■ HIP

Comparison of the outcome following the fixation of osteotomies or fractures associated with total hip replacement using cables or wires

THE RESULTS AT FIVE YEARS

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There are no recent studies comparing cable with wire for the fixation of osteotomies or fractures in total hip replacement (THR). Our objective was to evaluate the five-year clinical and radiological outcomes and complication rates of the two techniques. We undertook a review including all primary and revision THRs performed in one hospital between 1996 and 2005 using cable or wire fixation. Clinical and radiological evaluation was performed five years post-operatively. Cables were used in 51 THRs and wires in 126, and of these, 36 THRs with cable (71%) and 101 with wire (80%) were evaluated at follow-up. The five-year radiographs available for 33 cable and 91 wire THRs revealed rates of breakage of fixation of 12 of 33 (36%) and 42 of 91 (46%), respectively. With cable there was a significantly higher risk of metal debris (68% *vs* 9%; adjusted relative risk (RR) 6.6; 95% confidence interval (CI) 3.0 to 14.1), nonunion (36% *vs* 21%; adjusted RR 2.0; 95% CI 1.0 to 3.9) and osteolysis around the material, acetabulum or femur (61% *vs* 19%; adjusted RR 3.9; 95% CI 2.3 to 6.5). Cable breakage increased the risk of osteolysis to 83%. There was a trend towards foreign-body reaction and increased infection with cables. Clinical results did not differ between the groups.

In conclusion, we found a higher incidence of complications and a trend towards increased infection and foreign-body reaction with the use of cables.

Cables or wires are frequently used in complex total hip replacement (THRs)[1-4] and also for the fixation of fractures or osteotomies of the greater trochanter or femur. It has been reported that the transtrochanteric approach is necessary in 3% of primary and 57% of revision THRs.[5] Complications associated with the use of cables or wires include implant breakage, third-body polyethylene wear, loss of fixation, trochanteric fragment migration and nonunion.[2,6-8]

Stable fixation is necessary to achieve union. A biomechanical study[9] demonstrated that multifilament cables were better than monofilament wire with respect to resistance to breakage. However, cables have been shown to lead to accelerated polyethylene wear and osteolysis with subsequent aseptic loosening of the components due to debris arising from the cable.[2,4,10] It has also been postulated that cable debris may cause an inflammatory and foreign-body reaction, and be related to an increased rate of infection compared with wire fixation.[10] Despite these complications, cables are still commonly used. There is little in the contemporary literature to support the preferential use of either cables or wires.[11]

The objective of our study was to compare the five-year radiological and clinical outcomes of cables and wires when used to fix fractures or osteotomies associated with primary or revision THR.

Patients and Methods

We conducted a prospective study at a large teaching hospital of all primary and revision THRs performed between March 1996 and June 2005 where cables or wires were used for fixation of fractures or osteotomies. Wires were used during the entire period, whereas cables were used only from 2001. The study population is part of an ongoing prospective study that was begun in 1996.[12]

Stainless steel monofilament wires of different diameters were used according to surgeon preference and were always tightened with symmetrical twisting. The multifilament cables were 2.0 mm Dall–Miles Cables (Stryker Howmedica, East Rutherford, New Jersey) with a 7 × 7 filament pattern, and were always tightened by tensioning and crimping. Before the introduction of cables in 2001 all surgeons used wire, which was tightened in the same

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manner as described. When cable was introduced some surgeons changed to its use exclusively, and the technique of tensioning was the same among all surgeons. We excluded patients with wires or cables associated with other forms of fixation, such as a plate for osteosynthesis of a periprosthetic fracture, or a cable-grip system. The procedures were performed in an ultra-clean-air laminar-flow operating theatre by surgeons with different levels of experience. All patients received a single dose of a second-generation cephalosporin before induction, as well as standard thromboprophylaxis consisting of low-molecular-weight heparin (nadroparin) during the first week followed by an anti-vitamin-K antagonist (acenocoumarol) up to six weeks unless indicated otherwise. In patients receiving a cemented femoral component, a third-generation cementing technique using gentamicin-loaded cement with pulsed lavage and an intramedullary plug was used.

