

Influence of Material Composition on Corrosion of Modular Hip Prostheses

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Introduction

The usage of the artificial hip prostheses has existed since the early 1890s where ivory implants were utilized as femoral heads [1], whereas the first metallic hip replacement occurred in the late 1940s where a diseased bone was replaced with a metal ball on a stem [2]. The usage of artificial hip prostheses has been highly successful in alleviating severe osteoarthritis pain and joint damage. Their efficacy is foretold by the sheer number of recipients in the U.S. alone, where over 332,000 total hip replacement (THR) surgeries are conducted annually [3]. However, this success has been tarnished by their poor long term performance which has led to over 40,000 revision surgeries per year to correct for implant failure [4]. Further exacerbating the incidence of implant failure is the increasing number of younger patients undergoing THR, whose more active lifestyles place greater demands on their prosthetic joints [5]. Various implant complications have been reported in the past including aseptic

loosening [6], stress shielding, implant design and manufacturing method [7].

Implant loosening, commonly referred to as aseptic loosening, occurs as a result of stress shielding as well as osteolysis. In the case of stress shielding, the introduction of the femoral implant shifts the load once borne by the bone onto the implant of higher elastic modulus, thereby removing the mechanical stimulus that is required for bone formation. The result is bone resorption and reduced bone density in the areas surrounding the implant as shown in Figure 1 (a), ultimately leading to a loss of implant fixation. On the other hand, osteolysis is a complex physiological process initiated by metal ion release and/or wear particles from the implants head-stem interface that affect the immune system and bone metabolism [8, 9], causing pseudotumors, adverse immune reactions, and infections that lower the pH of nearby periprosthetic tissues as shown in Figure 1(b).

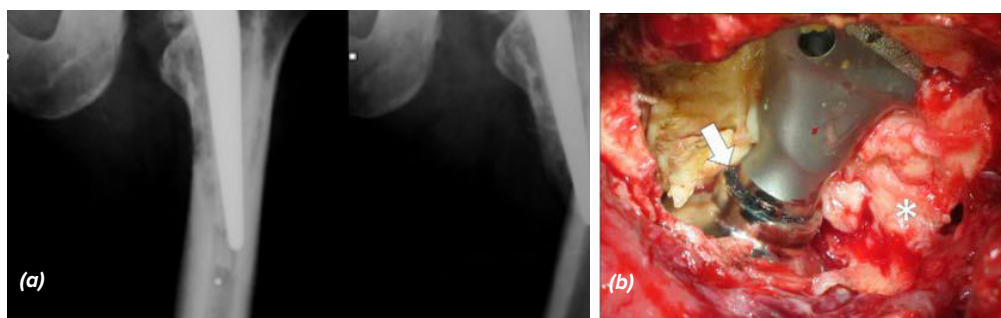


Figure 1: (a) X-Ray image illustrating femoral stress shielding (dark shade of the bone to the right is indicative of reduced bone density) [10]; (b) Intraoperative photograph illustrating corrosion at the head neck interface resulting in adverse local inflammation [11].

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In an effort to minimize the effect of stress shielding, modular prostheses were developed with femoral stems manufactured from materials of lower modulus similar to that of bone. This approach resulted in the development of the now widely accepted two piece stem design. However, the introduction of low modulus materials have led to aseptic loosening as a result of metal-on-metal wear. This tribological phenomenon at the interface between the femoral head and stem is accompanied by an electrochemical process, which together is termed fretting corrosion [12, 13, 14].

Significance

The femoral head has traditionally been considered the primary source for metal ion release as a result of tribocorrosion. In fact, any change in the material composition, microstructure or design of the implant material could significantly affect its performance. It is well-established that different manufacturing methods and material heat treatments result in different microstructures that affect a material's properties. However, there is a lack of comprehensive dimensional analysis to delineate whether the damage observed on explanted prostheses resulted from its design, the material properties or from clinical factors. This article focuses on an assessment of the severity of corrosion that occurred at the trunnion-head interface of explanted prostheses in an effort to understand the influence of material composition.

