Sixteen-Year Follow-Up of the Cemented Spectron Femoral Stem for Hip Arthroplasty

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Abstract: Clinical and radiographic follow-up was performed on a consecutive series of 105 patients who underwent 120 total hip arthroplasties at the authors’ institution from 1983 to 1988 with a straight, cobalt-chrome femoral stem implanted using a second-generation cementing technique. The mean age at the time of surgery was 68.5 years, and the mean follow-up was 16 years. At 16 years’ follow-up, the prevalence of revision for aseptic loosening of the Spectron femoral component was only 4.2%; 5 stems were revised for aseptic loosening at a mean of 10.2 years after implantation. Sixteen-year survivorship of the component was 93.9% ± 2.7% when revision for aseptic loosening was taken as the endpoint or 90.3% ± 4.4% when either revision for aseptic loosening or radiographic evidence of loosening was taken as the endpoint. Key words: hip arthroplasty, second-generation cementing techniques, femoral prosthesis.

Femoral stem loosening and implant failure are among the most prevalent clinical problems observed in long-term follow-up of patients with total hip arthroplasties. These complications, first noted at intermediate- and long-term follow-up of the stainless-steel Charnley femoral stem [1], prompted modifications in implant design and manufacture to provide more durable stem fixation. These analyses suggested that alloys with long stems and broad, rounded medial borders would provide greater resistance to stem failure and protect the cement mantle from excessive stresses [2]. In addition, the introduction of second-generation cementing technique, characterized by distal plugging of the medullary canal and retrograde introduction of cement with a cement gun [3], was expected to increase cement penetration into trabecular bone and minimize loosening. Collectively, these modifications, it was believed, would significantly improve the survival of cemented femoral stems. The purpose of this study was to determine whether these expectations were justified by evaluating the long-term (16-year mean) clinical and radiographic outcomes of a cohort of patients in whom a cobalt-chrome femoral stem was implanted using a second-generation cementing technique. To date, this is the longest follow-up study of the Spectron cobalt-chrome femoral stem.

Materials and Methods

Study Population

One hundred fifty-two consecutive total hip arthroplasties were performed on 136 patients at our...
institution between 1983 and 1988 using a collared, straight, cobalt-chrome femoral prosthesis (Spectron, Smith & Nephew, Memphis, TN) with 32-mm femoral head cases (except for the 5 cases of femoral neck fractures that received bipolar heads) and a second-generation cementing technique (Simplex bone-cement, Howmedica, Rutherford, NJ). Our group previously published a clinical and radiographic study evaluating the 10-year performance of these implants [4]. Approval to study patients was obtained from the Institutional Review Board at the authors’ institution. Patients were located by physician office records, a computer search program (Equifax), and a private investigator. At the time of the 10-year follow-up study, 20 hips in 20 patients were lost to follow-up, leaving 132 hips in 116 patients [4]. At the time of the present study (a mean of 16 years from the index surgery), an additional 12 hips in 11 patients were lost to follow-up, leaving 120 hips in 105 patients. Of these 120 hips (77 females and 28 males, with a mean age of 68.5 years [range, 17–85 years] at the time of the index procedure), 40 hips had radiographic and clinical follow-up, 12 hips had only clinical follow-up, 55 patients (62 hips) had died (none had been revised), and 6 femoral stems had been revised. The preoperative diagnosis of the 105 patients was osteoarthritis in 75, rheumatoid arthritis in 26, avascular necrosis in 9, displaced femoral neck fractures in 5, posttraumatic arthritis in 4, and developmental dysplasia in 1 hip (0.8%). Acetabular components consisted of 99 cemented metal-backed Spectron cups (Smith & Nephew), 12 uncemented threaded cups (11 Weill screw-in; Protek, Camarillo, CA), 1 Mecron ring (Mecron, Germany), 4 uncemented Optifex cups (Smith & Nephew), and 5 spectron bipolar heads. Ninety (75.0%) of the surgeries were performed by 3 surgeons and the remainder by 13 other surgeons.

**Radiographic and Clinical Evaluation**

Radiographic data were collected and evaluated at the time of the index surgery and at final follow-up as previously described [4]. Mean radiographic follow-up was 16 years (range, 13.3–17.4 years).

Clinical data were collected at the time of the index surgery and at final follow-up. The subset of patients with clinical follow-up in this report had their preoperative, 10-year, and 16-year results compared. Clinical performance was evaluated by physical examination at recent follow-up visits or by retrospective chart review using a modified Harris Hip Score [5].

