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ORIGINAL STUDY

Sealing the acetabular notch in cemented total hip arthroplasty. A radiological review of 380 cases

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Recent *in vitro* work has shown that sealing the acetabular notch with bone graft in bovine acetabulum samples results in improved cement penetration in the acetabular bone during total hip arthroplasty. Successful sealing of the notch may be identified on postoperative films by a lack of cement extrusion. This study aimed to assess the clinical effectiveness of this technique in preventing cement escape and early radiolucent lines by review of early postoperative radiographs.

We reviewed the post-operative radiographs of 380 consecutive patients who underwent primary total hip arthroplasty with implantation of the same flanged cemented polyethylene cup. The incidence, site and extent of cement extrusion and the incidence of any early postoperative radiolucent lines at the cement bone interface were measured.

We found the rate of inferior cement escape in our series was 9.2%, compared to 36.4% in a previous study. We also found a lower rate of early radiolucent lines compared to historical controls.

We believe placing bone graft on the medial/inferior wall prior to cementing helps to increase cement pressurisation by sealing the acetabular notch, as identified by reduced cement escape and early radiolucent lines.

Keywords : total hip arthroplasty ; cemented cup ; acetabular notch sealing.

INTRODUCTION

The cementing technique used for total hip arthroplasty (THA) has evolved significantly over the last decades. The aim of contemporary cementing is to achieve cement penetration into the cancellous bone by pressurisation of polymethylemethacrylate (PMMA) bone cement into a dry cancellous bony bed. However, pressurisation of the cement in the acetabulum may lead to inadvertent cement extrusion unless the cement is adequately contained during the pressurisation process, and this may lead to reduced bone penetration due to a loss of pressurisation. Recent work has shown *in vitro* that application of bone graft from reamings to the medial/inferior acetabular wall in bovine acetabula, thus sealing the acetabular notch beneath the transverse ligament, increased cement penetration from a mean of 3.6 mm to 5.4 mm ($p = 0.03$) (*5*). Furthermore the surface area of acetabulum with more than 3 mm cement penetration was

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increased from < 10% to > 50%. These figures suggest that sealing the acetabular notch enhances acetabular bone cement penetration.

In most instances cement extrusion is completely asymptomatic, but in a few cases serious complications have been reported. Neurological damage has been described involving the sciatic as well as the femoral and obturator nerves (*1,9,10,13,14*). Urological and vascular injuries have also been documented as a result of cement extrusion into the pelvis (*8,11,12*). The issue of cement extrusion has received relatively little attention in the literature but in a recent study the overall incidence was found to be 42.3-50% (*7*). The majority of this extrusion was antero-inferior as a result of escape under the transverse ligament.

The presence of radiolucent lines (RLL's) on early postoperative radiographs has been shown to be a predictor of subsequent component loosening (*3,6*). The incidence of acetabular RLL's on postoperative radiographs has been shown to range from 10.9% to 61.7% (*3,4,6*), depending on which area of the acetabulum is considered. In De Lee and Charnley (*2*) Zone 1 the rate of RLL's is reported to be 10.9-36.2 (*4,6*), whereas in Zones 2 and 3 the rates are 4.4-6.1% and 7.4-8.7% (*3,6*) respectively.

The aetiology of radiolucent lines on the postoperative radiograph is multifactorial but ultimately it represents a failure of adequate cement penetration into cancellous bone. In Zones 1 and 2 the surgeon may achieve interdigitation of the cement through exposure of the cancellous bone, which is washed and dried. Then cement is pressurised into this cancellous bed. However, on the medial floor of the acetabulum there is only the true acetabular floor, thus no cancellous bed, and so it is more difficult for the surgeon to achieve adequate fixation in Zone 3.

Over the past 35 years surgeons at our institution have used a technique of applying cancellous autograft under the transverse ligament and on the medial floor of the acetabulum. This method has been used for two reasons. Firstly, by sealing the acetabular notch it is hoped that pressurisation of the acetabulum will be increased, and secondly, by filling the gap under the transverse ligament it is hoped that the graft will prevent extrusion of cement.

The aim of this study was to assess the effectiveness of the medial graft *in vivo* at reducing the incidence of cement extrusion from the acetabulum and reducing the incidence of RLL's, particularly in zone 3, both of which may represent poor cement pressurisation in the acetabulum (*5*).

MATERIAL AND METHODS

Operative technique

A posterior approach to the hip was used in all cases. After resection of the femoral neck, a curved anterior retractor was placed over the anterior wall, and a curved inferior retractor was placed underneath the transverse ligament, which was retained as a guide to the correct centre of rotation and orientation of the acetabulum. If the medial wall was covered by a curtain osteophyte, this was removed to allow correct placement of the acetabular component. Having exposed the medial wall, the socket was sequentially reamed until cancellous bone was exposed. If the bone was very sclerotic, then a smaller diameter reamer was used to break through the subchondral plate, and for some cases a high-speed burr was used for the same purpose. Multiple fixation pits were made using an acetabular step drill ; smaller drill holes were made around the rim of the acetabulum using the distal smaller end of the step drill, and in the dome were placed multiple wide bore pits. Care was taken not to perforate the inner table of the acetabulum. The fixation pits were checked using a curved long artery forceps and if the cortex was breached, then bone graft from the femoral head or neck was used to fill the hole. Additional fixation pits were made in the pubis and ischium using the step drill or a combination of gouges and curettes.

