The Kent hip is a distally-locked femoral stem which was developed to address severe proximal bone loss, severe bony deformity and peri-prosthetic fracture.

We reviewed the results of 145 consecutive Kent hips implanted into 141 patients between 1987 and 2000. The indications for implantation were aseptic loosening (75 hips), septic loosening (two), peri-prosthetic and prosthetic fracture (37), severe bony deformity (24), and fracture through a proximal femoral metastasis (seven).

The median time to full weight-bearing after surgery was two days and the mean length of follow-up was 5.1 years (2 to 15). Further revisions were required for 13 femoral stems. With removal of the stem for any reason as an end-point, the cumulative survival at five, ten and 15 years was 93%, 89% and 77%, respectively. In patients aged ≥70 years, the cumulative survival at 15 years was 92%, compared with 68% in those aged <70 years. Because of these findings, we recommend the use of interlocking stems in patients aged ≥70 years, particularly in those with a peri-prosthetic fracture, for whom alternative methods are limited. Outcome scores and survival data, compared with other systems, indicate that the Kent hip should be used with caution in younger patients.

Severe proximal bone loss presents the surgeon with substantial problems in revision hip surgery.1-5 In the presence of proximal lysis, after debridement for infection, or after an extended femoral exposure for removal of the implant, the proximal femur may be deficient. Various methods to deal with this deficiency have been proposed and used. These include the use of long-stemmed fluted implants,6,7 impaction grafting,8 the use of coated cylindrical implants,9,10 allografting and other prostheses.11-13 The Kent hip (Biotron Europe, Dordrecht, The Netherlands) first implanted in 1986, belongs to a group of implants specifically designed for distal fixation alone. It was made to overcome the difficulties of loosening of the femoral component and osteolysis, peri-prosthetic fractures, tumours of the proximal femur and severe bony deformity, such as may follow developmental dysplasia of the hip. Our study is the first to assess its medium- to long-term survival.

**Patients and Methods**

The Kent hip has a straight stem made from a cobalt-chromium alloy. It is available in two sizes, of 12.5 and 14 mm in diameter. When possible the 14-mm diameter should be used, the 12.5-mm stem being indicated only for lighter patients. There are four lengths, 190, 239, 295 and 340 mm, with 6, 9, 13 and 16 screw holes, respectively. Two offsets are available (Fig. 1a). The implant can also be used as a hemiarthroplasty.

Since it has a straight stem it may press against the anterior cortex because of the anterior curve of the femur. There is, therefore, a risk of penetrating the femur, particularly in osteoporotic bone. For this reason, we recommend that a transverse osteotomy should be performed to allow safe insertion of the prosthesis, unless a femoral fracture is already present, such as in peri-prosthetic fractures. Fixation is primarily through its locking screws, at least six bicortical screws through good bone being recommended (Fig. 1b).

Between 1987 and 2000, we implanted 145 Kent hip stems into 141 patients. Of these hips, 63 (61 patients) were in men and 82 (80 patients) in women. The mean age of the patients at surgery was 66.1 years (18 to 93). No patient was excluded from the study.

The operations were performed by two surgeons (CAS, EM). The indications for implantation were aseptic loosening (75 hips), septic loosening (two), peri-prosthetic and prosthetic fracture (37), severe bony deformity (24), and fracture through a proximal femoral metastas-
sis (seven). Patients were followed for a mean of 5.1 years (2 to 15), until either their most recent follow-up, revision or death.

Both the Harris\textsuperscript{14} and Oxford hip scores\textsuperscript{15} were used to assess outcome. These were estimated from the outpatient notes before surgery and by postal questionnaire sent to all surviving patients at the end of the study.

**Statistical analysis.** Survivorship was calculated using Kaplan-Meier analysis, with removal of the component for any reason as the criterion for failure. Survivorship data and 95% confidence intervals (CI) are presented with \( p \leq 0.05 \) being regarded as significant.

