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CORR Insights

CORR Insights®: Does Surface Topography Play a Role in Taper Damage in Head-neck Modular Junctions?

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Where Are We Now?

Head-neck modularity is a universally accepted option in hip arthroplasty, and it has worked extremely well in millions of cases over the years. But there is also a large body of evidence that modularity is a source of metallurgical problems including fretting corrosion and wear, producing particles that can potentially lead to clinical problems [1, 8].

There is a lack of knowledge about the particles produced by hip replacements, and about their possible causes and effects; however, we are concerned about corrosion at the trunnion-taper interface observed in the retrieved modular hip prostheses, and elevations of serum metal levels on laboratory testing. Although the precise ion levels and imaging findings that should be considered severe enough to trigger clinical interventions remain controversial, the fact that these findings have the potential to cause harm seems clear, even if the true incidence of these problems remains unknown [3, 5, 7, 9]. This should be a warning call to the orthopaedic community.

Where Do We Need To Go?

The findings in the current study do not justify the abandonment of the head-neck modularity, the Morse taper as connection system, or the alloys used in these junctions. Many tapers perform well. The problems seem to be more dependent on imperfect trunnion design rather than modularity itself, and future efforts need to focus on improving trunnion design to minimize the kinds of risks noted earlier, in particular the reduction of fretting corrosion occurring in the trunnion. It is essential to obtain a perfect mechanical and electrochemical stability at the interface.

With regard to the mechanical stability of trunnion, we must reconsider all the factors affecting it, such as modifications shortening the length and reducing the thickness of the neck to avoid femoroacetabular impingement, and ultimately decreasing the contact area of the taper. There are other fundamental intrinsic factors to consider such as geometry, surface topography, and roughness of the head-neck junction.

This CORR Insights® *is a commentary on the article* "Does Surface Topography Play a Role in Taper Damage in Head-neck Modular Junctions?" *by Pourzal and colleagues available at:* DOI: 10.1007/s11999-016-4933-x.

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Conversely, contact area, surface topography, and roughness, together with the type of constitutive materials of the head-neck couple, are all factors in the electrochemical stability of the interface [2, 10]. The use of different metal combinations in the head-neck couple, highlighted further by modular necks that add a new interface between neck and stem and promote the use of dissimilar metals in the construct head-neck stem, remains unresolved.

Taper damage is influenced by many factors. Cobalt-chrome (CoCr) is more susceptible than titanium (Ti) alloys to galvanic corrosion, but is also harder and more resistant to wear. A rough finishing Ti-alloy neck-taper, with large machining marks, is unsuitable for insertion into a CoCr head because body fluids filling the valleys stimulate crevice corrosion in the head taper. A taper with a smooth finish presents less fretting and seems preferable in this respect [10]; at least we thought that was the case—until the results of the current study showed exactly the contrary. Keep in mind that variations in the topography of the surfaces of the taper may compromise its interlock strength.

Much of this remains controversial. Experimental studies are subject to important biases, and the analyses of retrieved implants usually are incomplete, and so firm conclusions can be difficult to draw.

How Do We Get There?

Surgeons should not reject modularity outright; rather, they might try to use it selectively, avoiding any unnecessary modular interfaces, and choosing a well-designed trunnion that reduces fretting corrosion. We also need to teach orthopaedic surgeons how to properly handle and assemble the head-neck tapers, in particular focusing on cleanliness and dryness of the interface.

Modular hip prostheses must be tested under strict conditions in a preclinical stage to characterize their behavior, and all retrieved implants must be analyzed following a detailed protocol that addresses the specific issue of taper damage.

In vitro models and finite element analyses can help explain the performance of trunnions in modular prostheses. These approaches also would help us evaluate the changes made so far, and allow us to develop and propose modifications and innovations aimed at improving these systems. Use of other nonmetallic materials such as ceramics, surface treatments of metallic materials [4], and coatings [11], are promising methods to improve fretting and tribocorrosion performance of trunnion components. We must adopt a well-established lexicon that accurately describes fretting, corrosion, and wear of this mechanism, and a comprehensive, validated and more-objective classification of resultant damage than previous studies [6].

The standardization of tapers is mandatory, even if the market pressure often overrides the engineering principles. Orthopaedic surgeons must know these principles in order to assist, instruct, and, when necessary, criticize engineers in planning the necessary changes to achieve an accurate design and taper fit. Collaboration between engineers, orthopaedic surgeons, and manufacturers is essential.

An international multidisciplinary consensus based on these considerations and scientific evidence, as was done for the periprosthetic infections, is needed. Following this, the regulatory agencies would have to proceed through the development of appropriate rules, closely monitoring undesirable alterations and violations thereof.

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