Material Characterization

Forty eight total hip prostheses utilized in this study were acquired from revision surgeries conducted to correct a variety of implant failures including but not limited to aseptic loosening, acetabular liner degradation and dislocation. The heads consisted of high carbon Co-Cr-Mo and the stems consisted of Ti-6Al-4V and low carbon Co-Cr-Mo. Furthermore, the alloys were subjected to different manufacturing processes such as casting followed by hot isostatic pressing and solution treatment. The explants were sterilized, sectioned and cleaned to remove any organic residue. Photographs of cleaned samples were

taken using a digital camera in order to observe evidence of corrosion and for scoring as per the Goldberg criteria [15].

In order to determine the degree of fretting corrosion, evidence of corrosion at taper regions where relative

Table 1: Goldberg criteria for corrosion and fretting observed on taper interfaces

Score	Corrosion Criteria	Fretting Criteria
1 (None)	No visible corrosion	No visible signs of fretting
2 (Mild)	<30% surface discolored/dull	Band(s) for fretting scars across ≤ 3 machine lines
3 (Moderate)	>30% surface discolored or <10% containing black debris, pits or etch marks	Band(s) involving >3 machine lines on taper surface
4 (Severe)	>10% of surface containing black debris, pits or etch marks	Several bands of fretting scars involving several machine lines or flattened areas with nearby fretting scars.

Results and Discussion

Most revision surgeries for patients after total hip arthroplasty are caused by tribocorrosion at the modular femoral head-neck taper junction [11]. This is due to the chemically enclosed nature of the head-neck taper junction and the micron displacement that occurs at the junction during physical activities. The modular interface experiences galvanic corrosion due to dissimilar metals, fretting corrosion due to relative surface motion and crevice corrosion due to oxygen depletion. Furthermore, fluid stagnation results in reduced repassivation at the interface. Besides material type and microstructure, the important modular hip prosthetic components that influence corrosion behavior include: a) morse taper, b) neck and taper diameter, c) trunnion-head interface and d) femoral head size.

surface motion occurred were compared with that of no relative motion. A comparison of corrosion severity was conducted between prostheses with high carbon Co-Cr-Mo head with low carbon Co-Cr-Mo stems (Co/Co) and those composed of high carbon Co-Cr-Mo heads with Ti-6Al-4V stems referred to as mixed alloy (Ti/Co). Figure 2 shows a photomicrograph comparing worn and unworn surfaces of a trunnion taper interface. Unworn surfaces can nearly always be found in the distal taper area of femoral heads. However, unworn regions are rare in trunnion tapers unless the taper extended beyond the bore of the femoral head. In cases where the entire trunnion taper was in contact, the asymmetrical nature of fretting wear along the circumference of the taper can be used as a reference point.

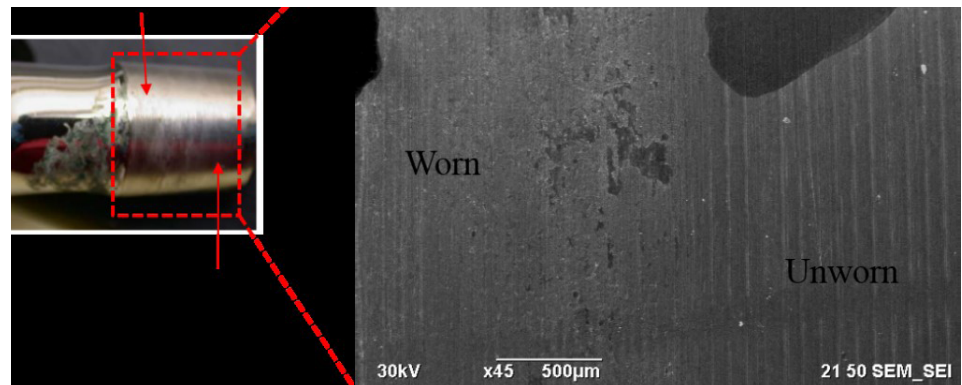


Figure 2. Taper surface of explanted prosthesis on left and the SEM micrograph of the taper showing worn and unworn mating surfaces

Discoloration in the form of a tarnish film was considered to be a mild form of corrosion as shown in Figure 3a. Dullness can either be the result of a proteinaceous film or etching of the fine microstructure of the taper components. Homogenous dullness that covered the entire surface area was attributed to surface finish particularly with titanium components.

