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Contribution of Cable Debris Generation to Accelerated Polyethylene Wear

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The decision of the senior author of a large total hip replacement practice to switch from wire to braided cable for reattachment of the greater trochanter provided the opportunity to evaluate the long term effects (on acetabular component wear, osteolysis, and component loosening) caused by the introduction of metallic debris (generated by cable fretting and breakage) into the total hip arthroplasty construct. Seven hundred and nine consecutive primary total hip arthroplasties were performed during a 5-year period and followed up for a minimum of 10 years. Wire and cable reattachment of the greater trochanter was used sequentially. At minimum 10-year followup the cable group had significantly more wear, osteolysis, and acetabular radiographic evidence of loosening. Those involved in the design and use of total hip arthroplasty devices must minimize potential sources of metallic debris and other potential sources for third body wear in the total hip arthroplasty construct to help ensure longevity of the arthroplasty.

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The contribution of third body debris introduction at the bearing surface of the total hip arthroplasty construct, to the acceleration of wear, has been shown in vitro.[24] In addition, anecdotal cases of metallic debris migration to the bearing surface with acceleration of bearing surface wear have been reported.[1,2,6,7,25,29] However, there has been no opportunity in the past to study the potential long term effects of debris accumulation at the bearing surface of the total hip arthroplasty in vivo in a large series of patients.

The decision of the senior author to switch from the use of wire to braided cable in the reattachment of the greater trochanter, during the total hip arthroplasty procedure (in hopes of a stronger reattachment construct) between June 1981 and December of 1983, provided a unique opportunity to examine the effect on wear and component fixation in vivo of metallic debris migration (produced by cable fretting and breakage) to the bearing surface of the total hip arthroplasty construct (Fig 1) Cable reattachment was abandoned in December of 1983, when the debris produced by fretting and breakage of the cable with bearing surface migration was recognized[19] (Figs 2, 3). Hence, the total hip arthroplasties performed by the same

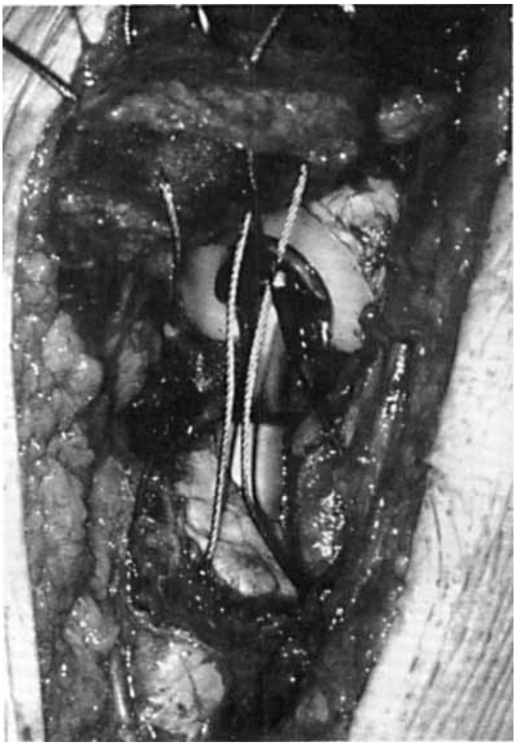

Fig 1. Intraoperative photograph of 1.5-mm diameter seven-strand multifilament cable.

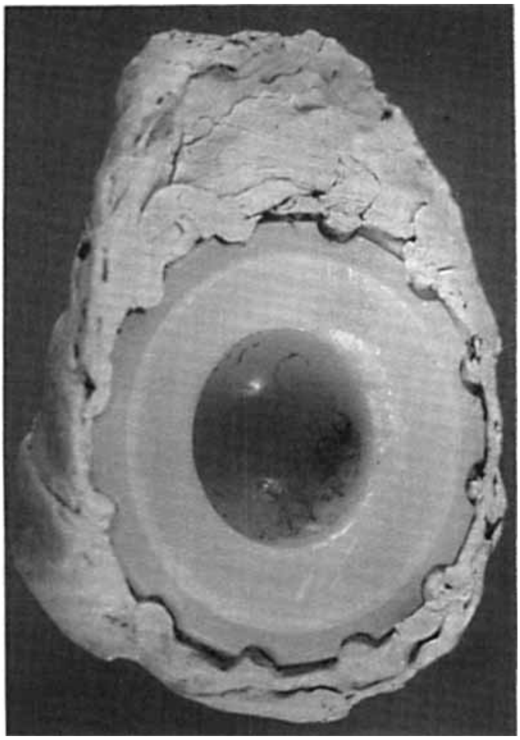

Fig 2. Retrieval of Charnley acetabular component where cable debris was embedded in the articulating surface.

surgeon with wire greater trochanteric reattachment immediately preceding and immediately after the use of cable provided a fortuitous control for the long term evaluation.

The hypothesis of the present study was that the metallic particulate debris generated from fretting and breakage of the CoCr cable would migrate to the bearing surface of the total hip arthroplasty construct and accelerate bearing surface wear, osteolysis, and component loosening.[27] The present study evaluates any differences (between cases with wire and cable greater trochanteric reattachment) in acetabular component wear, osteolysis, component loosening, revision rates, and greater trochanteric nonunion rates in a consecutive series of primary total hip arthroplasties where wire and cable greater trochanteric reattachment were used sequentially by one surgeon during the total hip arthroplasty procedure. The study also sought to evaluate any differences in acetabular component wear, osteolysis, component loosening, and revision rates between 22– and 28–mm femoral head articulations.