**Statistical Analysis**

Kaplan-Meier analysis was used to evaluate survival of the implant with regard to revision or both revision and loosening [6]. Survivorship curves with corresponding confidence intervals were generated with failure defined according to 3 endpoints: (1) revision because of any reason, (2) revision because of aseptic loosening of the femoral component, and (3) loosening of the femoral component based on radiographic evidence or revision surgery because of aseptic loosening. For the purpose of survivorship analysis, impending implant failure or loosening was defined as radiographic evidence of stem migration, stem bending or breakage, cement fracture, prosthesis-cement radiolucency, or a circumferential radiolucent line of >1 mm around the cement-bone interface [7].

**Survivorship Analysis**

Of the 120 femoral stems with follow-up, there was 1 stem that was revised at 10.5 years for late infection and 3 stems that were revised at a mean of 10.2 years for aseptic loosening. Two of the 5 stems revised for aseptic loosening were revised between 10 and 16 years’ postsurgery. With revision for any reason as the endpoint, 16-year survivorship of the component is 92.7% ± 2.9% (Fig. 1A). If the septic hip is excluded from the survivorship analysis, 114 (95.8%) of the remaining 119 femoral components remained in place at a mean follow-up of 16 years (Figs. 1B, 2A, and 2B). With revision for aseptic loosening taken as the endpoint, 16-year survivorship of the component is 93.9% ± 2.7% (Fig. 1B).

All 5 aseptic revisions involved loosening of both the femoral stem and cup. Of the implants not revised, 1 (0.8%) demonstrated radiographic evidence of impending failure with radiolucencies at the implant-cement interface in multiple zones and implant-cement debonding. With either revision for aseptic loosening or radiographic evidence of loosening taken as the endpoint, 16-year survivorship of the component is 90.3% ± 4.4% (Fig. 1C), and the prevalence of aseptic loosening based on revision surgery or radiographic evidence is 5.0%. With revision for aseptic loosening taken as the endpoint, 16-year survivorship of the total hip arthroplasty (revision of either cup, stem, or both) is 84.0%, with a revision rate of 11.8%. 
Radiographic and Clinical Results

Final radiographs were obtained on 40 patients. Three femoral stems (7.5%) among those not revised showed focal areas of cystic osteolysis—all of these demonstrated radiographic loosening of the originally implanted, cemented, metal-backed cups as well as significant polyethylene wear. One osteolytic lesion was located in Gruen zone 3, and 2 osteolytic lesions were located in Gruen zone 5. All 3 lesions were present in this subgroup at 10-year follow-up. Cement mantle thickness as measured in the midsection of each Gruen zone (excluding zones 4 and 11) was 3.0 mm (range, 0–18 mm) compared with 3.6 mm at 10 years [4].

Host-bone adaptation to the implant was demonstrated by medial proximal femoral bone resorption beneath the collar and distal femoral cortical hypertrophy. Twenty-eight of these (70%) had resorption of ≤25%, 6 hips (15%) had resorption of 26% to 50%, 4 hips (10%) had resorption of 51% to 75%, and 2 hips (5%) had resorption of 76% to 100%. Distal femoral cortical hypertrophy ranging from 1 to 8 mm was identified in 10 patients (25%). The position of the stem at follow-up ranged from 10° of varus to 5° of valgus, with 31 stems (77.5%) within 2° of neutral. Heterotopic ossification as defined by Brooker et al. [8] occurred in 40 hips: 18 hips had grade 1, 15 hips had grade 2, 5 hips had grade 3, and 2 hips had grade 4 heterotopic ossification.

The mean modified Harris Hip Score for the subset of patients at 16-year follow-up was 86.3 (range, 53–100); this same cohort score at 10-year follow-up was 90.4 (range, 56–100). Four patients in this group were markedly worse clinically since their 10 year follow-up: 1 had loosening of a cemented acetabulum component (16.3 years’ follow-up), 1 had stem migration (16 years’ follow-up), 1 had eccentric polyethylene wear (16.5 years), and 1 had developed dementia and become bed-bound, with no changes in implant fixation.