Of the 47 randomly selected head and stem/trunnion explanted prostheses, approximately 15% exhibited severe (score 3) general corrosion as well as fretting corrosion. There was no significant difference in the degree of corrosion severity between the head and stem/trunnion interface. However, of the 36 head and stem/trunnion Co-Cr-Mo samples, 11% exhibited severe

may be attributed to galvanic corrosion, tribological response (relative surface motion between a hard head and the softer stem) and greater susceptibility of the titanium alloy to the physiological environment. Ultimately, an in-depth understanding of the influence of prosthesis design, material microstructure and their role in adverse local tissue reactions are required in

order to improve not only the implant life but also to minimize the number of revision surgeries. An overview of the effect of modular hip prostheses design on their corrosion behavior is forthcoming in a future article.

References

1. R. A. Brand, M. A. Mont and M. M. Manring, "Biographical Sketch The-mistocles Gluck," Clinical Orthopaedic Related Research, vol. 469, pp. 1525-1527, 2011.
2. T. Stevenson, "Advances in Hip Replacement Surgery," South Australian Medical Heritage Society Inc.
3. US Department of Health and Human Services, "Procedures by selected patient characteristics- number by procedure, category and age," CDC/ NCHS National Hospital Discharge Survey, 2013.

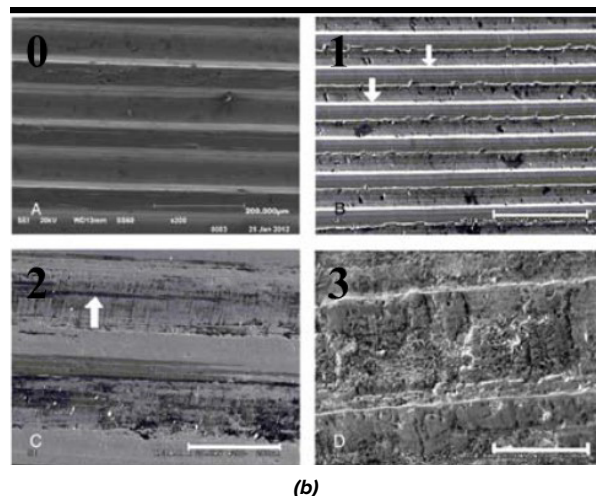
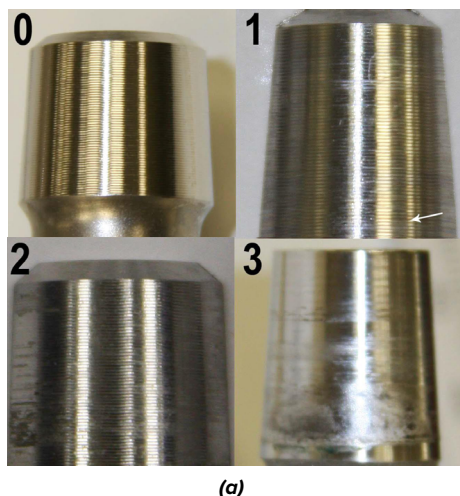


Figure 3: (a) Tapers with various degrees of corrosion damage as classified by Goldberg: (0) None, (1) Mild, (2) Moderate and (3) Severe. (b) SEM micrographs of fretting corrosion as per Goldberg criteria.

Ascertaining the difference between fretting and general corrosion can be difficult, particularly when a surface is extensively corroded. Fretting corrosion refers to corrosion damage under load and in presence of repeated relative surface motion, whereas general corrosion is more or less uniform corrosion without appreciable localization or pits. In some cases, damage is severe enough to warrant assigning the same score to both fretting and corrosion. Fretting damage tends to manifest itself as single, off-angle, long narrow scratches over many machine lines. Fretting damage caused by impaction or disengagement during retrieval were disregarded. Utilizing Goldberg criteria, the explanted prostheses samples were scored and reported in Figure 4.

corrosion whereas of 10 head and stem/trunnion Ti-6Al-4V samples, 40% exhibited severe corrosion.