Exposure and potential confounding variables. We collected the following potential confounding variables: age at operation; gender; body mass index (BMI); American Society of Anesthesiologists (ASA) score[13]; Charnley disability grade[14]; number of comorbidities; type of surgery (primary or revision); elective or emergency; location of osteotomy or perioperative fracture (greater trochanter, femur or both); surgical approach with or without osteotomy; bearing surface; type of femoral component; head size; pre-operative Merle d'Aubigné score[15] (available for patients operated on between March 1996 and January 2002); and pre-operative Harris hip score[16] (available from January 2002).

Outcomes of interest were: 1) radiological features, including the presence of linear or focal osteolysis around the cable or wire, at the acetabulum, or at the femur; nonunion of the greater trochanter; cable or wire breakage; and the presence of metal debris; 2) complications, including foreign-body granuloma, prosthetic infection and revision; and 3) clinical outcomes, including functional outcome, residual pain, activity and satisfaction.

Radiological analysis. Immediate post-operative standardised anteroposterior (AP) pelvic and lateral hip radiographs were compared with those taken five years post-operatively. They were analysed independently by two orthopaedic surgeons (CB, GJP) who did not participate in the follow-up evaluation. Radiological loosening of the femoral component was defined by the criteria for cemented stems[17] and uncemented stems,[18] and by the criteria of Massin, Schmidt and Engh[19] for the acetabular component. Radiographs were examined for evidence of osteolysis in each of the seven femoral zones of Gruen, McNeice and Amstutz[20] and the three acetabular zones of DeLee and Charnley.[21] In cases of revision surgery, and when osteolysis was already present before the initial procedure, only progressive osteolysis was considered an event.

Clinical outcomes. Patients were evaluated using the Harris hip score (HHS),[16] the Merle d'Aubigné score,[15] the University of California, Los Angeles (UCLA) activity scale,[22] which assesses activity in patients after THR and has proved to be both reliable and valid,[23] and a visual analogue scale (VAS) to evaluate satisfaction, scaled between 0 (lowest satisfaction) and 10 (highest satisfaction). In addition, we noted the presence of a limp and/or Trendelenburg sign, as well as pain at three specific locations (greater trochanter, groin and thigh).

Data collection. Information about pre-operative status and surgical intervention, including implant- and technique-related details, was routinely documented by the operating surgeon on specifically designed data collection forms. Pre-operative, immediately post-operative and follow-up radiographs were collected. Information about comorbidities and in-hospital complications was retrieved from the anaesthetic record and the discharge summary. The treatment of any major complication or further revision performed at our hospital or reported to the orthopaedic surgeon at the follow-up visits was recorded. The follow-up examinations were undertaken by three surgeons who had not performed the operations (including two authors, AL and PC).

Statistical analysis. Differences in radiological and clinical outcomes between the cable group and the wire group were evaluated with relative risks (RR) and their 95% confidence intervals (CI) for categorical outcomes and mean differences and their 95% CIs for continuous outcomes (clinical scores). In addition, p-values were obtained using Student's *t*-test for continuous variables and the chi-squared test for categorical variables, with statistical significance set at $p < 0.05$. Given the observational nature of this study, and the fact that the two groups differed in several baseline characteristics, we adjusted the results for imbalances using the propensity score method, which is a multivariable confounder score corresponding to the probability of being selected into one or the other group based on baseline characteristics (covariates). Adjustment for the score balances the covariates in the two groups and therefore reduces bias.[24,25] Given that all the covariates are combined into one single variable, adjustment for a large number of factors is possible even in a study with few outcome events. We used the general linear model (GLM) for the binomial family using STATA version 11.1 (Stata Corp., College Station, Texas) to obtain adjusted RRs and their 95% CIs.

With respect to the radiological outcomes, our primary analysis included all THRs. A second analysis included only those with osteotomy of the greater trochanter, and in a third analysis we evaluated the outcomes for the primary and the revision THR cohorts separately.

Results

Overall, cables or wires were used in 59 of the 2820 primary THRs (2.1%) and 118 of the 254 revision THRs (46.4%) performed between 1996 and 2005. Thus, a total of 177 THRs, in 167 patients, with an additional fixation system were included in this study. Of those, cables were employed in 51 THRs (29%) in 49 patients, and wires in 126 (71%) in 118 patients. The two groups differed with respect to the indication for additional fixation (type of

Table I. Distribution of baseline characteristics (THR, total hip replacement; ASA, American Society of Anesthesiologists; BMI, body mass index; CI, confidence interval)

