The Exeter™ Universal Hip in Patients 50 Years or Younger at 10–17 Years' Followup

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Abstract The Exeter™ Universal hip (Stryker Inc., Newbury, UK) has reported survival rates of 91.74% at 12 years in all patients with reoperation as an endpoint. However, its performance in younger patients has not been fully established. We reviewed survivorship and the clinical and radiographic outcomes of this hip system implanted in 107 patients (130 hips) 50 years old or younger at the time of surgery. The mean age at surgery was 42 years. The minimum followup was 10 years (mean, 12.5 years; range, 10–17 years) with no patients lost to followup. Twelve hips had been revised. Of these, nine had aseptic loosening of the acetabular component and one cup was revised for focal lysis and pain. One hip was revised for recurrent dislocation and one joint underwent revision for infection. Radiographs demonstrated 14 (12.8%) of the remaining acetabular prostheses were loose but no femoral components were loose. Survivorship of both stem and cup

from all causes was 92.6% at an average of 12.5 years. Survivorship of the stem from all causes was 99% and no stem was revised for aseptic loosening. The Exeter™ Universal stem performed well, even in the young, high-demand patient.

Level of Evidence: Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Many previous studies have demonstrated inferior survival and clinical performance of other cemented THAs when used in patients younger than 50 years [2, 6, 7, 13, 17, 20, 40, 47]. One of the reported reasons for stem failure is the quality of cementation [3]. First-generation cementation with finger packing as described by Charnley demonstrated radiographic stem loosening of up to 24% at 5 years and 40% at 10 years [4, 48], whilst improved cementation techniques have substantially lowered this to around 3% at 11 years [38]. However, younger patients are presumed to place more demands on their implant than older patients due to higher activity levels [46] and resultant higher bearing wear rates, thus raising a question of longer-term survival beyond 10 years owing to loosening from particulate debris rather than the mechanical effects of cement technique [33].

The survivorship of the Exeter™ Universal series (Stryker Inc., Newbury, UK) femoral stem has been reported as 100% at 12.5 years [50], but its use in the younger, more active patient has never been reported fully. The Exeter stem was introduced in 1988 to offer head/neck modularity. Stem subsidence within the cement is a feature of the normal behavior of this stem and is dependent on

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Each author certifies that his or her institution has approved or waived approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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loading of the joint [23]. Its geometry is similar to the original stem with no collar and a double taper extending proximally to the neck of the prosthesis, with a highly polished surface ($R_a = 0.01\text{--}0.03\ \mu\text{m}$). In 1988, modifications were made to the shoulder, with the superolateral straight edge changed to include a curved surface, convex laterally. Beginning in 1983, the implant was made of the stronger Rex 734 [42] Orthinox® alloy (Howmedica, Rutherford, NJ), whereas the original stem was made from EN58J [22], a weaker and more ductile alloy. The stem centralizer is constructed from PMMA, is placed on the stem tip, extending 5 to 10 mm distally, and contains a void to allow taper engagement. Since quality of cementation is a reported predictor of outcome, we suspect that whilst it should in general be more important for a younger patient group, the load transmission of this particular stem (with anticipated subsidence and taper engagement) may be protective.

We hypothesized that Exeter™ Universal hips in young, active patients have comparable results to those used in patients of all ages for this duration of followup. Furthermore, we questioned if the implants behaved differently in younger patients as could be evidenced by greater stem subsidence, higher bearing wear rates and evidence of radiographic failure. Finally, we examined whether these higher demand patients had satisfactory clinical outcomes.

Materials and Methods

We retrospectively reviewed the medical records and radiographs of 107 selected patients (130 hips) aged 50 years and younger at the time of surgery and who had an Exeter™ Universal stem inserted by Exeter-based surgeons from 1988 to 1995. We excluded 44 patients operated in our hospital but who lived outside the area and were operated on by non-Exeter-based surgeons since these patients did not fall within our followup control. However, no patients operated on by Exeter-based surgeons were excluded. Six patients with seven THAs died during the study period from causes unrelated to their hip surgery (2–10 years); their hips were functioning well both clinically and radiographically at the time of death and none had been revised. This left 101 patients (123 hips) for review. The minimum followup was 10 years (mean, 12.5 years; range, 10–17 years) with no patients lost to followup.