Conclusions

The severe degree of corrosion (both general and fretting) observed by the mixed Ti/Co head-stem assembly as compared with the Co/Co assembly

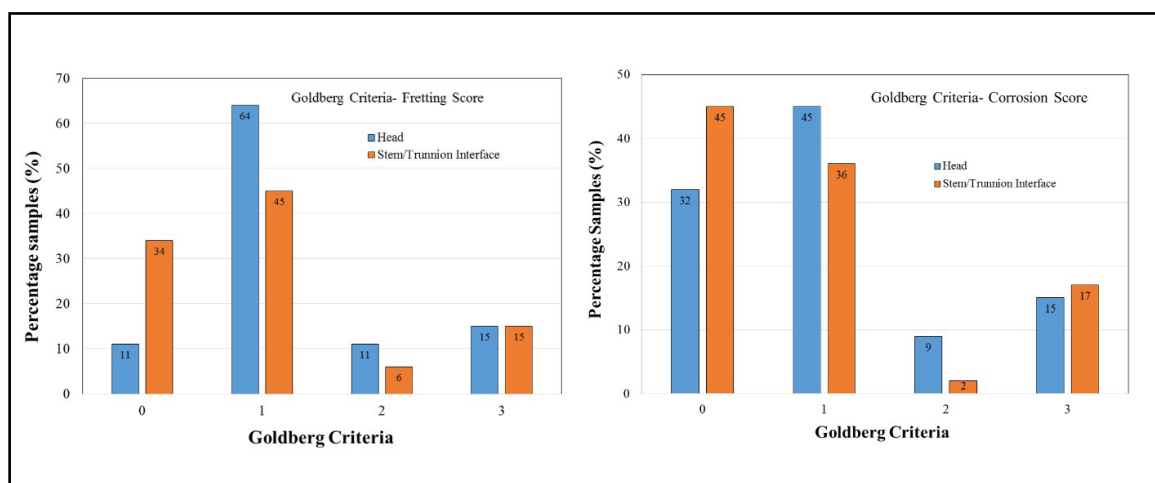


Figure 4: Corrosion severity of explanted prosthesis as per Goldberg's criteria: (0) None, (1) Mild, (2) Moderate and (3) Severe; (a) Fretting scores (b) Corrosion scores

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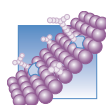
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Coating Scratch Resistance and Interfacial Adhesion Evaluation through Nanoscratch

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Protective coatings are designed to prevent substrate from corrosion, erosion, oxidation, scratch, and wear. A high performance thin and sometimes an ultra-thin film coating are used to protect or decorate a substrate for economical reasons and for conservation of precious and rare materials. Nanoscratch testing is an important technique for characterization of surface properties of these protective and decorative coatings. Knowing the characteristics of a coating in the aspects of scratch resistance and interfacial adhesion can aid the development of coating material with desired performance, functionality and lifetime.

One of the nanoscratch systems equipped in Ebatco's Nano Analytical and Testing Laboratory (NAT Lab) is capable of carrying out nanoscratch tests under ramp or constant load, pre-selected scratch length and other control parameters. During a nanoscratch, four parameters: normal force, normal displacement, lateral force, and lateral displacement are measured and recorded as a function of time. From these parameters, comprehensive information about a material's nanoscratch properties can be characterized. Commonly characterized nanoscratch properties include friction between the sample surface and the scratch probe, critical load of interfacial failure, and scratch resistance.

Nanoscratch testing has been widely accepted as a way of evaluating interfacial adhesion of thin film/substrate systems. Failure events may be found where the probe produces delamination, debonding, crack, fracture, or breakthrough at the film/substrate

scratch data graphs. The critical load of adhesion failure is a good indication of interfacial adhesion strength. Normally, a higher critical load represents a higher interfacial adhesion. However, the true relationship between interfacial adhesion and critical load is rela-

