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Uncemented total hip arthroplasty in young patients with juvenile chronic arthritis

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The hip joint is commonly affected in juvenile chronic arthritis (JCA) and involvement is usually bilateral.

It is well established that the involvement of the hip in JCA is the most important reason that the patient will lose independence and mobility. The positive gains, both in terms of hip function and the overall functional capability, of the patients of JCA after hip replacement have been shown by several studies.

There have been many reports regarding cemented total hip replacement in young patients with JCA. The short-term results have been excellent, but failure rates were considerably higher with further follow-up. To our knowledge there have been no other reports to date of the results of cementless arthroplasty of the hip in this condition.

We reviewed the results of 25 primary uncemented total hip replacements (THR) in 16 patients with JCA. The mean postoperative follow-up time was 4.5 years (range 1–19 years). The clinical results were evaluated using the modified Harris hip score. The functional outcome was assessed by a scoring system described by Witt *et al.* The most significant long-term problem was acetabular loosening (12%) in our series.

It is now certain that total hip replacements in patients with juvenile chronic arthritis (JCA) produces gratifying results *(1)*. The uncertainty is regarding the type of hip replacement—whether it should be cemented or not. There is no doubt that the results of cemented THR are excellent over a limited period of time in patients with JCA *(1–5)*. However, the incidence of loosening and the need for revision are a cause for concern. Loosening is probably inevitable owing to the relative youth of these patients and the presence of inflammatory disease. Revision procedures are difficult because of poor bone quality, atypical anatomy, osteoporosis, and vascularity with increased bleeding *(1,2)*. The femoral anatomy in patients with JCA differs from normal owing to the presence of marked anteversion, alteration in canal shape and increased femoral bowing. These factors make cement removal a tiresome task associated with risk of further bone damage.

The obvious attraction of an uncemented hip replacement is of technically easier and possibly safer revisions if they do become loose. The initial enthusiasm for uncemented hip replacements in adults has dwindled of late following reports of osteolysis, thigh pain, difficulty in obtaining the optimal fit and fill, and conflicting views on the phenomenon of osseointegration. We have attempted to evaluate our results against the background of these reports.

Material and methods

A total of 17 patients underwent 27 uncemented total hip replacements for JCA at Wexham Park Hospital, Slough, between 1977 and 1995. One patient with bilateral hip replacements was lost to follow-up. The average age of the patients at operation was 24.9 years (range 15–39 years). The average length of follow-up was 4.5 years (range 1–19 years). There were seven males and ten females. The average interval between the onset of hip involvement and hip replacement was 12 years (range 1–25 years). Of the patients, 44% had systemic onset disease, and 56% had

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polyarticular juvenile chronic arthritis. All patients belonged to class 'C' of the Charnley classification (disease complicated by involvement of multiple joints or by systemic illness that impairs the ability to walk). Five patients (31%) had active disease at follow-up.

Both custom-made and off-the-shelf implants were utilised. Custom-made implants (five hips) were generally reserved for patients with small skeletons. Ten implants were hydroxyapatite (HA) coated. The acetabulae were all press fit.

All the operations were performed by a single surgeon (MS). A modified Hardinge lateral approach was used in all cases. The patients were mobilised on the second postoperative day using either a frame or crutches. Only toe touching on the operated side was permitted for the first 6 weeks, and then partial weight bearing for a further 6 weeks. At the end of this time they had a clinical and radiological review before full weight bearing was permitted. On an average, patients remained in hospital for about 2 weeks, but their progress and discharge was also influenced by other factors relating to the disease. Patients were followed up initially at 6 monthly intervals and then annually.

Anteroposterior and lateral radiographs were obtained immediately postoperatively and at each review. Changes around the femoral component were recorded using the methods of Gruen *et al. (6)*. Acetabular changes were recorded using the method of DeLee and Charnley *(7)*. The fit of the femoral component within the femur was assessed using the method described by Heekin *et al. (8)*. Subsidence of the femoral implant was measured by determination of the change in distance from the superomedial tip of the stem to the most proximal point on the lesser trochanter. Migration of the acetabular cup was measured using the method described by Nunn *et al. (9)*. Heterotopic ossification was graded according to the method of Brooker *et al. (10)*. Osteolysis was defined as progressive, non-linear radiolucency related to either components *(11)*. The fixation of the femoral component within the femur at the latest radiological review was graded using the criteria of Engh *et al. (12)* into three groups—fixation by bone ingrowth, fixation by stable fibrous ingrowth, and unstable fixation. Acetabular cup fixation was considered unsatisfactory if the following changes were noted:

1 Presence of a radiolucent zone 2 mm or more in width in all three zones. If this radiolucency was limited to one or two zones only, then loosening was inferred if the radiolucency was progressive or when the hip was painful.
2 Progressive migration of the cup either in a horizontal or vertical direction. Non-progressive shifts of a small magnitude (less than 5 mm) unassociated with hip symptoms were not taken to indicate loosening.
3 Changes in the angle of inclination of the cup (less than 5° in the absence of hip symptoms were not considered significant).
4 Wear or fracture of the cup.