MATERIALS AND METHODS

From June 1979 through December 1984, the senior author (RCJ) performed 709 consecutive primary total hip replacements at the authors' institution using a transtrochanteric approach to the hip. Seven hundred nine hips were replaced in 565 patients during this period. Three hundred twenty-two hips were replaced in men and 387 hips were replaced in women. The average age of the patients at time of index arthroplasty was 65 years (range, 18–93 years). Three hundred twenty-six patients with 437 hips were known to be alive at least 10 years postoperatively with the average age of 62 years (range, 18–91 years) at the time of index arthroplasty.

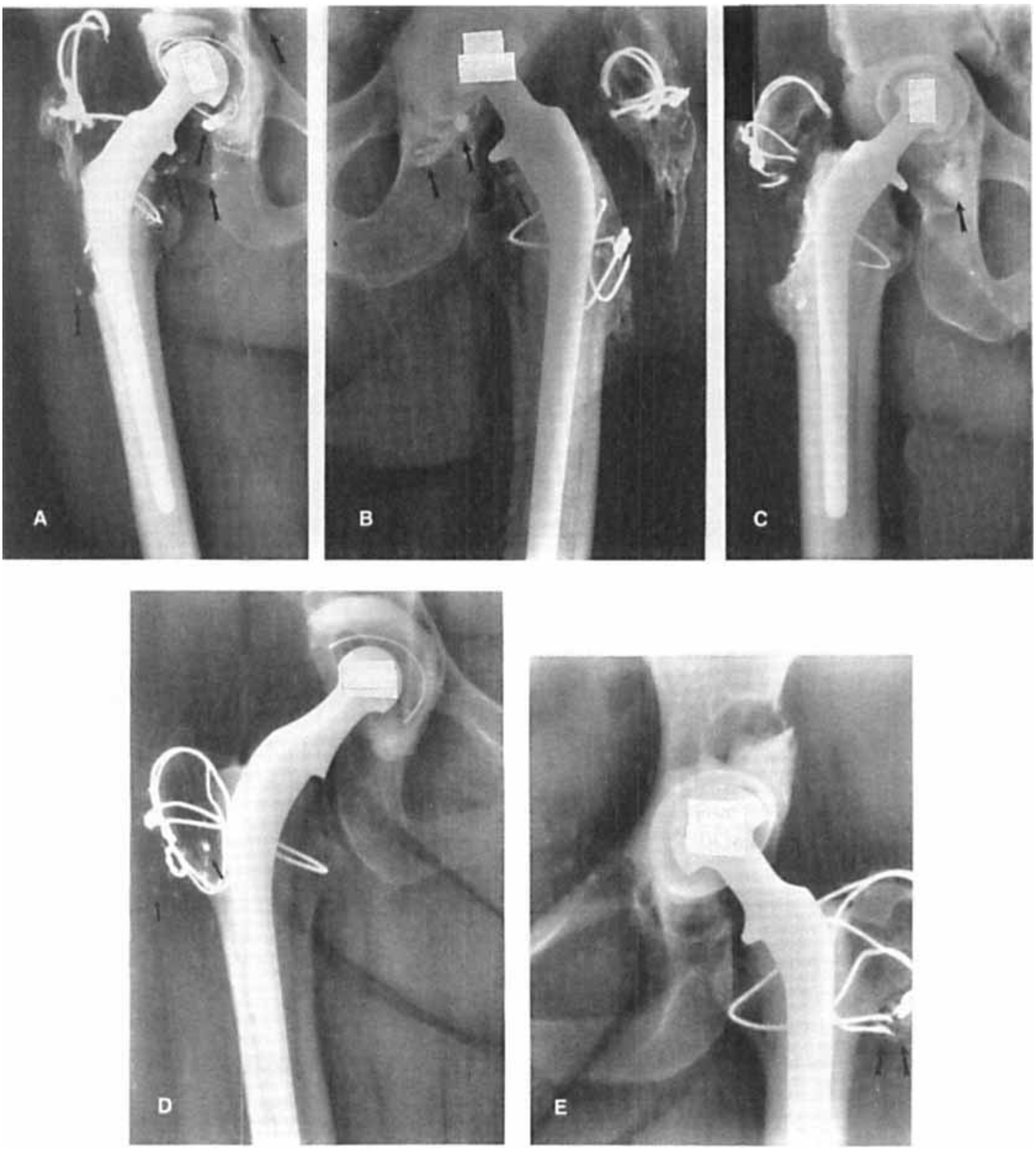

Fig 3A–E. Examples of cable debris migration. (A) Radiograph showing breakage and fretting of cable at the greater and lesser trochanter with debris migration to the lateral femur, calcar area, inferior acetabulum and into the pelvis along the iliopsoas tendon (arrows). Acetabular osteolysis and acetabular component loosening are present. There is acetabular component wear. (B) Radiograph showing intraarticular and extraarticular cable debris (arrows) and acetabular component wear. (C) Radiograph showing intraarticular cable debris (arrow) and loosening and migration of the acetabular component. (D) Radiograph showing intact cables with extraarticular debris. (E) Radiograph showing extraarticular cable debris with breakage of the cable distal to the knot (most cables broke in areas away from the knot). Acetabular component wear is seen.