	Cable	Wire	Relative risk* (95% CI)	p-value†	Mean difference (95% CI)
No. THRs (no. patients)	51 (49)	126 (118)			
THRs in female hips (n, %)	29 (*56.9*)	81 (*64.3*)			
THRs in male hips (n, %)	22 (*43.1*)	45 (*35.7*)	1.2 (0.8 to 1.8)		
ASA score (n, %)					
1 or 2	32 (*62.7*)	76 (*60.3*)			
3 or 4	19 (*37.3*)	50 (*39.7*)	0.9 (0.6 to 1.4)		
Charnley disability grade (n, %)				0.186	
A	14 (*27.5*)	34 (*27.0*)			
B	18 (*35.3*)	48 (*38.1*)			
C	14 (*27.5*)	41 (*32.5*)			
Data missing	5 (*9.8*)	3 (*2.4*)			
Type of THR (n, %)					
Primary	15 (*29.4*)	44 (*34.9*)			
Revision	36 (*70.6*)	82 (*65.1*)	1.1 (0.9 to 1.3)		
Elective surgery	39 (*76.5*)	115 (*91.3*)			
Emergency surgery	12 (*23.5*)	11 (*8.7*)	2.7 (1.3 to 5.7)		
Location (n, %)				0.002	
Greater trochanter	29 (*56.9*)	106 (*84.1*)			
Femur	13 (*25.5*)	13 (*10.3*)			
Both	9 (*17.6*)	7 (*5.6*)			
Surgical approach (n, %)‡					
Without osteotomy	22 (*43.1*)	39 (*31.0*)			
With osteotomy	29 (*56.9*)	87 (*69.0*)	0.8 (0.6 to 1.1)		
Bearing surface (n, %)				0.021	
Ceramic–polyethylene	29 (*56.9*)	93 (*73.8*)			
Metal–polyethylene	12 (*23.5*)	11 (*8.7*)			
Metal-on-metal	10 (*19.6*)	22 (*17.5*)			
Type of stem (n, %)					
Cemented	30 (*58.8*)	105 (*83.3*)			
Uncemented	21 (*41.2*)	21 (*16.7*)	2.5 (1.5 to 4.1)		
Head size (n, %)					
28 mm	48 (*94.1*)	122 (*96.8*)			
32 mm	3 (*5.9*)	4 (*3.2*)	1.9 (0.4 to 8.0)		
Mean (SD) age (yrs)	71.1 (14.9)	71.5 (11.5)			0.4 (3.7 to 4.6)
Mean (SD) BMI (kg/m^2)	26.2 (4.3)	26.1 (4.6)			-0.1 (-1.6 to 1.4)
Mean (SD) comorbidities	1.7 (1.3)	1.6 (1.3)			-0.1 (-0.5 to 0.3)
Mean (SD) pre-operative scores§					
Merle d'Aubigné	10.1 (3.3)	9.6 (2.3)			0.5 (-2.1 to 1.1)
Harris hip score	53.7 (17.8)	46.2 (20.2)			-7.5 (-19.5 to 4.5)

* relative risks given for binary variables
† p-values (chi-squared test) given for variables with more than two categories
‡ surgical approaches without osteotomy included 57 lateral and four posterior approaches; with osteotomy included 88 classic transtrochanteric, five transtrochanteric flip, 16 transfemoral and seven lateral approaches with osteotomy
§ data on pre-operative scores were available: Merle d'Aubigné from March 1996 to January 2002 (n = 93); Harris hip score from January 2002 until end of inclusion period (n = 41); no information available (n = 43)

osteotomy or per-operative fracture), bearing surface, type of femoral component, and whether the indication for the procedure was elective or emergency (Table I). There were no substantial differences with respect to gender, age, mean BMI, comorbidities (mean ASA score, Charnley disability grades and number of comorbidities), type of surgery (primary or revision THR), femoral head size, surgical approach or pre-operative clinical scores.

At a mean of 61 months (40 to 84) post-operatively, 36 of 51 THRs (70.6%) in the cable group and 101 of 126 THRs (80.1%) in the wire group were available for review (Fig. 1).