Results

The postoperative results were analysed by analysis of covariance (with preoperative score as the covariant) to test for differences between the type of implant and type of coating.

The Harris hip score ratings of the 25 hips improved from an average of 21 points (range 5–38) before the operation to an average of 84 points (range 52–101) at the latest review. Functional assessment score improved from an average of 3.5 (range 0–6) preoperatively to an average of 7.0 (range 2–10) postoperatively.

Three hips (12.0%) required revision. In two patients, only the acetabular cup needed revision. In one patient both the cup and the stem were revised. Thus, the overall

Radiological results (Number of hips (25))

Acetabulum	*Not revised (22)*	*Revised (3)*
Mean increase in acetabular angle (degrees)	3.4	23.3
Osteolysis	0	0
Radio-opaque lines	2 (8.0%) Limited to a single zone only	3 (12.0%) Involves two or more zones
Mean migration of the cup (mm)	2.4	13.3
Femur	*Not revised (24)*	*Revised (1)*
Osteolysis	0	0
Mean subsidence	2.5 mm (18 hips)	3 mm (1 hip)
Radio-opaque lines parallel to the implant (ie a stable stem)	6 (24%)	0
Radio-opaque lines divergent from the implant (ie unstable stem)	0	1 (4%)
Varus tilt of the stem	0	1 (4%)
Cortical thickening at the tip of the stem	2 (8%)	1 (4%)
Pedestal formation	5 (20%)	0
Medial neck resorption	0	1 (4%)
Proximal stress shielding	2 (8%)	0
Fit of the stem		
Excellent	11 (44%)	0
Good	11 (44%)	0
Poor	2 (8%)	1 (4%)
Heterotopic bone formation		
Grade 1	4 (16%)	1 (4%)
Grade 2	1 (4%)	0
Grade 3	0	0
Grade 4	0	0
Stability		
Fixation by bony ingrowth	2 (8%)	0
Fixation by stable fibrous ingrowth	22 (88%)	0
Unstable fixation	0	1 (4%)

revision rate for the acetabular cup was 12% and for the femoral stem 4%. These patients have done well so far after revision, with mean improvements in Harris hip score from 59 before revision to 96 after revision.

There were no dislocations and no wound infections. There was no evidence of osteolysis, and no patient experienced thigh pain. However, four patients (16%) experienced groin pain, and three of them required a revision of the cup. The remaining one settled down with further observation. Slight heterotopic ossification was noted in some patients: 20% showed grade 1 changes, and 4% had grade 2 changes.

There was no statistically significant difference between patients with customised implants and off-the-shelf implants and between those who had HA-coated implants, and non-HA-coated implants. There was also no statistically significant difference in outcome between those who had excellent fit compared with those who had good fit. The lack of significant differences are owing to two reasons—the small numbers in the study group, and the wide variation in the preoperative scores between patients, making this a rather heterogeneous group.

Discussion

The hip joint is commonly affected in juvenile chronic arthritis (JCA) and involvement is usually bilateral. In 9% of patients with juvenile chronic arthritis, the hip is involved within 1 year of the onset of disease. While the disease affects many joints, the involvement of the hips is the single most important cause of loss of mobility in these patients.

There have been many reports regarding cemented total hip replacement in young patients with JCA *(1–5)*. The short-term results have been excellent, but failure rates were considerably higher with further follow-up (Table I).

Juvenile chronic arthritis is a relatively rare disease (incidence 1 per 1000 under 16 years of age) and only a few of these unfortunate victims will develop such severe disease of their hips that a replacement is indicated. These are generally patients who not only lack mobility, but also are in a great deal of pain even at rest.

Since 1967 we have tackled this problem with cemented arthroplasties of varying design. These have produced worthwhile results in the short and medium term, and have given patients the opportunity to integrate at their place of education, socially, and at work. However, inevitably failures began to occur, and later this became a serious concern. The practical problems of a revision were daunting. These patients had friable bone and distorted anatomy, and the methods available for revision did not include the modern techniques now available for the removal of cement, nor were there image intensifiers and other surgical aids, including bone grafting and custom-made prostheses.

The senior author therefore thought there might be an indication to use uncemented implants, particularly at a time when they were beginning to become heralded as a possible alternative in younger patients, irrespective of the pathology.