The operative technique involved a lateral approach, using a greater trochanteric osteotomy, and a complete capsulectomy. The acetabulum was prepared by using cement introduced in the doughy stage and placing the component as inferiorly and medially as possible. A plunger pressurizer was used to pressurize the cement. The femoral canal was prepared by removing all loose cancellous bone and meticulously drying the femoral canal. A cement plug was placed distally and a cement gun was used to introduce cement in a retrograde manner (so called contemporary cementing techniques).[15] Prophylactic antibiotics were used. The greater trochanter was reattached as far laterally as possible. In 379 hips, three 18-gauge stainless steel monofilament wires (two vertical, one horizontal) were used to reattach the greater trochanter. In the other 330 hips, three CoCr cables or two CoCr cables and one 18-gauge stainless steel wire were used for greater trochanteric reattachment. The cables were 1.5 mm diameter, seven strand multifilament cables composed of CoCrWNi alloy (Zimmer, Warsaw, IN). Cable reattachment was used consecutively from June 1981 to December of 1983, and wire reattachment was used consecutively from June 1979 to May 1981 and January 1984 to December 1984. A body exhaust system and a high air exchange room was used. Postoperatively, the patients were treated initially with bed rest followed by progressive partial weightbearing with crutches for 6 weeks, then progressing to weightbearing as tolerated.

As will be shown by the data, fortuitously (for the purposes of this study) during the period where cable was used for greater trochanteric reattachment, the senior author was converting from the use of a Charnley femoral component with an all polyethylene acetabular component to an Iowa femoral component with an all polyethylene acetabular component and then to an Iowa femoral component with a metal backed acetabular component. The femoral prosthesis used was either a Charnley flat back prosthesis (Zimmer) or an Iowa femoral component (Zimmer). The Charnley prosthesis was constructed of stainless steel, which was polished, and had a 22.25 mm diameter head that articulated with an ultrahigh molecular weight polyethylene acetabular component with an outer diameter of 40 or 44 mm. With the Iowa femoral prosthesis, initially an ultrahigh molecular weight all polyethylene acetabular component followed by a titanium metal backed ultrahigh molecular weight polyethylene acetabular component (TiBac, Zimmer) was used. All components were inserted with Simplex P cement (Howmedica, Rutherford, NJ), (Table 1).

The authors attempted to interview all living patients and the families of deceased patients. Living patients were encouraged to return for clinical and radiographic followup. If unable to return, they were asked to send a radiograph (made locally) to the authors for evaluation. All living patients who were unable to present to the authors' office for clinical evaluation were interviewed by telephone using a Standard System of Terminology for reporting results described by Johnston et al.[17] Family members of deceased patients were interviewed to determine the function of their hip at the time of death.

At minimum 10-year followup, 326 patients with 437 hips were known to be alive and 196 patients with 214 hips had died. Forty-three patients with 58 hips were lost to followup. Thus, the status of 671 hips in 522 patients was known at the most recent followup examination. The demo-

TABLE 1. Components of Study Group and Control Group (Zimmer)

Femoral	Acetabular
Study group: cable reattachment	
Charnley stainless steel (22.25 mm)	Molded polyethylene
Iowa CoCr (28 mm)	Molded polyethylene
Iowa CoCr (28 mm)	Machined polyethylene metal backed
Control group: wire reattachment	
Charnley stainless steel (22.25 mm)	Molded polyethylene
Iowa CoCr (28 mm)	Molded polyethylene
Iowa CoCr (28 mm)	Machined polyethylene metal backed

graphics for the cable and wire groups and for the various subgroups are shown in Table 2 Of the 326 patients with 437 hips known to be alive, 275 patients with 370 hips were evaluated clinically and with an anteroposterior (AP) radiograph of the pelvis that included the tip of the femoral stem made at a minimum of 10 years after the index arthroplasty. Hence, 84.4% of the known living patients had a minimum 10–year followup radiograph. Two hundred fifty-three of these patients returned for examination and 21 patients sent radiographs that had been made elsewhere. The remaining 51 patients with 67 hips refused to have final followup radiographs made. For these 51 patients, the most recent radiographs had been made in the minimum of 5 years for 54 hips. Hence, only 13 hips lacked minimum 5–year radiographs.

Radiographic Evaluation

Observations and measurements were made on AP pelvis radiographs (which included the tip of the prosthesis) obtained early in the postoperative period and at 5–year intervals until the latest followup. Every radiograph for each patient was reviewed by two observers (JDH, JJC) in a nonblinded fashion and a consensus opinion was made on each parameter. These observers were not the treating physicians. Intraobserver and interobserver variability studies were performed for the wear method only as will be described later. Magnification was corrected for by standardization of all measurements against the magnification between the known and measured head size. Osteolysis of greater than 5 mm or bone and cement radiolucencies were recorded in the three acetabular zones described by De Lee and Charnley[10] and the seven femoral zones described by Gruen et al,[14] respectively. Heterotopic ossification was graded according to Brooker.[4] The radiographs were analyzed for breakage of the greater trochanteric fixation and the migration of broken wire or cable (intraarticular or extraarticular). The presence or absence of greater trochanteric union also was recorded.