**Results**

During the follow-up period, 37 patients died although their data were included in the survivorship analysis. The remaining patients were reviewed over a period of two years. In addition, a questionnaire was sent to all patients in order to measure the hip scores, patient satisfaction, and their subjective assessment of any improvement in levels of pain. The response rate of the surviving patients was 65\% (68 patients).

**Complications.** One patient died from a myocardial infarction and another developed a myocardial infarction but recovered to be discharged home. Three patients had a venous thromboembolic event from which each made a full recovery. One patient had a perforated gastric ulcer and underwent partial gastrectomy. One patient had a palsy of the sciatic nerve which had not recovered by the final follow-up, three years after operation. In one patient, pain related to entrapment of the sciatic nerve was successfully relieved by excision of scar tissue.

**Re-operations.** During the follow-up period 13 components required revision for a variety of reasons. In six, this was due to screw fracture and loosening of the stem, in three to loosening of both femoral and acetabular components and in one to fracture in the line of the screw holes. This hip was revised again after a further screw fracture. One patient suffered recurrent dislocation and infection requiring an excision arthroplasty. Two peri-prosthetic fractures required revision to a longer stem.

There were ten re-operations for reasons other than stem failure. Revision of the acetabular component was required in six hips, in five because of aseptic loosening and in one because of recurrent dislocation secondary to a malpositioned acetabular component. One hip was converted to an excision arthroplasty after loosening of the acetabulum with extensive bone loss. One patient had pain after fracture of screws necessitating replacement of the relevant screws. One fracture distal to the femoral stem, in a patient with an osteoarthritic knee, was treated by total knee replacement.

Radiological follow-up revealed a symptomatic fracture of screws in five hips. Dislocation, treated by closed reduction, occurred in six hips. In one patient, recurrence of an infection occurred after implantation of the Kent hip for septic loosening of a primary total hip arthroplasty. In view of the patient’s comorbidity the implant was left *in situ* with an adequate functional result.

**Fracture of a screw.** This occurred in 13 patients. The mean time from insertion to fracture was 3.1 years (3 months to 7 years). In five patients the screw fracture gave no symptoms and no treatment was required. In two the fractured screws were replaced at the same time as an acetabular revision. In the remaining six patients, fracture led to loosening of the stem and its subsequent revision. In 11 patients four distal screws had been used and in two six distal screws.

In five patients all the screws fractured although only four of these were symptomatic and required revision. In six only some of the screws fractured. Three of these required revision while the remaining three had no further fractures at follow-up at one, two and five years, respectively, from the time at which the screw fracture was first
noticed. In two patients fracture of some of the screws was noted, with progression to further screw fracture; in one, all the screws had fractured by 11 months and revision was required, and in the other, two further screws had fractured five years later. Because of the small number of patients involved, we could not draw any conclusions on the order of screw fracture although it appeared that the distal screws were usually the first to break. We saw only two patients with an isolated fracture of the proximal screw.

Functional evaluation. The median time to full weight-bearing was two days (mean 3.9; 95% CI 1.9 to 5.8). The mean Harris hip score improved from 25.7 (95% CI 20.3 to 31.1) pre-operatively to 66.6 (95% CI 59.9 to 73.5) at the time of the postal questionnaire. The mean Oxford hip score improved from 47 (95% CI 45.5 to 49.8) pre-operatively to 25 (95% CI 21.9 to 28.2) at the time of the questionnaire.

We found that 38 (55%) patients were very pleased with the results of their surgery, 17 (25%) were fairly pleased, five (7%) were not pleased and nine (13%) were very disappointed. When asked about improvement in pain, 47 (68%) patients felt that it was much improved, eight (12%) slightly improved, seven (10%) unchanged, five (7%) slightly worse and two (3%) thought that the pain was much worse.