Bone graft from the final reamer was compacted and placed along the medial and inferior aspect of the acetabulum, sealing the notch (fig 1). This medial graft was covered while the acetabulum was thoroughly cleaned using high pressure pulsatile lavage and then dried by insertion of small gauze swabs soaked in hydrogen peroxide. The cement was then pressurised for several minutes before insertion of the acetabular component (*15*).

Clinical Study

Between 2002-2003, 389 patients underwent implantation of a flanged cemented polyethylene cup with dome spacers (Contemporary flanged cup, Stryker, UK).

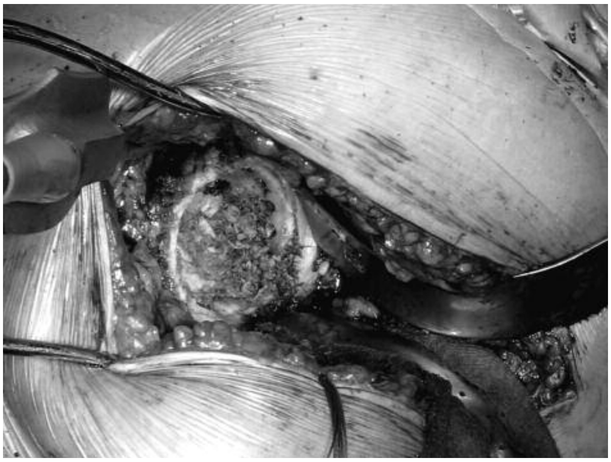

Fig. 1. — Bone graft over inferior/medial floor and under transverse ligament.

Nine patients had previous hip surgery and were excluded from the review. The study group included 160 male and 220 female patients and the median age at the time of surgery was 68 years (range 29-92). The procedure was performed by surgeons of all grades including junior doctors under supervision. In 109 cases a consultant was the primary surgeon, whereas in 223 the procedure was performed by an arthroplasty fellow. Eighteen cases were performed by a locum consultant, 28 cases were done by registrars and two by senior house officers.

The details of each operation were recorded prospectively using a standardised operation note, with specific fields for all aspects of the procedure and these fields were then entered into a database. The operation notes of all cases were reviewed during the course of this study.

Radiographic review

Two of the authors (AA, TP) reviewed the post-operative radiographs, which included an antero-posterior view of the pelvis and a lateral view of the operated hip. Radiographs were assessed for cement extrusion as defined by Martin *et al* (7). We classified cement extrusion according to the location of the cement ; pelvic, inferior or along the path of retractors. Radiographs with cement extrusion were scanned and were measured using Roman software (Roman, The Institute of Orthopaedics, Oswestry, UK) to calculate the size of the cement mass and its distance from the main cement mantle (minimum and maximum).

Radiolucent lines of any length or width were recorded using the acetabular zones described by DeLee and Charnley (2). The study protocol demanded that in cases where the reviewers felt that the early post-operative radiograph was of insufficient quality to allow an accurate assessment of radiolucent lines, subsequent review radiographs taken at a later (but next available) follow-up appointment were used.

Statistical analysis was performed using SPSS 11 (SPSS Inc, Illinois). The rates of cement extrusion and RLL's were calculated and cross-tabulation was used to investigate the effect of surgeon grade on the incidence of cement extrusion and RLL's.

RESULTS

Radiographs reviewed for this study were taken at a median of postoperative day four. In 124 cases the reviewers found that the immediate post-operative radiograph did not allow an accurate assessment of RLL's and so those taken at a later date (as early as available) were reviewed.

We identified cement extrusion in 46 hips (12.1%). In 35 cases the cement extrusion was inferior, in six cases the extrusion was into the pelvis and in five cases it was along the retractors (table I). The effect of surgeon grade on the incidence of cement extrusion is shown in table II. There was no significant correlation between the grade of the operating surgeon and the incidence of cement extrusion ($p = 0.15$). The mean size of the cement extrusion was 240.5 mm^2 (median, 167.8 ; range 15.5-967.8). The average minimum distance was 2.7 mm (median 1.6 ; range 0-13.4) and the maximum distance was 17.6 mm (median 15.4 ; range 4.6-50.6). Review of the operation notes showed that the acetabular floor was accidentally pierced in nine cases, and of these, five cases had cement extrusion. In two cases the cement extrusion was into the pelvis, and in two cases it was inferior, whilst in one case the escape was anterior, along the retractor. No patient has required re-operation because of cement extrusion.