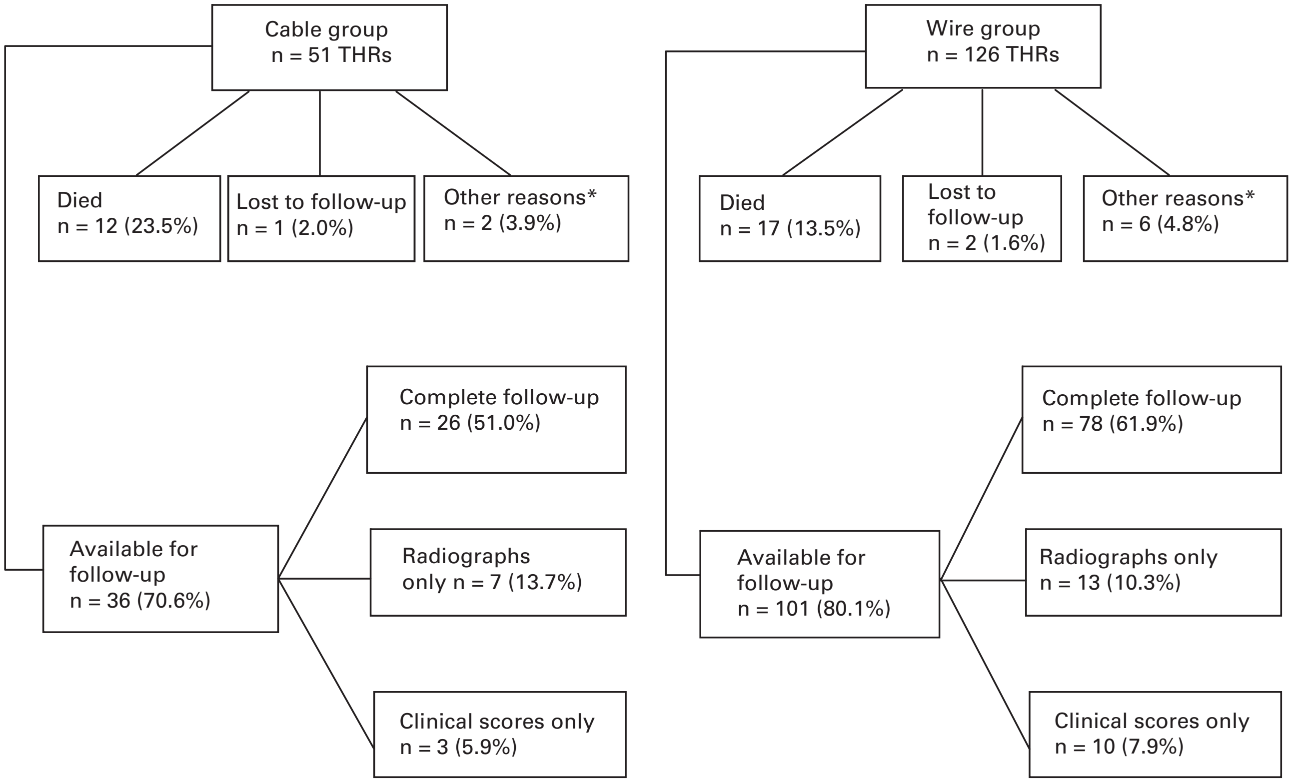

Fig. 1

Flowchart of patient inclusion (*, including poor general health and refusal to attend follow-up; THR, total hip replacement).

Complete (pre-operative, immediate post-operative and five-year follow-up) radiographs were available for 33 THRs with cables and 91 with wires. Clinical scores were obtained for 29 THRs with cables and 88 with wires.

The patients in the cable group developed substantially more osteolytic lesions in each of the three locations (around the material, acetabulum and femur) (Table II and Fig. 2). The risk of developing osteolysis in any location was 60.6% in the cable group and 18.7% in the wire group (unadjusted RR 3.2; 95% CI 1.9 to 5.4). The RR was even higher after adjusting for baseline differences (adjusted RR 3.9; 95% CI 2.3 to 6.5). In those patients with a broken cable the incidence of osteolysis around the cable was significantly higher, at 83.3%, compared with 33.3% in those with an intact cable (RR 2.5; 95% CI 1.3 to 4.8). Comparing broken with intact cables, osteolysis occurred on the femoral side in four of 12 (33.3%) *vs* four of 21 THRs (19.0%), respectively, and on the acetabular side in three of 12 (25.0%) *vs* three of 21 THRs (14.3%), respectively. The use of cables was also associated with a significantly increased risk of nonunion of the greater trochanter (adjusted RR 2.0; 95% CI 1.0 to 3.9) and of metal debris (adjusted RR 6.6; 95% CI 3.9 to 14.1). No substantial difference was seen for breakage of fixation (adjusted RR 1.1; 95% CI 0.6 to 1.8).