Femoral Loosening

Loosening of the femoral component was classified according to the criteria of Harris et al.[15] Definite loosening was defined as subsidence of the femoral component, fracture of the cement or stem, or the development of a cement and prosthesis radiolucent line on serial radiographs. The last criterion was modified to include only lucencies greater than 1 mm for the Charnley group (where a polished stem was used) and any lucency for the Iowa component. These always occurred in Gruen Zone 1 when present. Any loosening between the prosthesis and cement in Gruen Zone 1 regardless of the width was recorded as debonded. Probable loosening was defined as the presence of a continuous radiolucency along the entire bone to cement interface. Possible loosening was defined as a radiolucent line at the bone to cement interface that encompassed more

TABLE 2. Demographic: Cable Wire and All Groups

Group	Number of Hips	Age of Surgery (years)	Male: Female	Diagnosis (%)Osteoarthritis	% 10 Year Radiograph	% Lost
Cable and wire groups						
Cable (10 years, n = 181)	330	67.1	154:176	79.4	85.4	5.8
Wire (10 years, n = 189)	379	67.7	168:211	76.8	77.8	10.3
All groups						
CPC	52	66.3	12:40	84.6	93.3	8.3
CPW	141	67.3	51:91	84.3	87.5	17.5
IPC	81	68.7	44:37	75.3	84.0	2.0
IPW	81	70.0	47:34	79.0	89.1	13.2
IMBC	197	66.3	98:99	79.7	84.1	4.3
IMBW	157	70.0	70:87	76.4	66.7	3.3

CPW = Charnley (all polyethylene 22.25 mm) with wire; CPC = Charnley (all polyethylene 22.25 mm) with cable; IPW = Iowa (all polyethylene 28 mm) with wire; IPC = Iowa (all polyethylene 28 mm) with cable; IMBW = Iowa (28 mm) metal back with wire; IMBC = Iowa metal back with cable (28 mm).

than 50% but less than 100% of this circumference of the stem on at least one radiograph.

Subsidence of the femoral component was determined with the use of the method of Louden and Charnley.[21] A vertical line, drawn through two measured midpoints on the distal (straight) part of the stem, defined the central axis of the stem. Lines then were drawn perpendicular to this line, at the distal tip of the stem, and at the point where the trochanteric wire or cabie passed through the lateral cortex of the femur. The distance between these two lines was measured on the initial postoperative radiograph and on the radiograph that was made at the latest followup evaluation. Subsidence was defined as a difference in measurement (considering magnification) of more than 5 mm when the two radiographs were compared, fracture of the cement, or the presence of a superolateral lucency of more than 1 mm at the cement to prosthesis interface for Charnley stems and any prosthesis cement lucency for Iowa stems.

Acetabular Loosening

Definite loosening of the acetabular component was defined as migration of the component or the presence of any new fracture in the cement mantle; probable loosening, as a circumferential radiolucency around 100% of the component at the bone to cement interface; and possible loosening, as radiolucency around 50% to 99% of the component at the bone to cement interface. Migration of the acetabular component was evaluated using the criteria of Massin et al.[23] On each radiograph, the vertical distance between the center of the cup and the line joining the two teardrops was measured. The horizontal distance between the center of the cup and a vertical line through the teardrop also was measured. If these distances varied more than 5 mm between the radiograph that had been made immediately postoperatively and that made at the latest followup examination, or if any new crack was detected in the cement mantle around the prosthesis, the acetabular component was considered to have migrated.

Wear

Linear wear was determined by measuring the change in the distance between the center of the femoral head and the shortest distance to the periphery of the acetabular component from immediate postoperative radiographs to those at latest followup. Volumetric wear was calculated using πr^2 times linear wear. Measurements were made with a digitizing stylus and tablet (Sigma Scan, Jandel, LaJolla, CA) with an accuracy of 0.025 mm. Magnification was standardized against the known circumference of the femoral head. All measurements were made by a single observer (JPO) experienced at measuring acetabular component wear. The intraobserver and interobserver variability for this method, with the measurements made by the same observer, were evaluated in a previous study and were found to be 0.3 and 0.2 mm, respectively.[5]

Statistical Analysis

The Kaplan-Meier method[18] was used to evaluate implant survival regarding revision or loosening for all hips. Survivorship curves were generated with corresponding confidence intervals with failure defined according to these five end points: (1) revision for aseptic acetabular loosening; (2) revision for aseptic femoral loosening; (3) revision for aseptic loosening of either component; (4) loosening of the acetabular component, defined as radiographic definite or probable loosening or revision for aseptic acetabular loosening; and (5) loosening of femoral component, defined as radiographic definite or probable loosening or revision for aseptic femoral loosening.

Wear rates also were analyzed statistically. The wear rates for the entire cable group were compared with the entire wire group. In addition, wear rates were compared for the variables of head size and metal backed versus nonmetal backed components.

Clinical and radiographic results were analyzed with the two tailed Fischer exact test for categorical variables and a two tailed Student's t test when one variable was continuous. The Wilcoxon rank sum test was used when comparing wear rates by categoric values, because wear rates are not normally distributed. Survivorship curves were compared using linear regression analysis.

RESULTS

Analysis of patients with 10–year followup are noted below. In addition, the survivorship curves for all patients are shown with p values reported for the comparison of survivorship curves using linear regression analysis.