We therefore changed our policy for hip replacement in JCA. Younger patients with burnt out disease and a stable skeleton were treated with uncemented components, which needed to be custom made in some cases. The criteria included a moderately good bone stock to accept the implant, and a large enough pelvis to accommodate the metal cup and liner, even with the smallest acceptable head size. In some patients the lack of development because of the disease sometimes precluded these criteria. Those patients who were still suffering active disease in

Table I. Comparative results of cemented total hip arthroplasty in young patients

Author	*Age of patient (years)*	*Follow-up (years)*	*Radiological loosening*	*Revision*
JCA group				
Roach and Paradies *(4)* (10 hips)	9–16	Mean 8	Not known	33% cup 0 stem
Lachiewicz *et al.* *(5)* (83 hips)	26 (mean)	6 (mean)	34%	32%
Learmonth *et al.* *(13)* (14 hips)	Not known	8.5 (mean)	57.1%	0
Witt *et al.* *(1)* (96 hips)	16.7 (mean)	9.5 (mean)	42.7%	25%
Williams & McCullough *(3)* (57 hips)	16.4 (mean)	4.7 (mean)	43.5%	35%
Composite group (long-term follow-up) young patients various disorders				
Halley & Wroblewski *(44)* (49 hips)	26 (mean)	10 (mean)	47%—cup 20.4%—stem	14.3% cup 4% stem
White *(45)* (45 hips)	Not stated	7.5 (mean)	45%	11.4%
Collis *(14)* (51 hips)	Not stated	12–18	Not known	19.6% stems 15.6% cup

the hip, and in many cases still growing, were excluded, as their soft and porotic bone was inadequate to receive the implants, particularly on the pelvic side. In this group we continued to facilitate fixation with cement.

Apart from the practical problems described, there are also other factors which need to be considered in the use of uncemented implants. These include the concept of the need to 'fit and fill', osseointegration, and the place of hydroxyapatite coating.

Fit and fill

In the absence of cement, the stability of the implants relies heavily on the fit and fill of the implant within the bone *(12)*. Preoperative templating of the off-the-shelf prostheses has been shown to be inaccurate in a significant proportion of cases in studies by Carter *et al. (15)* and Noble *et al. (16)*. While this was the case in a series involving adults with osteoarthritis, the difficulties in templating in JCA patients with atypical anatomy are even more obvious. The endosteal geometry of the femur is much more critical than the surface geometry, and it may be impossible to match the endosteal dimensions of each femur using off-the-shelf prostheses. While micromotion at the implant–bone interface is unavoidable, it is known that controlled axial micromotion is beneficial in maintaining stability. Rotational micromotion is not *(17–19)*. Implants with good fit and fill show less rotational motion at the interface *(20,21)*. It has been shown that the stability of the custom-made femoral stems is two to three times better than standard anatomic designs *(22)* and clinical trials have demonstrated superiority of outcome using customised implants *(23)*. In our study, there was no statistically significant difference in the Harris hip score between customised femoral implants and off-the-shelf implants, but this is possibly owing to a relatively short follow-up period of the customised implants (less than 5 years). We also classified the degree of the fit of the femoral stem as excellent, good or poor , as described by Heekin *et al. (8)*. There was no statistically significant difference in the Harris hip scores between those implants which had excellent fit and those that had a good fit. One of the hips which had a poor fit required revision, but two more hips considered to have poor fit on radiographs have done well clinically so far. Their outcome will be more obvious in future years.

Figure 1. A custom-made uncemented hip after 6 years in a 35-year-old patient. This appears well fixed, has not sunk, and has a stable bone–implant interface. It is symptomless.

Growth and remodelling

The femoral cavity expands with age *(24)*. In young patients who are still growing, growth will add to the increase in girth. Learmonth *et al. (13)* have suggested that growth could be a cause of increased incidence of early radiological 'loosening' in JCA patients. The growth of diasphyseal bone on the outer surface occurs with simultaneous osteoclastic resorption from the endosteal surface. The bone surrounding the implant tends to grow away from it and this gives rise to the radiolucent areas around the implant interpreted as 'loosening'. Fortunately, this has not caused serious problems with our group of patients, as the disease activity retards growth in JCA patients with steroid intake often being a contributing factor *(25)*. These patients tend to remain small statured. In our study, patients who showed radiolucency on radiographs with no other adverse features did not have any clinical problems associated with loosening.

Osseointegration—fact or myth?

