ECRONICON OPEN ACCESS

EC ORTHOPAEDICS
Case Report

# Head-Neck Taper Corrosion in Total Hip Arthroplasty: Catastrophic Cases Report and Review

**Molfetta L[1]*, Florian A[2], Palermo A[3], Capozzi M[4] and Formica M[3]**

*[1,2,3]University of Genoa, School of Medical and Pharmacological Sciences, DISC Department, Genoa (Italy)*

*[3,4]Humanitas University, Orthopaedic Unit, Bergamo (Italy)*

***Corresponding Author:** Molfetta L, University of Genoa, School of Medical and Pharmacological Sciences, DISC Department, Genoa (Italy).

**Received:** March 23, 2022; **Published:** April 20, 2022

## Abstract

The modularity in total hip arthroplasty (THA) has reduced the inventory of the prosthetic system, allowing length and off-set adjustment of the limb, simplifying revision surgery through the replacement of the head only, whenever it is possible. Side effects of modularity, such as fretting and corrosion of the head-neck junction, are well known in revision surgery.

In this cases report we will describe a THA failure after 11 years on the head-neck junction of Accolade I femoral stem, chromium-cobalt (CoCr) femoral head and taper V40 (Stryker 1 Corporation, USA), and a THA failure after 4 years on the head-neck junction of SYMAX 7 (Ti-Al-V) femoral stem with cono-morse V40 (Stryker Orthopaedics) and large 50-4mm metal modular head (Co Cr Mo, Finsbury Orthopaedics), secondary to corrosion and subsequent disassembly of head-neck junction.

We will analyze the literature which highlights the need for greater awareness of the surgeon on the choice of the system implant about the modularity of the femoral neck-prosthetic head, evaluating the materials and geometry of the prosthetic components and overload and alignment of the implant that may be precondition for this complication with, occasionally, catastrophic results.

***Keywords**: Cono-Morse; Taper; Fretting; Corrosion; Disassembly*

## Introduction

The most common causes of revision in THA are aseptic loosening, infection, instability, dislocation and trauma [1]. Today there are high standards of THA in terms of materials, surgical techniques, design and modularity of the implants [2]. These factors reduced inventory and granted versatility and interchangeability among the different prostheses [3]. The concept of modularity is further applied to femoral stems providing length and off-set regulation; it also made easier revision surgery with preservation *in situ* of the stem and, when possible, just replacing the femoral head [4,5]. Many factors like cone design, materials, prosthetic head diameter, lateral off-set, stem malposition and durability of implants may cause the fretting of the components, which lead to corrosion at the head-neck junction [6-8]; corrosion debris behaves like debris from metal on metal (MoM) implants with large head [9-12]. According to the literature review we present two catastrophic cases in terms of damage at the taper-head modularity.

## Case Report

A 79-year-old male, who suffered from osteoarthritis of the hip, had a total hip replacement MoM with MITCH (Stryker, USA) metal cup and Accolade I femoral stem 127° valgus and taper V40 CoCr head and Ti neck.

After 11 years in absence of distress or malalignment, a severe and acute hip pain appeared. Rx showed disassembling of head-neck junction of the stem that was worned out and deformed (Figure 1). two modular components was confirmed.

***Figure 1:*** *Disassembly of head-neck due to corrosion of V40 femoral neck.*

There were severe signs of wear and tear especially on the lateral portion, without significant involvement of the CoCr female portion (Figure 2). There was an intense periarticular metallosis, secondary to the metal debris from the femoral stem's neck (V40 Taper). Histologically wear debris disease was confirmed (Figure 3). Blood levels of Cr and Co were normal without any clinical sign. The patient, moreover, had not reported any general disorders related to an increase of the two ions.

***Figure 2:*** *Fretting corrosion of the neck; note the damage at the base of the femoral neck, medially, caused by impact of the female portion of the head.*

***Figure 3:*** *Histological evidence of metallosis.*

A non-cemented Tracer cup and Exacta (Premedical, Milan) stem was implanted, restoring morphometric parameters of the hip. Post-operative course was regular with good clinical recover after rehabilitation in terms of muscle tone, proprioceptive, movements and gait scheme.

## Case Report

Male patient with elevated BMI, who underwent surgery at the age of 58 due to a bilateral osteonecrosis of the femoral head. A right THA was implanted: MITCH TRH 56 mm cup with large 50-4mm metal modular head (Co-Cr-Mo, Finsbury Orthopaedics) and SYMAX 7 (Ti-Al-V) femoral stem with cono-morse V40 (Stryker Orthopaedics).