Survival analysis. The cumulative survival rate, with failure defined as removal of the stem for any reason, was 93% at five years, 89% at ten years, and 77% at 15 years (Fig. 2). The standard error was 3.0%, 5.6% and 14.0%, respectively. Table I shows the number of patients at each time interval.

We also compared the survival curves for the stem in patients aged ≥ 70 years (71) with those in patients < 70 years (74) at the time of surgery. By 15 years the cumulative survival was 92% and 72%, respectively. Using Pearson rank correlation, we found a negative relationship between age and survival of the stem (r = -0.2302, p = 0.0042). These results indicated that survival of the stem in older,
lower-demand patients was good, but the failure rate was unacceptably high in younger, higher-demand patients (Figs 3 and 4).

Discussion

There is an increasing need for total hip arthroplasty to be undertaken in the presence of severe proximal bone loss or peri-prosthetic fracture.16-20 The Kent hip was designed to address the difficulties in controlling length and rotation, by allowing per-operative adjustment. Because the component is locked distally, early full weight-bearing was also possible. Our rate of cumulative survival up to ten years for this implant is comparable with that of other revision stems used in similar situations.21 However, by 15 years the cumulative survival was lower. Most studies on survivorship analyses at 15 years have wide confidence intervals, therefore although no firm conclusions can be drawn our results indicate that survival of this implant after ten years deteriorates when compared with other components.22-27 It appears that, for patients aged ≤70 years, the failure rate of the Kent hip is unacceptably high. Few studies have analysed survival of the femoral stem by age, it is therefore difficult to state how the Kent hip compares with other prostheses for this age group.

Screw fracture. Biomechanical studies by one of the authors (CAS) on the Kent hip indicated that three interlocking screws in the distal bone would provide adequate support (unpublished data). Four were chosen in the early operative technique. However, screw fracture still occurred in vivo, leading to the recommendation that at least six interlocking screws should be used to distal bone. Screw fractures subsequently reduced although still occurred in two hips.

In the proximal fragment, three or more interlocking screws are required. If there are fewer than six, angulation of the proximal fragment imparts an angular strain, leading to increased stress concentration on the implant at the site of the fracture.

No screw should be passed through the prosthesis at the site of the fracture as this may lead to fracture of the prosthesis, although this did not occur in our study. In vitro stress tests have indicated that, when possible, adjacent holes should be used, but that more than six screws placed distally into sound bone are not required (unpublished data). Despite this, screw fracture occurred in two of our cases in which six distal screws had been used.

The functional outcomes using the different prostheses described in the literature are not easily compared since differing outcome scores are used and patient cohorts are dissimilar. Although we found a substantial improvement in the functional outcome as measured by the Harris and Oxford hip scores, post-operative mean values of 25 and 66.6, respectively, indicated that there remained substantial functional impairment.

The Kent hip allows early weight-bearing and discharge from hospital. This compares favourably with many of the other prostheses used in this type of patient.11,15,28 However, the Kent hip, as a first-generation locking device, has several disadvantages. First, fixation is only distal and provided by screws alone. There is no proximal fixation. Consequently, as there is no bony ingrowth onto any part of the stem, proximal stress shielding occurs, and there is a risk of screw fracture. Secondly, since it is a straight stem, the prosthesis does not follow the curvature of the femur. A transverse osteotomy is therefore required in order to avoid penetration of the anterior cortex of the femur. Second-generation devices address some of these problems. The Kent hip represents the precursor of the newer locking stems available on the market which now offer the potential of ingrowth, a greater range of sizes, customisation and better proximal fill.

In the frail, elderly patient with a peri-prosthetic fracture, or with loosening of a femoral stem and extensive proximal bone loss, touch or partial weight-bearing is often not possible. By allowing the patient to bear full weight early, the Kent hip helps to maintain the patient’s independence and the return to previous levels of activity. Because of the high survival of the Kent hip in patients aged ≥70 years we believe that this implant has an important place in the management of these difficult problems and is particularly useful as a salvage procedure when alternative methods of fixation are limited.

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References