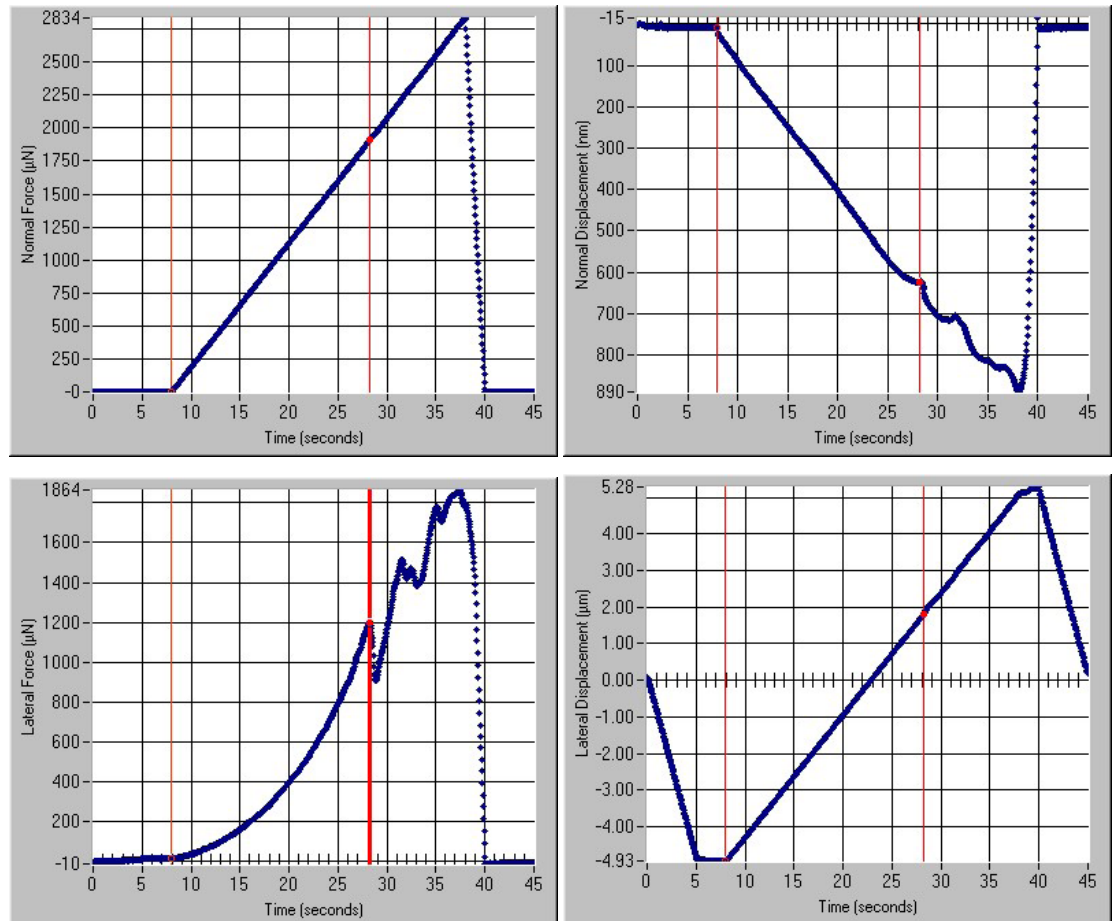


Figure 1. Nanoscratch test data obtained on an organic thin film on Si substrate specimen.

interface. The failure events of the film are normally symbolized by a combination of sudden changes in the lateral force, normal displacement, and/or normal force data. The critical load is defined as the normal force applied to the scratch probe at the time when interfacial failure is detected and can be determined by analyzing the

tively complicated and may be affected by many factors such as the fracture toughness of the materials involved, film thickness, and the scratch testing parameters.

In addition to determination of the critical load at interfacial failure, the nanoscratch tests can be applied to evaluate material's resistance to

scratch such as for clear coat of auto body. It can be used to simulate mar resistance by quantifying the minimum load for generating visible scratches or change of surface gloss or by measuring the scratch width and depth under a selected load.

The friction measurement through nanoscratch is deemed very useful in studying thin film and coating frictional characteristics under extremely lighter load or under very high contact pressure. It is regarded as an invaluable tool for research on friction mechanisms and debris generation under the terminology of nanotribology.