Acetabular Component Wear

Acetabular linear and volumetric wear were significantly higher in hips with cable greater trochanteric fixation. Acetabular wear was evaluated in patients with 10–year followup and those who underwent revision for aseptic acetabular loosening. The median volumetric acetabular component wear in the cable group was significantly higher at 51.69 mm^3 per year versus the wire group at 45.78 cubic mm year ($p = 0.045$). The median linear wear also was increased significantly in the cable group at 0.0856 mm per year versus wire group at 0.0744 mm per year ($p = 0.039$). The median volumetric wear for the Iowa metal back cable group was 53.66 mm^3 per year, Iowa metal back wire 36.52 mm^3 per year, Iowa all polyethylene cable 64.41 mm^3 per year, Iowa all polyethylene wire 59.99 mm^3 per year, Charnley all polyethylene cable 36.27 mm^3 per year, and the median volumetric wear for the Charnley all polyethylene wire group was 44.48 mm^3 per year. The median linear wear for the Iowa metal back cable group was 0.0874 mm per year, Iowa metal back wire 0.0594 mm per year, Iowa all polyethylene cable 0.1047 mm per year, Iowa all polyethylene wire 0.0975 mm per year, Charnley all polyethylene cable 0.0597 mm per year, and the median wear for the Charnley all polyethylene wire group was 0.0723 mm per year.

Acetabular linear and volumetric wear were significantly higher in 28–mm articulations when compared with 22–mm articulations. The median volumetric wear in 28–mm articulations was significantly higher at 50.20 mm^3 per year when compared with 22–mm articulations, 39.50 mm^3 per year ($p = 0.025$). The median linear wear in 28–mm articulations was also significantly higher at 0.0818 mm per year when compared with 22–mm articulations at 0.0642 mm per year ($p = 0.022$).

Osteolysis

Femoral and acetabular osteolysis were significantly higher in the group with cable fixation when compared with the group with wire fixation. The prevalence of femoral osteolysis in the cable group was 53% and in the wire group was 29.6% ($p = 0.0001$). The prevalence of acetabular osteolysis in the cable group was 16.6% and the wire group was 7.9% ($p = 0.0163$). The prevalence of femoral osteolysis was 67.9% for the Iowa metal back cable, 37.2% for the Iowa metal back wire, 54.8% for the Iowa all polyethylene cable, 29.3% for the Iowa polyethylene wire, 3.6% for the Charnley all polyethylene cable, and the prevalence of femoral osteolysis was 21.4% for the Charnley polyethylene wire. The prevalence of femoral osteolysis was increased significantly when cable was used in the Iowa metal back group ($p = 0.0002$), and the Iowa all polyethylene group ($p = 0.0262$). The prevalence of acetabular osteolysis was 19.8% for the Iowa metal back cable, 6.4% for the Iowa metal back wire, 19% for the Iowa all polyethylene cable, 4.9% for the Iowa all polyethylene wire, 0% for the Charnley all polyethylene cable, and the prevalence of acetabular osteolysis was 11.4% for the Charnley all polyethylene wire. The Iowa all polyethylene group showed a trend toward increased acetabular osteolysis when cable fixation was used ($p = 0.0882$). However, acetabular osteolysis was significantly higher with cable fixation in the Iowa metal back group ($p = 0.0108$). Acetabular osteolysis for the 22–mm all polyethylene was 8.1%, 28–mm all poly 12% and 28–mm metal back 14.3%. Femoral osteolysis for the 22–mm all polyethylene was 16.3%; 28–mm all polyethylene 42.2%; and 28–mm metal back, 53.4%.

Femoral and acetabular osteolysis were higher in hips with 28–mm heads when compared with hips with 22–mm heads. The prevalence of femoral osteolysis was significantly higher in the 28–mm articulations than in the 22–mm articulations ($p < 0.0001$). Twenty-two–millimeter articulations showed lower prevalence of femoral osteolysis when compared with the 28–mm metal back ($p < 0.0001$) and 28–mm all polyethylene groups ($p = 0.0001$). (The inability to detect adverse effects in the cable 22–mm Charnley group may be related to the small numbers and less length of followup in this group versus the 22–mm Charnley wire group in which the numbers were larger and the followup longer. The small numbers in the Charnley cable group was related to the short period of the use of cable with Charnley prostheses in the transition from wire to cable and Charnley prostheses to Iowa prostheses.)

Acetabular Revision or Loosening

Revision rates for aseptic acetabular loosening were not significantly different between cable and wire hips. However, the revision rate for hips with 28–mm heads was significantly higher than those with 22–mm heads. The prevalence of revision for aseptic acetabular loosening was 6.1% for the cable group and 5.8% for the wire group. The prevalence of revision for aseptic acetabular loosening was not increased significantly in the cable versus wire groups overall ($p = 0.35$), (Fig 4A). The prevalence of revision for aseptic acetabular loosening was 8.1% for the Iowa Metal back cable, 4.8% for the Iowa all polyethylene cable, 5.1% for the Iowa metal back wire, 12.2% for the Iowa all polyethylene wire, 0% for the Charnley all polyethylene cable and 2.9% for the Charnley all polyethylene wire. Twenty-two–millimeter heads showed less need for revision than 28–mm heads ($p = 0.0005$), (Fig 4B).