Discussion

There are few studies that report on long-term outcomes of the newer femoral prosthetic designs implanted using second-generation cementing technique. A 15-year mean follow-up of 162 forged, cobalt-chrome femoral stems (Computer-assisted design or Harris II design) implanted by multiple surgeons using a second-generation cementing technique demonstrated a probability of failure at of 6.8% at 15 years [13] and 6.2% at 18 years [14]. Charnley, flat-back, stainless-steel femoral stems implanted using a second-generation cementing technique have demonstrated aseptic loosening rates of 2.8% and 4.8% at 15 years’ and 20 years’ follow-up, respectively [15,16]. Garellick reported on a 10-year follow-up of 204 cemented Spectron stems in which the Spectron stem implanted with an all-polyethylene cup demonstrated stem survivorship of 95.9% ± 3.0%. None were revised and only 1 demonstrated radiographic evidence of loosening [17]. An 11-year follow-up from
the Swedish National Hip Registry of the Spectron stem implanted with cemented metal-backed or all-polyethylene components reported a prosthesis survival rate of 88.6% (this did not differentiate between revisions of the cup or stem). However, the survivorship of the Spectron stem with an all-polyethylene cup was 100% [18]. More recently, a 15-year follow-up study on the Harris II design cemented stem (a collared stem with a matte-finished surface) implanted with a second-generation cementing technique reported a femoral component survival rate of 92.2% [19].

It is difficult to assess the relative contribution of stem design and cement technique to survival of the Spectron prosthesis because there are no published series reporting survivorship of Spectron femoral stems implanted using first-generation techniques. A direct comparison of first- and second-generation techniques using the Charnley polished flatback stem suggests that a cement technique may improve stem survivorship. A minimum 20-year follow-up of 2 series of patients in which a Charnley stem was implanted by one surgeon using either first- or second-generation techniques demonstrated revision rates of 6.8% and 4.8%, respectively [15]; these differences were not statistically significant. These results, however, might more likely result from the surgical skill of the individual surgeon than cement technique, because similar series examining Charnley flatback stems implanted by multiple surgeons demonstrate statistically significant improved survivorship with second-generation techniques compared with first-generation techniques at 10- to 15-year follow-up [1,17,20,21].

Certain stem designs have been shown not to perform better despite the use of second-generation cementing techniques. Maurer and colleagues demonstrated revision rates of 25.6% at 5.2 years after implantation of the SLS (self-locking straight) stem, which is rough-blasted proximally [22]. Such stems have greater fixation strength than smooth stems but risk being abrasive in the case of micromotion. If the stem debonds, it abrades cement and rapidly generates particulate debris. A similar study examining surface finish compared Harris II design stems either uncoated or roughened with a methylmethacrylate precoating (Precoat). At a mean fol-

Fig. 2. (A) AP and (B) lateral radiographs of a 79-year-old man (taken 17.4 years’ postsurgery) who had a Spectron total hip arthroplasty performed with second-generation cementing technique because of osteoarthritis.
low-up of 8.4 years, 9.5% of the Precoat stems failed. At a mean follow-up of 13.5 years, only 3.9% of the uncoated stems failed [23]. Mechanisms of failure of the Precoat stem included bone-cement loosening and osteolysis.

Although there are no published series reporting survivorship of Spectron femoral stems implanted using first-generation techniques, one can speculate how this stem may have performed by examining the survivorship of stems with similar designs. Implantation of the Müller straight stem and first-generation cementing technique results in a failure rate of 10.7% when either revision for aseptic loosening or radiographic evidence of aseptic loosening was taken as the endpoint [24]. Failure rates of 7.3% resulting from aseptic loosening were observed in a 17-year mean follow-up study of the Stanmore femoral prosthesis (composed of either cobalt-chrome or titanium alloy) [25].

Overall, these observations suggest that the causes of aseptic loosening are multifactorial and include cement technique, stem design (stem size, finish, coating, composition) and the host’s response to particulate debris. Statistically significant improvements in stem survivorship can be attributed to both improved cementing techniques and stem design.

In our study, 3 of the 5 revised femoral stems and the single stem demonstrating radiographic evidence of loosening had cemented, metal-backed acetabular cups implanted during the original procedure, which may have contributed to osteolysis [26]. Consistent with this, 10-year follow-up of 86 total hip arthroplasties in which a Spectron cemented metal-backed acetabular cup was used demonstrated a 40.8% cup failure rate (9.2% of the cups were revised and 31.6% of the cups demonstrated radiographic evidence of loosening) [12]. Garellick and colleagues reported on a 10-year follow-up of 204 Spectron total hip arthroplasties in which cemented metal-backed acetabular components were implanted. Four metal-backed cups were revised for aseptic loosening and 23 cups demonstrated radiographic evidence of loosening [17,18,27]. They proposed avoiding cemented metal-backed cups in combination with large femoral heads to minimize wear.

The original hip arthroplasty technique used large-sized femoral heads and cemented-metal backed cups that may have contributed to wear, osteolysis, and premature failure of some of the stems. Despite these drawbacks, fixation of this collared matte-finished femoral component implanted with a second-generation cementing technique demonstrated good survivorship at a mean 16-year follow-up.

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