Patients had a variety of diagnoses and all were included for evaluation (Table 1). Seventy-seven percent had a primary diagnosis other than osteoarthritis. Previous surgery had been performed in 32% of cases and included arthrodesis, femoral and acetabular osteotomy, and débridement for septic arthritis. Because of the prevalence of abnormal anatomy, 15% of hips underwent major

Table 1. Primary diagnosis

Diagnosis	Number	Percent
Primary osteoarthritis	43	33.1
Dysplasia	40	30.7
Inflammatory arthritis	24	18.5
Legg-Calvé-Perthes	6	4.6
Avascular necrosis	4	3.1
Slipped upper femoral epiphysis	3	2.3
Septic arthritis	3	2.3
Other	7	5.4

acetabular reconstruction with structural grafts and fixation (Fig. 1A–B). Thirty-two percent of the patients were in Charnley Group C [11] with their function affected by systemic disease, 25% were in Charnley Group B with both hips involved, and 32% were in Charnley Group A with one hip involved.

All surgery was performed by Exeter-based surgeons, with 68% of cases performed by teams led by surgeons with a specialist hip interest and 32% by general orthopaedic surgeons from other teams. The surgery was performed by a consultant in 70% of the cases and the remainder by more junior members of the team and fellows. We used a posterior approach in 78% of hips and the direct lateral approach in 22%. Contemporary cementation techniques [35] were used in 88% of the cases, with earlier methods in the remainder. The contemporary technique included preparation of the acetabulum by reaming to remove the subchondral bone, creating multiple small drill holes, and pressurizing the cement using a balloon pressurizer. After femoral preparation and insertion of a cement restrictor, the cement was introduced to the femur in a retrograde fashion and then prolonged pressurization applied using a proximal Sorbothane® (Stryker Inc, Caen, France) seal, eliminating the method of finger packing. After implant insertion, the pressure was maintained using a proximal collar until cement polymerization.

The acetabular implant used was the Exeter™ concentric all-polyethylene cup (Stryker Inc, Caen, France) in 50% of hips, the Exeter™ metal-backed polyethylene cup (Stryker Inc) in 32%, the Ogee® (DePuy, Leeds, UK) in 15%, and the BiomEx™ (Biomet, Warsaw, Indiana) uncemented cup in 3%. The femoral head in all cases was of modular construction from the same Orthinox® stainless steel as the stem. The head diameter was 26 mm in all but five hips, with 30 mm used in three cases and 22 mm used in two cases performed through the direct lateral approach. The Exeter™ Universal stem (Stryker Inc.) was used in every case.

The department followed patients yearly for 5 years, then 5-yearly review clinically and radiographically, with

Fig. 1A–B (A) A preoperative radiograph demonstrates an example of the complex cases encountered. (B) A postoperative film of the same patient at 12 years shows well-fixed components.

all information collected prospectively and entered into a database (Orthographics Inc, Salt Lake City, UT). To ensure current data, all patients were seen for review within 12 months of the study date, either as part of their standard followup or in extra clinics for the purpose of this study. Pre- and postoperative clinical scores included the Charnley modification of the Merle D'Aubigné-Postel score [11], Harris hip score [25], and Oxford hip score [15]. The University of California, Los Angeles (UCLA) activity score was assessed at last review [1, 52]. The general health status of the patients was assessed with the EuroQol EQ-5D score, which provides a single index value of health-related quality of life that is derived from a descriptive profile of five dimensions. The reference score derived from an age-matched random UK population sample is 79% [19]. The tool also provides a “thermometer” on a visual analog scale to generate a self-rated current health-related quality of life. The age-matched reference is 0.8 [19, 31].