After 14 years, in orthostasis, the patient felt a clatter from right hip with subsequent failure and fall to the ground. Rx showed the break of prosthetic neck while the stem was correctly integrated into the bone, as the acetabular cup (Figure 4).

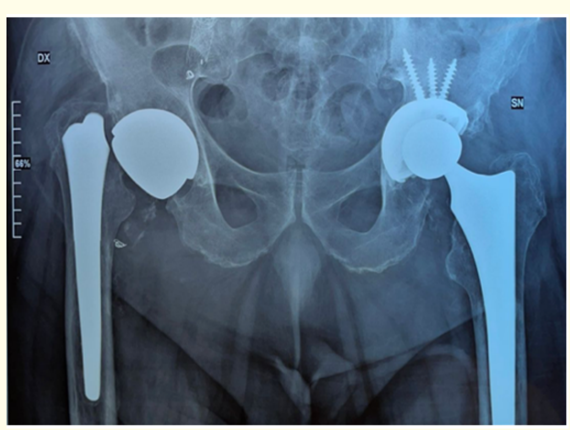


***Figure 4:*** *Second case of V40 disassembly.*

The revision surgery consisted in re-implantation of Wagner long stem with bone cerclages in order to stabilize the bone window. For the cup, that was intact without internal abrasion, a PE insert was used. The neck corrosion was located 1 cm below the inferior hedge of the cono-morse of the lower diameter (Figure 5). The break-section was divided in two parts; the lateral one, curved "crescent-like", opaque and almost horizontal due to prolonged contact with female portion of the large metallic prosthetic head; the medial part was wedge, "cotyledon-like", vertical and more polished.

***Figure 5:*** *The break-section divided in two parts: the lateral one, curved "crescent-like", horizontal; the medial part was wedge, "cotyledon-like", vertical.*

These aspects are secondary to an event occurred in two different moments: the first one, slow, lasting a few years and the second one, acute with sudden structural failure. Further demonstration was the diffuse metallosis with stack of the debris at calcar. More precisely, the accumulation was into the crook of female portion of the cono-morse, where the fractured part of the prosthetic neck was located.

## Discussion

Femoral stem's neck is a truncated cone, tapering towards extremity (taper) with a uniform variation of its diameter along the axis [13]. The femoral taper is lodged inside the female part of the cone of the head, creating a conical coupling named cone-morse, with interference, correlated to the load with mutual cold welding between the two components [4]. Radial forces create a resistance to separation in the head-neck junction, but also generate a friction between the two conical surfaces [14].

The metal alloys traditionally used for THA offer biocompatibility, corrosion resistance and optimal mechanical properties [15]. The most used materials for femoral head are delta ceramic or Chromium-Cobalt (CoCr), like MoM, connected to Ti-6Al-4V stems. Using a bigger femoral head reduces dislocation incidence and increase range of motion and strain on the femoral stem's neck [16].

The Australian Orthopaedic Association National Joint Replacement Registry highlighted correlation between the higher revision rate and the head's diameter greater than 32 mm in THA Metal on Metal (MoM) emphasizing the role of the conic junction as major responsible of corrosion [17]; that can be influenced by body mass index (BMI), lateral off-set, varum position of stem, long neck, wrong positioning of the head, including impact force, the vector applied and contamination of surfaces [18].

Normal., *et al.* analyzed many coupling between stem with increasing diameter of head and discovered that to a greater diameter corresponds a greater strain, in addition to higher horizontal lever arm at taper level and trunnion load off-set [19].

In MoM implants, assembled CoCr head and Ti neck resist quite well to corrosion due to self-passivation process secondary to a creation of a protective superficial oxide film; this layer though can undergo an alteration during load cycles because of some fluctuations. The subsequent fretting determines the disappearance of the same layer, exposing the metal to corrosion [20,21].

Hexter., *et al*. defined that kind of galvanic corrosion "mechanically assisted crevice corrosion" (MACC) [22] that, in mixed coupling, origins from corrosion of splits due to local chemical modification induced from corrosion [7,8]. Delta ceramic heads present less MACC, compared to CoCr, because they develop fretting at higher compression loads on Ti necks in a simulated model (Zimmer 12/14 and Stryker V40); the starting load was cycling in compression and the slope of mean curve is significantly increased [23].

Conical femoral necks have different dimensions and angle. Greater diameters, longer tapers and circular shape correlate with a lower rate of dislocation, ROM reduction despite lower diameters, short taper and trapezoidal shape [24,25].

