harris (1988) used wire mesh and acrylic cement. They found a 75% loosening rate at a mean of six years in patients with at least a 1 cm hole in the medial pelvic wall (for comparison, this applied to 36 of the 42 hips that we report), and concluded that the technique was ineffective. Oakeshott et al (1987) and Wilson et al (1989) reported that acetabular revision using bone grafts and bipolar prostheses had a high rate of failure, due to migration, in patients with large medial-wall deficiencies, particularly when good contact had not been obtained between the prosthesis and acetabular rim. Brien et al (1990) also reported 11 failures in 18 hips in which bipolar prostheses had been used with morcellised bone grafts to reconstruct large acetabular defects.

The use of bulky femoral head allografts and cemented sockets to reconstruct large acetabular defects has given short-term success, but Jasty and Harris (1990) reported a 32% failure rate in 38 hips at a mean follow-up of almost six years. Significantly, the failure rate was 58% in patients who required grafting of more than 66% of the socket; these patients are probably comparable to those in our series. Oakeshott et al (1987) reported encouraging results with bulk whole acetabular allografts in nine patients, but mean follow-up was 20 months.

In our series, the 12% failure because of sepsis is probably due to several factors: five cases were revisions of already infected arthroplasties. We did not routinely screen all the other failed arthroplasties for infection, and almost half of the revision operations were performed before intravenous peri-operative antibiotics were used. Modern methods of preventing infection will probably reduce the rate of deep sepsis.

The APC combines well with pelvic bone grafting. Healing and probable incorporation, without significant resorption, were usually seen. Successful bone grafting for acetabular deficiency has been widely reported (Harris et al 1977; Harris 1982; Gross et al 1985; Harris 1987; Jasty and Harris 1987; Oakeshott et al 1987; Harris et al 1988; Hedley et al 1988), but with longer follow-up problems of graft resorption and collapse have also been recognised (Trancik et al 1986; Wilson et al 1989; Brien et al 1990; Jasty and Harris 1990). The APC provides a bridge from host bone to host bone, allowing bone graft to be placed medial to the cage where it is protected from excessive forces. Although we found no advantage in terms of failure rates after using bone graft, we continue to use it to restore bone stock, and in the hope that it will improve long-term results.
Conclusions. Disappointingly high failure rates have been reported for many techniques of acetabular reconstruction. The anti-protrusio device that we used gave success in about three-quarters of the patients after an average of five years. Continued efforts to improve implants and techniques are needed to help in the management of the growing number of patients with these complex problems.

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