All patients had anteroposterior and lateral radiographs preoperatively, postoperatively, and at each review. These radiographs were digitized and scaled using the known size of the femoral head implant. Despite the presence of a stem centralizer and consequent lack of cement at the immediate stem tip (there was cement below the tip to the level of the cement plug), we (SL, BS) assessed the quality of femoral

cementation immediately postsurgery according to the system of Barrack et al. [3] because it predicts outcome [10]. On initial postoperative films, there were 40 Grade A femora, 51 Grade B, 27 Grade C, and two Grade D. In the 10 remaining stems, it was not possible to determine the cementation grade due to inadequate films or the presence of plates used for fixation of shortening and derotation osteotomies. A radiolucent line was defined as a sclerotic line adjacent to a linear radiolucency following the criteria described by Kobayashi et al. [33]. The position of lucent lines in the femur was described on the anteroposterior radiograph using zones of Gruen et al. [24] and on the lateral by Johnston et al. [27]. Osteolysis was defined as a progressive nonlinear lucency (> 2 mm) resulting in endosteal erosion of cortical or cancellous bone [38]. Failure of the femoral construct was taken as progressive signs of radiolucency or migration of the cement mantle within the femur. Since stem subsidence is recognized as taper engagement and part of the normal behavior of the ExeterTM stem, it was not used as a criterion for failure. We measured subsidence of the femoral stem using the method described by Fowler et al. [23] where the space between the shoulder of the prosthesis and the cement overlying it represents the amount of subsidence. Demarcation of acetabular components was expressed using zones described by DeLee and Charnley [16]. The classification of

Hodgkinson et al. [26] was used to indicate acetabular loosening. A radiolucent line in all three zones or migration was believed to indicate loosening and failure of fixation. Linear cup wear was estimated with digital radiographs at normal magnification using the method described by Livermore et al. [36].

We constructed life tables to indicate survivorship using the technique described by Kaplan and Meier, [29] and 95% confidence intervals (CIs) were calculated using the equation described by Peto et al. [41]. We included patients who died during the study. When sockets were revised, well-fixed stems were routinely removed to facilitate acetabular exposure and the original stem cement-bone interface was preserved. An in-cement replacement of stem was then carried out. Because the femoral cement-bone interface was not disturbed, these were not considered stem revisions in the survivorship analysis. We used the Student's *t* test to compare linear acetabular wear rates between failed and surviving sockets. We used the chi square test with Yates correction [51] to assess the relationship between the Barrack cement grade and femoral radiolucent lines. We compared stem subsidence in this cohort to a previously reported general group of patients [50].

Results

Our final review confirmed these were indeed high-activity patients: the mean UCLA activity score for all groups was 5.8 (standard deviation [SD], 1.9). Seventy-four percent of the patients maintained an active lifestyle indicated by a score of 5 and above. When patients in Charnley Group A were considered alone, the average activity score was 6.4 (SD, 1.9), with 83% of patients active at Level 5 or above and 69% at Level 7 or above, indicating regular sports (Table 3).

No stems were revised for aseptic loosening, giving a stem survival rate at 17 years of 100% (Fig. 2). The 10-year survival rate with reoperation for any reason as an end point was 94.4% (95% CI, 89.3%–97.9%). At an average followup of 12.5 years, this was 92.6% (95% CI, 87.3–97.9) (Fig. 3). Of the 123 hips for review, 13 (10.6%) had undergone further surgery by last review (Table 2). Using revision for aseptic loosening of the cup as an end point, the 10-year survival rate was 97.6% (95% CI, 93.2%–99.2%). At 12.5 years, this was 95.9% (95% CI, 89.4%–98.5%) (Fig. 4). Of the unrevised acetabular components, 78% had either no demarcation or minor changes in Zone 1, whereas 12.8% (14) of the cups had either demarcation in all zones or migration, thus fulfilling radiographic criteria for loosening (Fig. 5). Therefore, including the revisions, 23 (18.7%) of the acetabular components were judged to have failed clinically or radiographically at the time of final review.