Separate analyses of the radiological outcomes in primary and revision THRs confirmed the increased incidence of osteolysis (any location), nonunion of the greater trochanter and the presence of metal debris in the cable group compared with the wire group, with a similar incidence of breakage of fixation (Figs 3 and 4). An additional analysis including only THRs with osteotomy of the greater trochanter also yielded the same results (Table II).

Three patients in the cable group developed a painful mass in the upper thigh and radiological evidence of fragments of frayed cable. The mass and cables were removed, and histology revealed a foreign-body reaction. This was not seen in the wire group. In addition, there were six prosthetic infections (11.8%) in the cable group compared with three (2.4%) in the wire group (RR 4.9; 95% CI 1.3 to 19.0). Adjusting for baseline differences reduced the association and resulted in an adjusted RR of 3.7 (95% CI 0.8 to 16.6). The infections manifested at a mean of 2.6 years (0.1 to 5.3) after surgery in the cable group and 2.7 years (0.04 to 4.4) in the wire group. In all, six THRs (11.8%) were revised in the cable group, two for infection, one for aseptic acetabular loosening and three for recurrent dislocation. Two THRs (1.6%) were revised in the wire group, one for infection and one for aseptic femoral loosening. The unadjusted RR for revision (any cause) was 7.4 (95% CI 1.5 to

Table II. Results of radiological analyses comparing cable with wire (RR, relative risk; CI, confidence interval)

	Cable	Wire	Unadjusted RR (95% CI)	Adjusted RR* (95% CI)
Hips with radiological follow-up (n)	33	91		
Nonunion of greater trochanter (n, %)	12 (*36.4*)	19 (*20.9*)	1.7 (1.0 to 3.2)	2.0 (1.0 to 3.9)
Breakage (n, %)	12 (*36.4*)	42 (*46.2*)	0.8 (0.5 to 1.3)	1.1 (0.6 to 1.8)
Presence of metal debris (n, %)	19 (*57.6*)	8 (*8.8*)	6.5 (3.2 to 13.5)	6.6 (3.0 to 14.1)
Osteolysis (n, %)				
Any location	20 (*60.6*)	17 (*18.7*)	3.2 (1.9 to 5.4)	3.9 (2.3 to 6.5)
Around cable/wire	17 (*51.5*)	10 (*11.0*)	4.7 (2.4 to 9.2)	5.2 (2.5 to 10.6)
Acetabulum	6 (*18.2*)	1 (*1.1*)	16.5 (2.1 to 132.3)	15.7 (1.8 to 139.6)
Femur	8 (*24.2*)	9 (*9.9*)	2.5 (1.0 to 5.8)	3.1 (1.2 to 7.9)
Hips with only osteotomy of greater trochanter (n)	18	75		
Nonunion (n, %)	9 (*50.0*)	16 (*21.3*)	2.3 (1.2 to 4.4)	
Breakage (n, %)	9 (*50.0*)	40 (*53.3*)	0.9 (0.6 to 1.6)	
Presence of metal debris (n, %)	10 (*55.6*)	8 (*10.7*)	5.2 (2.4 to 11.3)	
Osteolysis (n, %)				
Around cable/wire	11 (*61.1*)	8 (*10.7*)	5.7 (2.7 to 12.1)	
Acetabulum	2 (*11.1*)	1 (*1.3*)	8.3 (0.8 to 86.9)	
Femur	6 (*33.3*)	9 (*12.0*)	2.8 (1.1 to 6.8)	

* adjusted for age, gender, body mass index, American Society of Anesthesiologists score, primary or revision total hip replacement, elective or emergency surgery, location of osteotomy/fracture, surgical approach, head size, stem type, bearing surface with use of propensity score method

Fig. 2a

Fig. 2b

Anteroposterior (a) and lateral (b) radiographs of a 74-year-old woman at five years after primary total hip replacement. She had a painful mass in the thigh with radiological evidence of osteolysis around the cable, pelvis and femur, and multiple fragments of broken cable.

35.5) and this was reduced to 4.2 (95% CI 0.7 to 23.6) after adjustment.

At five years post-operatively the two groups did not differ with respect to the mean HHS, Merle d'Aubigné and UCLA activity scores, or patient satisfaction. Adjustment for baseline differences did not change the results (Table III). Furthermore, the two groups were similar regarding residual pain and limping.