Hips with cable greater trochanteric reattachment showed significantly increased radiographic acetabular loosening than those with wire reattachment. Using definite or probable radiographic loosening plus cases revised for aseptic acetabular loosening as the definition of radiographic acetabular loosening, the prevalence of acetabular loosening was 29.8% for the cable group and 16.4% for the wire group. The prevalence of radiographic loosening was significantly increased in the cable group versus the wire group ($p = 0.0008$), (Fig 4C). The prevalence of radiographic acetabular loosening was 28.8% for the Iowa metal back cable group, 14.1% for the Iowa metal back wire group, 47.6% for the Iowa all polyethylene cable group, 34.1% for the Iowa all polyethylene wire group, 7.1% for the Charnley all polyethylene cable group, and 21.4% for the Charnley all polyethylene wire group.

Hips with 28–mm heads showed significantly increased radiographic loosening than those with 22–mm heads. At minimum 10–year followup the prevalence of radiographic acetabular loosening regarding head size showed 17.3% radiographic acetabular loosening for the 22–mm all polyethylene, 41% for the 28–mm all polyethylene, and 22.8% for the 28–mm metal back. 28–mm articulations showed a significantly higher prevalence of radiographic acetabular loosening versus 22–mm articulations overall ($p = 0.0001$), (Figure 4B). Twenty-eight–millimeter all polyethylene articulations showed significantly higher prevalence of radiographic acetabular loosening versus 22–mm all polyarticulations ($p = 0.0005$). Comparison of acetabular radiographic loosening rates for 22–mm all polyethylene and 28–mm metal back groups were not significant ($p = 0.3585$).

Femoral Revision or Loosening

The prevalence of aseptic revision of the femoral component was 0.5% for the cable and wire groups and was not significantly different. The prevalence of radiographic definite or probable loosening plus aseptic revision was 2.2% in the cable group and 1.1% in the wire group and was not significantly different. No significant differences in aseptic femoral loosening rates were seen when the individual groups were compared (Iowa versus Charnley).

Migration of Metallic Debris

Migration of metallic debris to the intraarticular and extraarticular areas of the hip was significantly higher in the hips with cable reattachment than those with wire reattachment. Extraarticular migration of metal debris was observed in 52.2% of cable hips and 17.5% of wire hips ($p = 0.0001$). Intraarticular migration