Fig. 2 A graph shows survivorship with any reoperation for aseptic stem loosening as an end point. Error bars = 95% confidence limits, obtained using the Peto equation [40].

Fig. 3 A graph shows survivorship with any reoperation, including periprosthetic fractures, as an end point. Error bars = 95% confidence limits, obtained using the Peto equation [40].

The mean stem subsidence at review was 1.29 mm (range, 0–2.9 mm; SD, 0.45). The only stem with no measurable subsidence was in a patient who was wheelchair-bound. Other activity levels were not associated with differing subsidence. There was no difference when comparing subsidence with cement grade.

The mean linear wear for all cups was 0.09 mm per year (range, 0–0.32 mm). The wear rates in those cups revised for aseptic loosening were higher ($p = 0.002$) at 0.21 mm per year. The linear wear rate for the surviving hips with a UCLA activity level less than 5 was 0.06 mm per year, whereas for those with scores from 5 to 10 it was higher ($p = 0.011$) at 0.1 mm per year.

No femur had evidence of focal endosteal lysis. Twelve femurs showed evidence of radiolucent lines at final review. Of these, six had lucent lines at the calcar (Zone 7), five had lines in two proximal zones, and one case had radiolucent lines in four zones. This hip had a 30-mm-diameter head articulating with an Exeter™ metal-backed cup. The lines were nonprogressive and there was no evidence of subsidence of the cement within the bone. The patient was asymptomatic, scoring 6-6-6 on the Charnley modification of the D'Aubigné-Postel scale and with a Harris hip score of

Table 2. Reoperation for any reason

Patient	Gender	Age at surgery (years)	Underlying diagnosis	Years to revision	Reason for reoperation	Comments
1	Male	32	Avascular necrosis	2.5	Acetabular aseptic loosening	Socket only revised
2	Female	44	Rheumatoid arthritis	4.3	Dislocation	Socket only revised
3	Female	48	Osteoarthritis	6.7	Acetabular aseptic loosening	Socket only revised
4	Female	48	Developmental dysplasia	7.2	Acetabular aseptic loosening	Socket only revised
5	Male	40	Osteoarthritis	8.5	Periprosthetic fracture type C	Original components retained
6	Female	40	Septic arthritis	8.5	Sepsis	
7	Female	18	Perthes	9.1	Pain and acetabular lysis	Socket only revised; pain resolved
8	Female	44	Osteoarthritis	10.9	Acetabular aseptic loosening	Socket only revised
9	Female	44	Osteoarthritis	11.1	Acetabular aseptic loosening	Socket only revised
10	Male	28	Avascular necrosis	13.3	Acetabular aseptic loosening	Socket only revised
11	Female	43	Developmental dysplasia	13.7	Acetabular aseptic loosening	Socket only revised
12	Female	36	Slipped femoral epiphysis	14.1	Acetabular aseptic loosening	Socket only revised
13	Female	50	Osteoarthritis	14.3	Acetabular aseptic loosening	Socket only revised

Table 3. University of California at Los Angeles Activity Score [1, 50]

Score	Description	Percent for all groups	Percent for group A
1	Very inactive, dependent on others; cannot leave home	2.1	0
2	Mostly inactive; restricted to minimal activities, such as washing, dressing, toileting	6.3	8.3
3	Limited housework, shopping; occasional walking	3.1	0
4	Regular mild activities, such as housework, walking, seated occupation	15.5	8.3
5	Unlimited housework or shopping; occasional moderate activities, such as swimming	6.2	4.2
6	Regular moderate activity, such as swimming; light occupational work	19.8	12.5
7	Regular sports, such as cycling, aerobics, gym, gardening once or twice a week	29.2	37.5
8	Regular very active events, such as bowling or golf, riding, aerobics; gym or gardening three or more times a week; farming; moderately heavy occupation	16.7	25
9	Occasional impact sports, such as running, jogging, tennis, cricket, football, rugby, martial arts, skiing, ballet, hiking, mountaineering; heavy occupation	1.0	4.2
10	Regular impact sports as previously described	0	0