Discussion

Our results are consistent with those of others[5] regarding the frequency of additional fixation with cables or wires in THR, with much greater use in revision surgery. Disappointing results in some cases of primary and revision THR are due to problems with the system used for fixation of fractures and osteotomies. These include material breakage, third-body polyethylene wear, trochanteric fragment migration and nonunion.[8] Additionally, third-body wear, a complication of fretting and breakage of cables and wires, is associated with accelerated polyethylene wear, osteolysis and loosening of the THR.[2,4,5,10] Several authors have compared cables and wires.[2,4,10,11,26,27] Most studies were performed more than two to three decades ago and are retrospective in nature. When used around the femur to manage peri-operative calcar fracture[26] or fixation following a transfemoral approach,[11] no difference was found between cables or wires in terms of complications or mid- to long-term survival. When used for reattachment following a transtrochanteric approach in primary THR, long-term survival (20 years) of the acetabular component was better with wires than with cables,[2] whereas mid-term survival (ten years) was not significantly different.[4] In accordance with previous studies,[2,4,5,10] we found that patients in the cable group had a significantly higher risk of osteolysis around the fixation and the femoral and

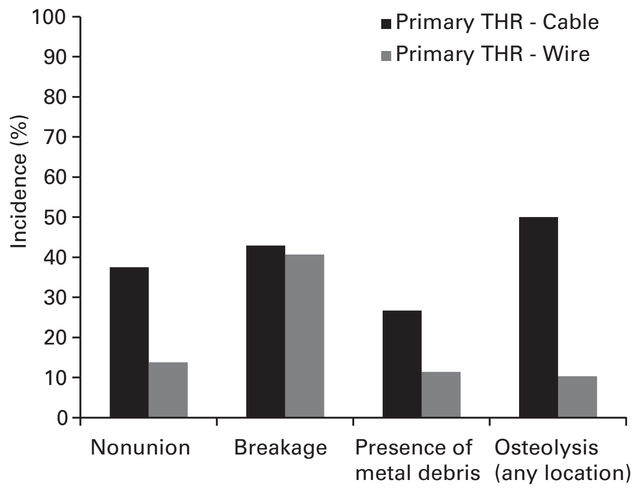

Fig. 3

Bar chart showing the incidence of trochanteric nonunion, material breakage, presence of metal debris and osteolysis (any location) comparing cable with wire fixation in patients with primary total hip replacement (THR).

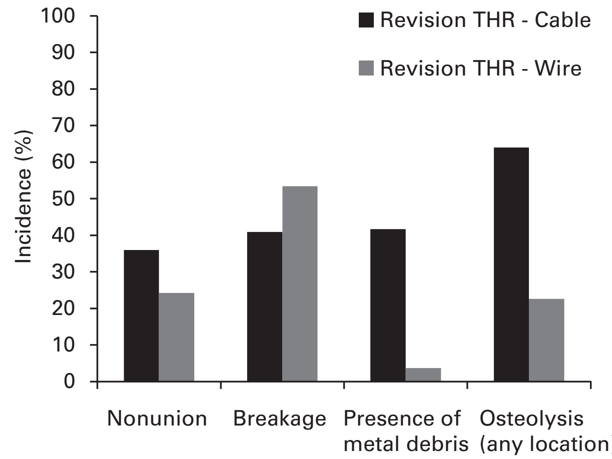

Fig. 4

Bar chart showing the incidence of trochanteric nonunion, material breakage, presence of metal debris and osteolysis (any location) comparing cable with wire fixation in patients with revision total hip replacement (THR).

Table III. Clinical outcomes at the five-year follow-up (CI, confidence interval)