Femoral head is fully occupied by short neck, increasing load and fretting at the cone's base. If necks are tighter there will be wrong coupling with micro-motion at the head-neck junction with fretting and corrosion [26,27]. Nassif., *et al*, on the contrary, found out that, because a wider surface, fretting is higher for thicker and longer taper [10].

About cone-morse, the effect of angular-mismatch suggests a threshold tolerance different from the industry accepted tolerance of 0.0167° beyond which micro-motion would have increased [28], after continuous load, with reduced contact area and greater roughness [29].

Goldberg., *et al.* have widely documented a higher percentage of corrosion damage both to the head and the taper in coupling between different alloys than mixed alloys (respectively 42% and 28%) [6]. In other studies, no corrosion or friction damage at the head's cone prevailed over the neck [18].

In THA with a neck in Ti-6Al-4V alloy and a head in austenitic stainless steel 316L, the fretting corrosion damage is greater for Ti [30]. In addition, it has been demonstrated that the axial load determines higher damage in Ti/Ti couplings than in CoCr/CoCr, with a better adaptation to interference by cold welding which sometimes that makes it difficult to disassemble during revision surgeries [31].

Ceramic has inert and electrically insulating properties. Fretting corrosion is lower in CoCr stems-Zirconia heads if compared to CoCr/CoCr couplings. A study demonstrated that in CoCr-Ceramic couplings the corrosion is lower in ceramic components despite a percentage of fracture and corrosion of ceramic head (0,02 - 1%) [32].

CoCr head and V40 taper has a low starting load (1.400 N) and Ceramic head and V40 taper has high load (2.200 N). It has been observed that it is the geometry of the cone, and not the material, that affects fretting at the conic junction [23].

Wylde., *et al.* have documented a characteristic destructive wear pattern of the femoral taper (trunnion) defined "bird beak" appearance in V40 Accolade I (Stryker) with head larger than 36mm. This wear pattern created excessive movement and loosening resulting in a trunnion/head dislocation or brittle fracture of the trunnion [33].

A peculiar type of corrosion of the cone involves metallic 32 mm head with LFIT (Stryker, Mahwah, NJ) stem or Accolade I (Stryker) Ti-12Mo-6Zr-2Fe stem enlarges the head's cone. This fact consumes the cone of the stem, made in softer alloy, and then touches the bottom of the cone. This study shows that the conic design of Ti-12Mo-6Zr-2Fe stem and 11/13 cone with 36 mm head represent an important risk factor of corrosion compared to larger cones made by stiffer materials and with different model in terms of micro-motion [34].

Spanyer J., *et al.* described three unsuccessful implants of Accolade I Ti-12Mo-6Zr-2Fe stems with CoCr femoral heads that resulted in rupture of the femoral neck after 7 years of minimal survival.

Authors attributed the failure to the fatigue load and corrosion of the head-neck joint, with the possible contribution of the design of the neck and the geometry of the cone. These factors could be potentially responsible for shorter duration of resistance to fatigue [35].

In addition, metal debris formation may cause a general reaction due to elevated blood level of Cr and Co generated from corrosion and fretting. A macrophage and lymphocytic response with synovitis, tissue necrosis and osteolysis up to loosening of prosthetic components is present [36]. From a histological point of view, there is a chronic periprosthetic inflammation with different cellular population, especially macrophages, reactive to both Ti and CoCr debris and several cytokines including IL-6 and TNFa [37,38]

Therefore, we can assume the taper corrosion when blood level of chromium and cobalt are elevated, with a differential increase of the two elements [39]. Corrosion debris may act as third foreign body, resulting in an abrasive wear at the head-cup junction.

## Conclusions

The cono-morse - head coupling is an important moment in THA and the head-neck fretting and corrosion are a well-known event [40]. This phenomenon appears in several ways, starting from mild corrosion without tissue reaction nor clinical signs until the presence of severe metallosis or pseudotumor formation with major implication, especially in MoM implants is observed [41,42]. The surgeon must consider the choice of material and the femoral head diameter. It is important to take care of implanting the cone in the metal head in an articular environment that should be clean without blood or adipose tissue [43]. Lastly, in order to avoid angular defects in the taper [46], impaction energy and a good technique must be properly considered [44,45].

The 12/14 cono-morse may be different in terms of dimension and cone angulation even if they come from the same manufacturer. We need to remember that the threshold of conic between head and taper is 0,075°; over this value, micro-motion at the head-neck junction is increased [28].