100. Of the 40 Barrack Grade A cemented femurs, three (7.5%) had some evidence of lucent lines. Grade B cemented femurs (51) had an incidence of lines in two (3.9%), whereas Grade C cementation (27) was associated with greater ($p < 0.01$) incidence of lucent lines (25.9%, seven femora). The two Grade D cemented stems were in a patient who died 8 years postoperation but had no evidence of femoral osteolysis at that time.

The mean Harris hip score improved to a satisfactory level at final followup (from a preoperative level of 36 ± 17 , range, 1–68 to 81 ± 19 , range, 18–100 at final review). The mean Oxford score at final review was 21 ± 8.5 (range, 12–47). The overall mean Charnley modification of the Merle D'Aubigné-Postel score before

surgery was 2.3 for pain, 2.3 for mobility, and 3.1 for range of movement. At final review, these scores were 5.2, 4.6, and 5.4, respectively (Table 4). The mean state of health on the EuroQol scale was 77% for all groups at final review. Those who were Charnley Group A scored 83%. The mean weighted health status index for all groups was 0.67, being 0.89 for Group A patients.

Discussion

The ExeterTM stem is associated with high survival rates at 12 years in all patients, but its performance in younger patients has not been established. We therefore asked

Fig. 4 A graph shows survivorship with reoperation for aseptic cup loosening as an end point. Error bars = 95% confidence limits, obtained using the Peto equation [40].

Fig. 5 A radiograph demonstrates linear socket wear and acetabular lysis behind a metal-backed cup at 15 years postsurgery.

Table 4. Charnley modification of Merle D'Aubigne-Postel Score [10]

Group	Percent	Pain	Function	Range of movement
Preoperative				
A	42.9	2.5	3.1	3.4
B	25.4	2.6	2.4	3.3
C	31.7	1.7	1.4	2.7
All groups		2.3	2.3	3.1
Final review				
A	26.9	5.2	5.5	5.5
B	45.2	5.4	5.4	5.5
C	27.9	4.9	3.0	5.3
All groups		5.2	4.6	5.4

whether the Exeter™ Universal hip performs as well in younger, more active patients as in patients of all ages by establishing if medium- to long-term survival rates were

comparable. Having established whether these young patients were indeed active, we then sought to ascertain if increased wear rates were observed and associated with radiographic evidence of implant failure.

For logistic and financial reasons, we were unable to obtain complete data on all patients operated upon within the hospital, since some came from outside the region as did their surgeons and we had no control over their followup regimes. Thus, this series is of selected rather than consecutive cases in reference to all surgery performed within the hospital. However, when considering THAs performed by all surgeons based in Exeter, their fellows and juniors, none was omitted. We presume the range of surgeons involved is nonetheless representative of those operated by outside surgeons.

Survivorships of THAs in young patients reportedly have had generally inferior results in the past when compared with those of a general population with overall survival rates averaging 80% at 10 years in patients under 50 years compared to 92% at 15–20 years in older patients [7, 13, 17, 20, 40, 47]. Younger patients are believed more active and so place more burden on their joint replacement in terms of higher cycle frequency and load [44–46]. These demands may lead to increased wear of the bearing surface [32, 43]. It has been postulated, therefore, it is this “use” rather than chronologic age that determines wear and, indeed, patients with higher activity levels when measured on the UCLA scale had higher rates of acetabular polyethylene wear in this study. We subjectively assessed activity levels of this group of patients throughout their followup, but only at the last review did we introduce the UCLA activity scale into the evaluation. We recognize patients’ activity levels after THA are highly variable and cumulative. Therefore, the patients with lower scores at last review may have been more active in the early years after THA and the patients with high scores may have been as active throughout the lifespan of their hip [18]. In both these scenarios, patient activity would tend to have been underrepresented by a single score. Despite this, 74% of our patients were still undertaking active lifestyles at an average of 12.5 years postsurgery.