Osseointegration was thought to be of paramount importance for long-term survival of uncemented implants, but recent studies have shown otherwise. Bone ingrowth into porous coated femoral components is not as common as was believed *(26)* and bone ingrowth has not been shown to prevent thigh pain or subsequent loosening *(27,28)*. Formation of good quality 'junctional tissue', not necessarily bone, appears to be the key to long-term success, and this has been shown to depend on mechanical rather than material factors *(29)*. Giori *et al. (18)* have studied the mechanical influences on tissue differentiation at the bone–cement interface. They found that frequently applied hydrostatic stress is likely to stimulate cartilaginous extracellular matrix production in the interface tissue and frequently applied distortional strain is likely to stimulate fibrous extracellular matrix production. An

Figure 2. A custom-made uncemented hip after 5 years in a 20-year-old patient. There are radio-opaque lines around the stem, particularly distally and medially. There has been no sinkage and no femoral cortical hypertrophy suggesting that the surrounding shell of bone has load-bearing function. It is symptomless.

implant with a good fill and fit is likely to impart favourable hydrostatic stress with its micromotion and induces the formation of a stable interface. The latter helps to distribute loads evenly from rigid metals to more compliant bone. Thus, osseointegration is not a must for success in the long term. In our study, we classified the radiographic appearance of fixation of implants into three categories as described by Engh *et al. (12)*; fixation by bone ingrowth, fixation by stable fibrous ingrowth, and poor fixation. Of our patients, 88% showed fixation by stable fibrous ingrowth as opposed to 8% who showed fixation by bone ingrowth. However, there was no evidence of thigh pain or progressive femoral loosening in patients who had stable fibrous fixation (similar results as in those who had fixation by bone ingrowth). Further follow-up will clarify this situation.

Hydroxyapatite coating

In the light of present knowledge about osseointegration, the role of hydroxyapatite needs rethinking. If it does improve the longevity of the cementless implants, it probably has a mode of action different from that of pure osseointegration. Soballe *et al. (30)* showed in a canine experimental trial that micromotion between implant and bone caused fibrous layer deposition around both HA-coated and non-HA-coated implants. However, the fibrous membrane consisted of a higher percentage of fibrocartilage with a higher concentration of collagen when the implant was coated with HA *(31)*. This may help in the more secure stabilisation with time. Faced with an unstable implant, the HA-coated one has a better chance of stabilising itself later when compared with an implant which is not HA coated. In our study, there have been no significant differences in the Harris hip score ratings between the HA-coated and non-HA-coated implants so far. However, follow-up of HA-coated implants is of less than 5 years' duration and requires further follow-up.

One reason for using the uncemented implants was anticipating that they would be easier to revise. In the event, three cups which had to be removed were all completely loose, and the femoral stem was readily unseated.

The overall results have shown a gratifying low incidence of surgical complications. There were no dislocations, but many of these hips are protected by very stiff muscles around the arthroplasty, which becomes firmly seated before the muscles finally loosen up.

The absence of wound infection was very fortunate, as 40% of the patients were on either steroids or a cytotoxic agent.

There was no incidence of osteolysis around implants in our series. Several studies have reported the occurrence of osteolysis around cementless components, especially the femoral stem *(32–35)*. The interface around a loose prosthesis has been shown to contain macrophages, synovial cells, and foreign body giant cells, with high concentrations of digestive enzymes such as acid phosphatase, collagenase and prostaglandins E_2 *(36–39)*. These latter probably act as mediators of osteolysis. Of our patients, 88% were taking non-steroidal anti-inflammatory agents (NSAID) such as indomethacin, 31% were on steroids, and 25% on cytotoxic agents such as methotrexate and azathioprene. It is known that the above medications control the disease activity in rheumatoid patients by interfering with mediators of inflammation *(40)*. It is possible that prevention of osteolysis is a desirable side-effect of these medications.

Indomethacin has been shown to prevent bone ingrowth into porous coated implants in experimental animal models *(41)*. This gave rise to concern regarding the role of indomethacin in patients with cementless implants. However, in the light of newer knowledge that osseointegration is not as critical as it was assumed to be, it appears that indomethacin may have taken more than its fair share of criticism as the cause of loosening of cementless implants.

The minimal amount of heterotopic ossification may at least be partly attributed to the fact that 80% of these

patients were taking a non-steroidal anti-inflammatory drug, such as indomethacin *(42)*.

Thigh pain has been a cause of concern in patients with uncemented total hip replacements. Campbell *et al. (43)* reported an incidence of 13% thigh pain at 1 year, and 22% at 2 years postoperatively. Whether the smaller build of our patients contributed to the absence of thigh pain is open to conjecture.

Conclusions

We have analysed our results of cementless hip replacements in this special group of patients with unique problems. Each of three patients who required revision of their acetabular may have loosened their own cups. One by a heavy fall, one by gaining an undue amount of weight, and one by continuing stressful sporting activity against advice.

All patients reported that the operation had been worthwhile in improving the quality of their lives. Six patients were attending college, and nine were engaged in sedentary occupations. One remained housebound because of severe multisystem involvement, but was pain free in the hips. All except two patients were able to drive cars, and all except one have the capacity to use public transport.

The authors feel there is still a continuing place for the uncemented total hip replacement in this particular group of patients. It is hoped and anticipated that good long-term results may be achievable with increasing experience and design.

To our knowledge, there have been no other similar reports of uncemented hip arthroplasty in JCA patients, and hence we could not compare our results.

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