On the postoperative radiographs RLL's were visible in a single Charnley zone in 58 cases (17.2%), in two zones in 7 cases (1.8%), and in one case a circumferential radiolucency less than 2 mm wide was seen (0.3%). There was no significant

Table I. — Number and size of cement extrusion cases by site

Site of cement extrusion	Number of cases (%)	Size of cement extrusion mm^2	Minimum distance in mm	Maximum distance in mm
Inferior	35 (9.2%)	143.6	1	15.8
Pelvic	6 (1.6%)	341.3	1.5	11.2
Along Retractor	5 (1.3%)	165.6	4.6	17.8

Table II. — Numbers of cases with and without cement extrusion by grade

Grade of surgeon	Cases without cement extrusion	Cases with cement extrusion	Total
Fellow	193	30	223
Consultant	100	9	109
Locum consultant	15	3	18
Registrar	25	3	28
SHO	1	1	2

correlation between the grade of operating surgeon and the presence of RLL's in zone 1 ($p = 0.15$) zone 2 ($p = 0.7$) or zone 3 ($p = 0.1$). The incidence of RLL's for each zone is shown in table III.

DISCUSSION

This study group consists of a large number of unselected patients who had surgery performed in one calendar year in a single institution by surgeons of all grades. When compared to previous studies (*3,4,6*), improved radiographic measures of acetabular cementing were demonstrated. This improvement was achieved by using the technique of medial/inferior acetabular bone grafting, thus sealing the acetabular notch. This was the case for surgeons of all grades, including those in training.

The acetabulum is not a complete hemisphere, being deficient inferiorly, where it is normally bridged by the transverse ligament at the level of the teardrop. Hence, intrinsically this site is vulnerable to cement extrusion during pressurisation. In the only previously reported study of cement extrusion, Martin *et al* (*7*) found that most cement leakage occurred inferiorly, affecting 36.4% of their cases. We have also found this to be the most common site, but in our cases, in which bone graft was applied, the rate is 9.2%.

We have also found that the use of medial/inferior bone graft helps to reduce the incidence of radiolucent lines on the post-operative radiograph, especially in Zones 2 and 3. Previous studies have reported that on early post-operative radiographs the rates of RLL's in Zones 2 and 3 are 4.4-6.1% and 7.4-8.7% respectively (*3,6*). In the present study there were 256 cases in which the immediate post-operative radiograph was deemed to be of sufficient quality to allow an accurate assessment of radiolucent lines and we found Zone 2 RLL's in only one case (0.4%) and Zone 3 RLL's in five cases (2%). Kneif *et al* (*6*) have shown that the rate of RLL's rises with time after operation, and in 95 of our cases we have relied upon radiographs taken more than six months postoperatively for an assessment of radiolucent lines. Using our review protocol we found that the overall rates of radiolucent lines in Zones 2 and 3 for all 380 patients were 2.4% and 3.2% respectively. These figures are better than those previously reported and yet we believe that they also represent a worst-case scenario because of the criteria used in our radiographic review.

In a separate laboratory study, Smith *et al* have compared pressures generated in acetabular models with and without simulated inferior and medial placement of bone graft (Smith, personal communication). Peak and total pressures generated at the

Table III. — Incidence of RLL's and its distribution based on timing of the radiograph

Time after surgery	Zone 1	Zone 2	Zone 3
within 14 days (256 cases)	10 cases	1 case	5 cases
14-160 days (29 cases)	6 cases	3 cases	0 cases
> 180 days (95 cases)	38 cases	5 cases	7 cases
Total (380 cases)	54 cases (14.2%)	9 cases (2.4%)	12 cases (3.2%)

apex and acetabular rim were recorded during cementing. There was a significant improvement in the pressures generated in the specimens when simulated medial/inferior bone grafting was performed ($p < 0.001$), consistent with our own clinical findings.

This was also found in another laboratory study using bovine acetabula (*5*). This group found that sealing the acetabular notch increased cement penetration from a mean of 3.6 mm to 5.4 mm ($p = 0.03$). Furthermore the surface area of the acetabulum where greater than 3 mm penetration was achieved was increased from < 10% to > 50%. They considered that cement extrusion may well reflect a failure of pressurisation, representing a failure of a good seal for the acetabulum against which pressurisation may be carried out.

The present study was designed to assess the *in vivo* use of medial/inferior wall bone graft in total hip replacement on the appearances seen on the early post-operative radiographs. The follow-up of our patients is therefore comparatively short and further studies will be required to assess whether the medial bone graft incorporates and whether this has any effect on aseptic loosening rates in the long term.

In a quest to improve the penetration and interdigitation of cement into the acetabular bone, surgeons have employed techniques that increase cement pressurisation. Without sealing the acetabular notch, cement extrusion may occur, and this may result in a reduction in cement pressurisation, and so cement penetration achieved. We have shown low rates of cement extrusion in comparison to previous studies, and low rates of early radiolucent lines, via the technique described above of applying bone graft to seal the acetabular notch. This reduction in cement extrusion and radiolucent lines may represent improved cement penetration as suggested in laboratory studies for this technique. Furthermore the complications of cement extrusion, which are often benign but can be serious, are avoided. We thus recommend our technique of grafting the medial floor to convert the acetabulum into a contained cavity for enhanced pressurisation.

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