The Exeter™ metal-backed cup was introduced in 1984 since it was believed to have theoretical advantages, but when the design became associated with excessive wear and early failure and the theory for metal backing was believed unsound by some [8, 9, 14], its use was abandoned in 1990. However, we found no association between metal-backed sockets and failure, possibly due to the low number of revisions encountered.

The sockets revised for aseptic loosening were associated with higher linear wear rates than the group as a whole. High rates of socket wear result in large volumes of particulate polyethylene debris, which stimulates osteolysis

at cement-bone interfaces. In studies of other cemented stems, this is also associated with high rates of femoral component failure of 13% at 25 years to 18% at 12.8 years [7, 12, 28]. However, in our patients the femoral cement-bone interface in such cases seemed durable. It has been postulated, in the case of the Exeter™ stem, that this is the result of the protective effects the compressive stem biomechanics have on this boundary [49].

Although the Exeter™ stem has been said to have a forgiving biomechanical behavior [50], it is important to emphasize the method of cementation of the femur must be meticulous because, as in previous studies [3, 48], results demonstrating poor cementation were associated with the appearance of radiolucent lines in the medium to long term.

The Exeter™ Universal series of 325 hips reported by Williams et al. [50] in 2002 demonstrated a survivorship rate with reoperation for any cause of 91.74% at 12 years. The study presented here of young patients has a comparable survivorship rate of 92.6% at 12.5 years. The revision rate for aseptic cup loosening was also similar with survivorship rates of 96.86% and 95.9%, respectively. The earlier paper, however, was made up of 94% metal-backed cups compared with 32%, with a lack of association between metal backing and failure in this group. This suggests factors other than the presence of a metal-backed socket contributed to failure, such as increased activity and consequent polyethylene wear rates. Neither series encountered revision for aseptic stem loosening. Our data were similar to those in the other study in other respects. The stem subsidence rate found in our series (1.29 mm) was comparable to that found by Williams et al. [50] (1.32 mm). The relationship of increased subsidence with poorer cementation grade was not, however, observed in this cohort. The incidence of radiolucent lines was 8.9% in the 2002 study and 9.8% in our study, with the majority appearing in the proximal zones. The correlation between Barrack C cementation grade and the presence of radiolucent lines is a new finding in this series. When compared with other reviews of cemented THAs in young people, the Exeter™ hip performs extremely well. Callaghan et al. [7] reporting on Charnley THAs in patients less than 50 years of age, demonstrated a 12-year survival rate for reoperation of approximately 85%; other studies reported similar results. There was a general finding of better performance of the stems than the sockets [5, 12, 28, 30]. McAuley et al. [37] reported a survivorship rate for reoperation of 88.8% at 10 years in young patients compared with 94.4% at the same point in time in our study. The Exeter™ also compares well with other studies of uncemented THAs in young patients with a similar length of followup [21, 34, 39]. These studies, all with patients younger than 50 years old, had survival rates of between 70.7% and 92.5% for all causes with a maximum followup of 14 years. Once again,

socket failures outnumbered stems, but all encountered stem revisions for aseptic loosening, with femoral failure rates of between 1.1% and 15.1%.

Our data suggest the Exeter™ Universal stem provides high survivorship in the medium- to long-term, even when used in young, high-demand patients, and can be implanted confidently in such cases. Despite poorer performance of the various sockets, the survival rate with an end point of reoperation for any reason was 94.4% at 10 years and 92.6% at a mean followup of 12.5 years. It is expected, when coupled with acetabular components less prone to wear, it is likely to exhibit further improvements in overall performance.

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