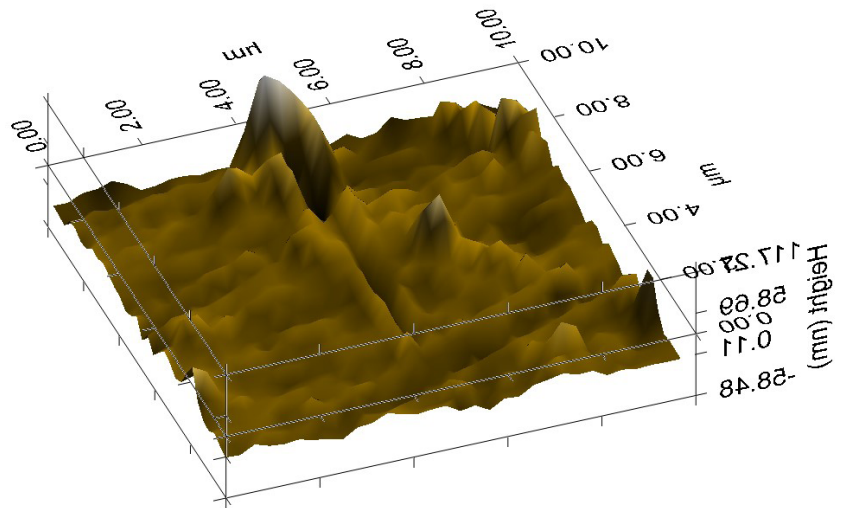


Figure 2. 3D plot of a nanoscratch conducted on a polymer film on metal substrate for interfacial adhesion evaluation imaged through in-situ SPM imaging.

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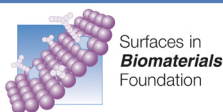
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4. S. Kurtz, K. Ong, E. Lau, F. Mowat and M. Halpern, "Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030," *Journal of Bone & Joint Surgery*, vol. 89, pp. 780-785, Apr 2007.
5. S. Kurtz, E. Lau, K. Ong, K. Zhao, M. Kelly and K. Bozic, "Future young patient demand for primary and revision joint replacement: national projections from 2010 to 2030," *Clinical Orthopaedic Related Research*, vol. 467, pp. 2606-2612, Oct 2009.
6. M. A. McGee, D. W. Howie, K. Costi, D. R. Haynes, C. I. Wildenauer, M. J. Pearcy and J. D. McLean, "Implant retrieval studies of the wear and loosening of prosthetic joints: A Review," *Wear*, vol. 241, pp. 158-165, 2000.
7. M. M. William, "Retrieval Studies in Orthopaedic Surgery: Editorial Comment," *Clinical Orthopaedics and Related Research*, vol. 470, pp. 1803-1804, 2012.
8. C. Cadosch, O. Gautschi and L. Filgueira, ""Metal is not inert: role of metal ions released by biocorrosion in aseptic loosening--current concepts," *Journal of Biomedical Materials Research A*, vol. 91, pp. 1252-1262, 2009.
9. D. Cadosch, C. Schlett, O. Gautschi, H. Frei and L. Filgueira, "Metal ions: important co-players in aseptic loosening," *Z Orthop Unfall*, vol. 148, pp. 393-397, Aug 2010.
10. I. Watt, S. Boldrik, E. v. Langelaan and R. Smithuis, "Hip- Arthroplasty: Normal and abnormal imaging findings," Feb 2006.
11. H. Cooper, C. Della Valle, R. Berger, M. Tetreault, W. Paprosky and S. Sporer, "Corrosion at the head-neck taper as a cause for adverse local tissue reactions after total hip arthroplasty," *Journal of Bone & Joints Surgery*, vol. 94, pp. 1655-1661, 2012.
12. H. Silva and T. Schmalzried, "Metal-on-metal total hip replacement," *Clinical Orthopaedic Related Research*, pp. 53-61, 2005.
13. J. Langton, T. Joyce, J. Gandhi, R. Sidaginamale, L. Mereddy and A. Nargol, "Accelerating failure rate of the ASR total hip replacement," *Journal of Bone and Joint Surgery*, pp. 1011-1016, 2011.
14. J. Gilbert, C. Buckley and J. Jacobs, "InVivo Corrosion of Modular Hip Prosthesis Components in Mixed and Similar Metal Combinations: The Effect of Crevice, Stress, Motion and Alloy Coupling," *Journal of Biomedical Materials Research*, vol. 27, pp. 1533-1544, 1993.
15. G. Goldberg Jr, J. Jacobs, T. Bauer, W. Paprosky and S. Leurgans, "A Multicenter Retrieval Study of the Taper Interfaces of Modular Hip Prostheses," *Clinical Orthopaedic Related Research*, pp. 149-161, 2002.
16. J. Robert M. Urban, J. L. Gilbert, S. B. Rice, M. Jasty, C. Bragdon and J. O. Galante, "Characterization of solid products of corrosion generated by modular-head femoral stems of different designs and materials," *Modularity of Orthopedic Implants*, pp. 33-44, 1997.

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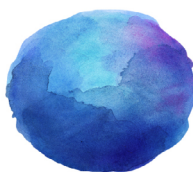
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