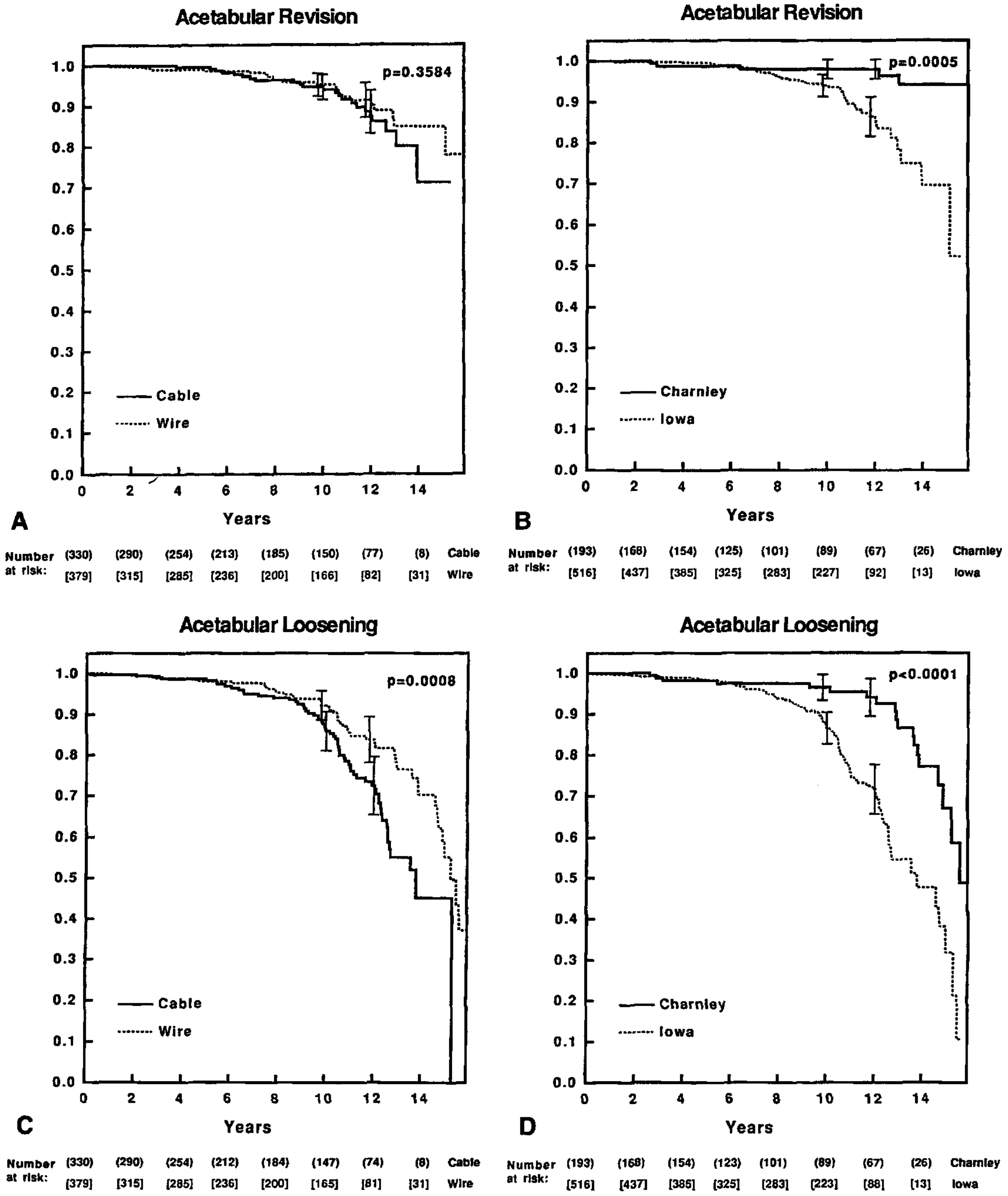

Fig 4A–D. Survivorship curves of cable versus wire groups and 22-mm femoral heads versus 28-mm femoral heads using aseptic loosening requiring revision and radiographic loosening (hips revised for aseptic loosening and those showing definite or probable loosening on radiographs). (A) The survivorship to acetabular revision for cable and wire groups. There were no significant differences (p = 0.36). (B) The survivorship to acetabular revision for 22-mm head articulation (Charnley) versus 28-mm head articulation (Iowa). The 22-mm head articulation showed significantly less acetabular revision (p = 0.0005). (C) The survivorship to acetabular radiographic loosening for the cable and wire groups. The cable group had significantly more loosening (p = 0.0008). (D) The survivorship to acetabular radiographic loosening for the 22-mm (Charnley) and 28-mm (Iowa) articulations. The 22-mm head articulation had significantly less loosening than the 28-mm articulation.

of metal debris was seen in 18.8% of cable hips and 8.5% of wire hips (p = 0.0001).

Acetabular Wear Versus Metallic Debris Migration

The presence of intraarticular metallic debris was associated with increased acetabular component wear. The median linear wear when intraarticular metallic debris migration was observed was 0.1145 mm per year in the cable group, 0.1398 mm per year for the wire group and 0.1158 mm per year for the groups combined. When extraarticular or no migration of metallic debris was seen, the median linear wear was 0.0834 mm per year for the cable group, 0.0667 mm per year for the wire group, and 0.075 mm per year for these groups when combined. The median linear wear was increased significantly in the wire group (p = 0.007) and the combined groups (p = 0.023) when intraarticular migration of metallic debris was observed. Intraarticular metallic debris increased the median wear in the cable group but this was not significant (p = 0.594).

The median volumetric wear when intraarticular migration of metallic debris was seen was 70.45 mm^3 per year for the cable group, 86.04 mm^3 per year for the wire group, and 71.26 mm^3 per year when these groups were combined. When extraarticular or no migration of metallic debris was seen, the median linear wear was 50.94 mm^3 per year for the cable group, 41.03 mm^3 per year for the wire group, and 46.12 mm^3 per year when these groups were combined. The presence of intraarticular metallic debris significantly increased volumetric wear in the combined group (p = 0.022) and in the wire group (p = 0.007). Intraarticular metallic debris increased volumetric wear in the cable group but this was not significant (p = 0.555).

Acetabular Loosening and Revision Versus Migration of Metallic Debris

The presence of intraarticular metallic debris was associated with significantly increased rates of revision for aseptic acetabular loosening. The prevalence of revision for aseptic acetabular loosening when intraarticular migration of metallic debris was observed was 26.5% for the cable group, 31.2% for the wire group, and 28% for the cable and wire groups combined. The prevalence of revision for aseptic loosening when only extraarticular migration of metallic debris or no migration was observed was 9.5% for the cable group, 8.6% for the wire group, and 9% when the groups were combined. The prevalence of revision for aseptic loosening was significantly greater when intraarticular migration of metallic debris was present in the cable group (p = 0.0122), the wire group (p = 0.0088), and when these groups were combined (p = 0.0424) when compared with those cases with no intraarticular metallic debris shown on radiographs.

The presence of intraarticular metallic debris was associated with increased rates of acetabular loosening. The prevalence of probable or definite radiographic acetabular loosening including revision for aseptic acetabular loosening when intraarticular migration of metallic debris was observed was 64.7% for the cable group, 31.3% for the wire group, and 54% when the groups were combined. The prevalence of probable or definite radiographic aseptic acetabular loosening when extraarticular migration or no migration of metallic debris was observed was 21.8% for the cable group, 20.1% for the wire group, and 20.9% when the groups were combined. The prevalence of radiographic acetabular loosening was significantly greater when intraarticular migration of metallic debris was present in the cable group (p = 0.0001) and when the groups were combined (p = 0.0001). The prevalence of radiographic acetabular loosening in the presence of intraarticular migration of metallic debris was not significantly greater when compared with extraarticular migration or no migration in the wire group (p = 0.1811).

Greater Trochanteric Nonunion

Greater trochanteric nonunion rates were higher in hips with cable greater trochanteric reattachment than those with wire reattachment. The prevalence of greater trochanteric nonunion was 19.7% in the cable group and 14% in the wire group (p = 0.044).