The data obtained from the study of the prostheses extracted cannot be generalized especially in the absence of local and general clinical signs. We must consider that the surgeon choice is based on the data reported by the manufacturer, unaware of some minor angular variations of the cono-morse that may lead to corrosion. In resssion Surgery the stem with taper damage can remain *in situ* if it is stable, in revision surgery. Mild or moderate corrosion does not affect torsion properties of the cone junctions. Doubts remain about the use of ceramic head with damaged cono-morse [47]. The positioning of ceramic head on worn cone should be avoided because of stress that can induce a head fracture [48]. Keeping in mind that manufacturers do not recommend this behavior and so on the legal implications. Other important factors to be considered are the entity of the trunnion alteration and the stabilization of the head [49].

The multifactoriality of the corrosive process by fretting at the head-neck junction allows to say that tests are not clarifying at the moment and we need controlled studies in order to identify the relative contribution of each design factor that takes part in the corrosion of the taper [50].

## Bibliography

1. Bozic KJ., *et al*. "The epidemiology of revision total hip arthroplasty in the United States". *Journal of Bone and Joint Surgery American* 91 (2009): 128-133.
2. Cooper HJ., *et al*. "Corrosion at the head-neck taper as a cause for adverse local tissue reactions after total hip arthroplasty". *Journal of Bone and Joint Surgery Amer* 94 (2012): 1655-1661.
3. Lee EW and Kim HT. "Early fatigue failures of cemented, forged, cobalt-chromium femoral stems at the neck-shoulder junction". *The Journal of Arthroplasty* 16 (2001): 236-238.
4. Srinivasan A., *et al*. "Modularity of the femoral component in total hip arthroplasty". *Journal of the American Academy of Orthopaedic Surgeons* 20.4 (2012): 214-222.
5. Dyrkacz RMR., *et al*. "The influence of head size on corrosion and fretting behaviour at the head-neck interface of artificial hip joints". *The Journal of Arthroplasty* 28.6 (2013): 1036-1040.
6. Goldberg JR., *et al*. "A multicenter retrieval study of the taperBioMed Research International 7interfaces of modular hip prostheses". *Clinical Orthopaedics and Related Research* 401 (2002): 149-161.
7. Higgs GB., *et al*. "Is increasedmodularity associated with increased fretting and corrosiondamage in Metal-on-Metal Total Hip Arthroplasty devices? Aretrieval study". *The Journal of Arthroplasty* 28.8 (2013): 2-6.
8. Higgs GB., *et al*. "Method of characterizing fretting and corrosion at the various taperconnections of retrieved modular components from metalon-metal total hip arthroplasty". in Metal-on-Metal Total HipReplacement Devices, S. M. Kurtz, A. S. Greenwald, W. M.Mihalko, and J. Lemons, Editions., STP 1560, American Society for Testing and Materials, Conshohocken, Pa, USA (2013).
9. Langton DJ., *et al*. "Taper junction failure in large-diametermetal-on-metalbearings". *Bone and Joint Research* 4 (2012): 56-63.
10. Nassif NA., *et al*. "Taper design affects failure of large-head metal-on-metal total hip replacements". *Clinical Orthopaedics and Related Research* 472.2 (2014): 564-571.
11. Kurtz SM., *et al*. "Do ceramicfemoral heads reduce taper fretting corrosion in hip arthroplasty?A retrieval study". *Clinical Orthopaedics and Related Research* 471.10 (2013): 3270-3282.
12. Brown SA., *et al*. "Frettingcorrosion accelerates crevice corrosion of modular hip tapers". *The Journal of Applied Biomaterials* 6.1 (1995): 19-26.
13. Oxford Dictionaries (2014).
14. Hernigou P., *et al*. "One hundred and fifty years of history of the Morse taper: from Stephen A. Morse in 1864 to complications related tomodularity in hip arthroplasty". *International Orthopaedics* 37.10 (2013): 2081-2088.
15. Hoeppner DW and Chandrasekaran V. "Fretting in orthopaedic implants: a review". *Wear* 173 (1994): 189-197.
16. Brummitt IK., *et al*. "Effect of counterface material on the characteristics of retrieved uncemented cobalt-chromium and titanium alloy total hip replacements". *Proceedings of the Institution of Mechanical Engineers, Part H* 210.3 (1996): 191-195.
17. Australian Orthopaedic Association National Joint ReplacementRegistry, "Hip and knee arthroplasty" *Annual Report* (2013).

18. Moga I., *et al*. "Variables influ- encing tribo-corrosion of modular junctions in metal-on- polyethylene THR?" *In Proceedings of the American Academy of Orthopedic Surgeons Annual Meeting, Paper* 614 (2020): 2.

19. Norman TL., *et al*. "Taper-Trunnion Interface Stress Varies Significantly With Head Size and Activity". *Arthroplasty* 34.1 (2019): 157-162.

