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Original Article

Clinical Cold Welding of the Modular Total Hip Arthroplasty Prosthesis

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ABSTRACT

Background: A head that is "clinically cold welded" to a stem is one of the commonest reasons for unplanned removal of the stem. It is not clear which hip designs are at greatest risk of clinical cold welding.

Methods: This was a case-control study of consecutively received hip implant retrievals; we chose the design of hip that had the greatest number of truly cold-welded heads (n = 11). For our controls, we chose retrieved hips of the same design but without cold welding of the head (n = 35). We compared the clinical variables between these 2 groups using nonparametric Mann-Whitney tests to investigate the significance of differences between the cold-welded and non–cold-welded groups.

Results: The design that most commonly caused cold welding was a combination of a Ti stem and Ti taper: 11 out of 48 (23%) were truly cold welded. Comparison of the clinical data showed that no individual factor could be used to predict this preoperatively with none of the 4 predictors tested showing any significance: (1) time to revision ($P = .687$), (2) head size ($P = .067$), (3) patient age at primary ($P = .380$), and (4) gender ($P = .054$).

Conclusion: We have shown that clinical cold welding is most prevalent in Ti-Ti combinations of the stem and taper; approximately 25% of cases received at our center were cold welded. Analysis of clinical variables showed that it is not possible to predict which will be cold welded preoperatively. Surgeons should be aware of this potential complication when revising a Ti-Ti stem/head junction.

Modular hip arthroplasty systems are commonly used during primary total hip arthroplasty (THA) surgery, with approximately 70,000 modular hips implanted annually in the United Kingdom [1]. The additional interface found between the head and neck or the stem and sleeve adapter allows for variable reconstruction of the implant. During primary surgery, this affords the surgeon greater flexibility to adjust the femoral head size, offset, and leg length [2-4]. Furthermore, the ability to retain a well-fixed femoral stem simplifies revision surgery as only the head in this instance would require exchange [5]. The head-neck interface, however, has also been shown to be subject to corrosive processes and fretting that can lead to premature implant failure [6].

When the modular hip cannot be separated during revision surgery, this is referred to as "clinical cold welding." As a consequence, the inseparable implant must be removed, often requiring specialized instruments, osteotomy, and a new stem with diaphyseal fixation. Alternatively, the femoral head may be sectioned to remove it from the stem trunnion; however, this approach has a limited margin for error. With a large at-risk population, surgeons should be aware of the possibility of a clinically cold-welded head when planning revision surgery, to ensure the appropriate equipment is available for the procedure.

Several retrieval studies have reported this phenomenon in the literature [7-11]; however, no study has directly investigated the extent to which cold welding is prevalent within the population or the risk factors which may lead to the formation of this inseparable interface. Our aim was to investigate the factors that influence the formation of a clinical cold weld, to better understand its clinical significance and guide surgeons during revision surgery.

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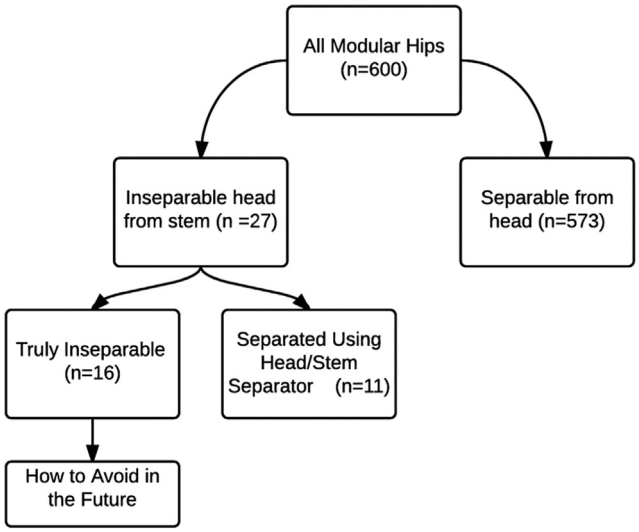

Fig. 1. Study design.

To achieve this, we defined the following objectives: (1) determine the effectiveness of current intraoperative equipment at separating the head from the stem, (2) determine the force required to mechanically disassemble the head from the stem in cases that could not be separated using intraoperative equipment, (3) correlate the difficulty of head-neck separation with clinical and implant factors using a control group of non–cold-welded hips to ascertain if the presence of a clinical cold weld can be predicted preoperatively.

Table 1
Demographic, Metal Ion Concentrations, Reason for Revision and Implant Information.

Demographic, Clinical and Implant Information	Number	Medians	Range
Gender (male:female)			12:15
Age at primary surgery (y)			50-78
Time to revision (mo)			25-131
Femoral head diameter (mm)			28-58
Whole blood cobalt (ppb)			0.60-97.53
Whole blood chromium (ppb)			0.71-60.53
Bearing design			
Biomet Magnum	13		
Stem design			
Biomet—Taperloc	11		
Biomet—Bi-Metric	2		
Bearing design			
ASR	4		
Stem design			
Corial	4		
Bearing design			
Pinnacle	2		
Stem design			
Corial	1		
S-ROM Modular Hip System	1		
Bearing design			
Cormet	5		
Stem design			
Zweymuller	5		
Bearing design			
Mitch	2		
Stem design			
Exeter	2		
Bearing design			
Metasul	1		
Stem design			
Sulzer Allo Pro	1		
Reason for revision			
Unexplained pain	12		
Aseptic loosening (femoral)	10		
Aseptic loosening (acetabular)	1		
Fracture	2		
Osteolysis	1		
Gluteal atrophy	1		

ASR, articular surface replacement.

Table 2
Implant Design and Material Combinations.

Bearing Design	Head Material	Taper Sleeve Yes/No	Taper Sleeve Material	Stem Material	Number
Biomet M2a-Magnum	CoCr	Yes	Ti	Ti	13
ASR	CoCr	Yes	CoCr	Ti	4
Pinnacle	CoCr	No	N/A	Ti	2
Cormet	CoCr	No	N/A	Ti	5
Mitch	CoCr	No	N/A	SS	2
Metasul	CoCr	No	N/A	SS	1

N/A, not applicable; ASR, articular surface replacement; CoCr, cobalt-chromium; SS, stainless steel; Ti, titanium.

Patients and Methods

This was a retrieval study of a consecutive series of implants at our tertiary retrieval center. Figure 1 provides a summary of the study design.

Demographics

Between 2007 and 2015, a total of 600 metal-on-metal failed THA prostheses were received at our center. These consisted of 440 THA-bearing couples that were received without a femoral stem and 180 bearing couples with a femoral stem. Of the 180 received with a femoral stem, 27 had the femoral head retained on the femoral stem such that the implant appeared to be clinically cold welded (CCW) (Table 1).

The 27 bearings that appeared to be CCW consisted of Biomet M2a-Magnum (Warsaw, IN) paired with a Taperloc or Bi-Metric femoral stem (n = 13), Pinnacle (DePuy) paired with a Corail (n = 2), articular surface replacement [ASR] (DePuy) paired with a Corail (n = 4) Mitch Exeter (Kalamazoo, MI) (n = 2).

The Biomet M2a-Mangnum are such that the stems (Taperloc and Bi-Metric) and the taper sleeve are both Ti with CoCr bearings; all other head-stem junctions had a cobalt-chromium-titanium (CoCr-Ti) or cobalt-chromium-stainless steel (CoCr-SS) material combination with either monoblock CoCr head or a CoCr head with a CoCr taper sleeve (Table 2).

These implants were retrieved from 13 male and 14 female patients with a median age of 58 years (48-78) and a median time

Fig. 2. Image of the JRI head/neck separator.