Outcome*	Cable (n = 29)	Wire (n = 88)	Unadjusted mean difference (95% CI)	Relative risk (95% CI)	p-value†	Adjusted mean difference (95%CI)‡
Mean (SD) Harris hip score						
Total	79.8 (15.1)	76.4 (18.6)	3.4 (-4.6 to 11.4)		0.405	3.6 (-5.4 to 12.7)
Pain domain	38.7 (7.5)	36.6 (10.0)	2.1 (-2.1 to 6.4)		0.319	1.1 (-3.7 to 5.9)
Mean (SD) Merle d'Aubigné score	13.7 (2.9)	14.0 (2.6)	-0.3 (-1.6 to 1.1)		0.712	1.0 (0.7 to 2.6)
Mean (SD) UCLA scale§	4.6 (1.8)	4.3 (2.2)	0.3 (-0.9 to 1.7)		0.578	-0.2 (-1.7 to 1.3)
Mean (SD) VAS patient satisfaction	7.5 (2.1)	7.7 (2.3)	-0.2 (-1.2 to 0.8)		0.706	-0.4 (-1.5 to 0.7)
Presence of limping (n, %)	16 (*55.2*)	49 (*55.7*)		1.0 (0.7 to 1.4)	0.962	
Trendelenburg sign (n, %)	7 (*24.1*)	26 (*29.5*)		0.8 (0.4 to 1.7)	0.576	
Pain reported (n, %)						
Groin	3 (*10.3*)	7 (*8.0*)		1.3 (0.4 to 4.7)	0.691	
Greater trochanter	8 (*27.6*)	24 (*27.2*)		1.0 (0.5 to 2.0)	0.973	
Thigh	3 (*10.3*)	9 (*10.2*)		1.0 (0.3 to 3.5)	0.986	

* UCLA, University of California, Los Angeles; VAS, visual analogue scale
† p-values for the unadjusted analysis were obtained using Student's *t*-test for continuous and chi-squared test for categorical variables
‡ adjusted for age, gender, body mass index, American Society of Anesthesiologists score, primary or revision total hip replacement, elective or emergency surgery, location of osteotomy/fracture, surgical approach, head size, stem type, bearing surface with use of propensity score method
§ introduced to standard clinical evaluation in 2006, available for 23 patients with cables and 16 patients with wires

acetabular components. Additionally, we found that cable breakage increased the risk of osteolysis to 83%.

In vitro studies have demonstrated that multifilament cables have mechanical properties far superior to those of monofilament wire, with better resistance to fatigue and higher breaking strength.[27,28] Kelley and Johnston[10] found a substantially lower rate of breakage with cables than with wires (12% and 43%, respectively), but we observed no advantage in terms of breakage with the multifilament cable compared with the monofilament wire.

We found that nonunion of the greater trochanter was more frequent with cables than with wires (50% *vs* 21.3%). This is in accordance with Hop et al,[4] who also observed a significantly higher rate of nonunion with cables than with wires in patients seen ten years after primary THR. This complication has been related to a higher rate of metal debris generated by fretting of the cables, which induces local inflammation and osteolysis.[29] However, in a retrospective study comparing 160 hips with cobalt–chrome multifilament cables to 162 hips with stainless steel monofilament wires, Kelley and Johnston[10] observed no difference with respect to nonunion of the greater trochanter (21% and 25%, respectively). Other studies regarding trochanteric nonunion[2,11] found only a small difference between the two groups, of 25 *vs* 19%, respectively.

Three patients in our study underwent further surgery for painful foreign-body granulomata in the presence of broken cables and abundant metal debris. We believe only one other study[10] has reported a similar finding related to cable use. In that report, removal of the cables was required in four of 65 THRs because of local inflammation and histology revealed an intense foreign-body reaction. Furthermore, we found a trend towards a higher incidence of prosthetic infection in the cable group, albeit with a large confidence interval, possibly owing to the small number of events. However, it is in accordance with Kelley et al,[10] who reported four revisions for infection in 160 THRs (2.5%) with cables compared with none in 162 THRs with wire fixation, and with Altenburg et al,[2] who described three revisions for infection in 59 THRs (5.1%) with cables and. one in 92 THRs with wires (1.1%). Kelley et al[10] suggested that cable debris might facilitate bacterial seeding and thus lead to a higher infection rate. This may be related to reduced phagocytosis in the presence of cobalt ions,[30,31] as approximately 60% of the Dall–Miles cable alloy (Vitallium, Stryker Howmedica) is made of cobalt. This finding is a concern that needs to be investigated in a larger study.

In our study, at five years we found no difference between the two groups with respect to the functional outcome, residual pain, activity and satisfaction, despite substantial radiological differences predictive of future failure. Only one other study[11] compared the HHS total score and pain sub-score between patients with cables and wires, and reported similar scores at a mean of 4.4 years.

In conclusion, we found that cables did not offer any benefit over wires despite reports of better *in vitro* mechanical properties. Importantly, the higher incidence of osteolysis leading to reduced implant survival, the greater incidence of nonunion of the greater trochanter, the potential for increased infection, as well as foreign-body reaction, strongly favours the use of wires instead of cables in the context of THR.

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