DISCUSSION

The authors had a unique opportunity to study the long term effects of metal particulate debris generation (from fretting and breakage of trochanteric cables) on acetabular wear, osteolysis, and loosening. In addition, because of the change in prosthetic components (in femoral head size and from all polyethylene to metal backed acetabular components) the authors were able to evaluate the long term contribution of other potentially important variables on acetabular wear, osteolysis, and loosening. The authors hypothesized that the metallic debris generated by the fretting and breakage of fine filament cable would lead to an increase in the acetabular component wear, osteolysis, and loosening when compared with a control group where the greater trochanter was reattached with wire.[1–3,7,8,16,22,26,28,29]

The strengths of the present study include one surgeon's involvement with use of the same cement technique in all cases, the large number of hips included, the relatively long term followup (minimum 10 years), the consecutive series of hips with sequential changes in variables (wire to cable, 22– to 28–mm head, all polyethylene to metal back acetabular components) for a very short period (2–3 years), and the measurement of wear by a single experienced observer on radiographs, which mostly were obtained at the same office throughout the study. (In a previous study the intraobserver and interobserver variability of wear measurements for this observer was 0.3 and 0.2 mm, respectively.)[5]

Weaknesses of the study include inherent potential errors in wear measurements[11,12] (albeit somewhat less with standard radiographs, long term films, and one experienced observer), the intraobserver and interobserver variability of determining osteolysis and loosening (determinations were made by consensus agreement between two observers in this study), and the fact that all groups were not matched exactly (more females in the cable Charnley group than in the wire Charnley group) because of the availability of the newer components (the Iowa components became readily available during a 6–month transition period during the time cable was used). In addition, the metallic debris observed was probably only a small portion of the actual amount present intraarticularly and extraarticularly.

Accepting these many strengths and relatively few weaknesses, the following information was obtained from the study of this unique and large group of patients.

The rate of greater trochanteric nonunion was higher in the hips with cable greater trochanteric reattachment than those with wire reattachment. The original goal of cable fixation was to provide theoretically superior fixation and consequently produce higher trochanteric union rates. Long term followup actually showed higher nonunion rates with cable and introduced the unfortunate variable of third body wear debris.

Migration of metallic debris generated from cable used for trochanteric reattachment was seen in the extraarticular and intraarticular areas of the hip long term. Cases with cable greater trochanteric reattachment showed significantly increased amounts of acetabular volumetric wear, osteolysis, and radiographic acetabular loosening compared with the same surgeon's cases where wire reattachment was used. To the authors know-ledge this is the first relatively well controlled, long term, large (>700 hips) clinical series to show the deleterious effects of metal particulate debris on wear, osteolysis, and loosening. Although the transtrochan-teric approach to the hip has been abandoned by most surgeon's in the primary total hip arthroplasty, cable systems still are used extensively in revision surgery.[9] Early reports have revealed fretting of cable with the newer cable systems that are available and used in revision surgery.[28] In addition, especially with the advent of modularity and the use of uncemented devices, there are numerous new sources for the production of metal particulates (screws, beads, nonarticulating surfaces of acetabular and femoral components, modular femoral head tapers, and femoral stem modularity) that have been documented clinically from anecdotal retrievals or small series of patients to be potential long term problems.[1,2,6–8,25,29]

Another important finding from this study was the decreased prevalence of revision and radiographic loosening in the cases with 22–mm head articulations compared with those with 28–mm head articulations (all polyethylene and metal backed acetabular components), regardless of whether cable was used for greater trochanteric reattachment. Although 28–mm head components are most commonly used today, there is growing basic, clinical and retrieval data, including the findings from this study, that suggest the need to reconsider the use of smaller head sizes in total hip arthroplasty (understanding that design modifications may be necessary to incorporate the smaller head sizes with the modularity used today).[3] Interestingly, the particulate debris had no demonstrable effect on the stability of the femoral construct, with revision rates of 0.5% and loosening rates of less than 2% at minimum 10–year followup. This data supports the idea that cement or any other proximal seal potentially can prevent or inhibit the tracking of the debris generated histiocyte response around the femoral component.[13] A final finding in this study was that the metal backed acetabular component with the 28–mm head out performed the all polyethylene component with the 28–mm femoral head. Hence, the poor 28–mm results can not be attributed to metal backing. This finding has been corroborated recently.[30]

This study further supports the need to be able to observe patients regularly, and the need to be able to obtain long term followup on all patients who receive total hip arthroplasties (a practice that managed care systems have little interest in incorporating into their budget) so that by outcome surveillance the surgeon can determine whether changes he or she makes in their hip arthroplasty practice have been beneficial to improving long term fixation. The findings from this study as they became apparent after 3 to 4 years of followup made the experienced senior surgeon recognize that the use of cable fixation and the departure from 22–mm heads were two of the biggest mistakes he had made in a 25–year experience with total hip arthroplasty. The regular followup of patients enabled the senior surgeon to abandon the use of cable after a relatively short period and eventually led him to return to the use of 22–mm femoral heads.

Most importantly, these findings (from the clinical long term study of a large number of patients) should alert those involved in the study, the design, and implantation of total hip arthroplasty devices that the generation of particulate debris from whatever source must be minimized to ensure the maximum longevity of the total hip arthroplasty construct and to minimize acetabular component wear, osteolysis, and component loosening long term. Unfortunately, any of the adverse effects of the decisions made today in total hip arthroplasty reconstruction do not become apparent clinically or radiographically for an extended period.

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