20. Sivakumar B., *et al*. "Fretting corrosion behaviour of Ti-6Al-4V alloy in artificial saliva containing varying concentrations of fluoride ions". *Wear* 270 (2011): 317-324.

21. Virtanen S., *et al*. "Special modes of corrosion under ph.ysiological and simulated physiological conditions". *Acta Biomaterialia* 4.3 (2008): 468-476.

22. Hexter A., *et al*. "Mechanism of corrosion in large diameter head metal-on metal total hip arthroplasty: a retrieval analysis of 161 components". *Bone and Joint Journal-British Volume* 95.12 (2013): 4-9.

23. Rowan FA., *et al*. "The onset of fretting at the head-stem connection in hip arthroplasty is affected by head material and trunnion design under simulated corrosion conditions". *Journal of Orthopaedic Research* 36.6 (2018): 1630-1636.

24. Barrack RL., *et al*. "Stem design and dislocation after revision total hip arthroplasty: clinical results and computer modeling". *The Journal of Arthroplasty* 16.1 (2001): 8-12.

25. Padgett DE., *et al.* "Influence of total hip design on dislocation: a computer model and clinical analysis". *Clinical Orthopaedics and Related Research* 447 (2006): 48-52.

26. Rodriguez JA and Rathod PA. "Large diameter heads: is bigger always better?" *The Journal of Bone and Joint Surgery British* 94 (2012): 52-54.

27. Berry DJ., *et al*. "Effect of femoral head diameter and operative approach on risk of dislocation after primary total hip arthroplasty". *Journal of Bone and Joint Surgery American* 87.11 (2005): 2456-2463.

28. Parekh J., *et al*. "Effect of angular mismatch tolerance on trunnion micro-motion in metal-on- metal THA designs". *Bone Joint Journal - British Volume* 95.34 (2013): 261-265.

29. Panagiotidou A., *et al*. "Enhanced wear and corrosion in modular tapers in total hip replacement is associated with the contact area and surface topography". *The Journal of Orthopaedic Research* 31 (2013): 2032-2039.

30. Duisabeau L., *et al*. "Environmental effect on fretting of metallic materials for orthopaedic implants". *Wear* 256 (2004): 805-816.

31. Kop AM., *et al*. "Proximal component modularity in THA-at what cost? An implant retrieval study". *Clinical Orthopaedics and Related Research* 470 (2012): 1885-1894.

32. Hannouche D., *et al*. "Fractures of ceramic bearings: history and present status". *Clinical Orthopaedics and Related Research* 417 (2003): 19-26.

33. Wylde CW., *et al*. "Catastrophic failure of the Accolade I hip arthroplasty stem: a retrieval analysis study". *HIP International* 30 (2020): 481-487.

34. Morlock MM., *et al*. "Head Taper Corrosion Causing Head Bottoming Out and Consecutive Gross Stem Taper Failure in Total Hip Arthroplasty". *The Journal of Arthroplasty* 33.11 (2018): 3581-3590.

35. Spanyer J., *et al*. "Catastrophic Femoral Neck Failure after THA with the Accolade I Stem in Three Patients". *Clinical Orthopaedics and Related Research* 474 (2016): 1333-1338.

36. Urban RM., *et al*. "Local histological and systemic effects ofmetalcorrosion products". In Proceedings of the Hip Society Meeting,Chicago, Ill, USA (2013).

37. Lee SH., *et al*. "Human monocyte/macrophage response tocobalt-chromium corrosion products and titanium particles in patients with total joint replacements". *Journal of Orthopaedic Research* 15.1 (1997): 40-49.

38. Trindade MCD., *et al*. "In vitro reaction to orthopaedic biomaterials by macrophages and lymphocytes isolated from patients undergoing revision surgery". *Biomaterials* 22 (2001): 253-259.

39. Garbuz DS., *et al*. "The John Charnley award: metal-on-metal hip resur- facing versus large-diameter head metal-on-metal total hip arthroplasty: a randomized clinical trial". *Clinical Orthopaedics and Related Research* 468 (2010): 318-325.

40. Engh CA., *et al*. "The surgical options and clinical evidence for treatment of wear or corrosion occurring with THA or TKA". *Clinical Orthopaedics and Related Research* 472 (2014): 3674-3686.

41. Hussenbocus S., *et al*. "Head-Neck Taper Corrosion in Hip Arthroplasty". *BioMed Research Internationa Volume* (2015): 9.

42. Rowan FE., *et al*. "The onset of fretting at the head-stem connection in hip arthroplasty is affected by head material and trunnion design under simulated corrosion conditions". *Journal of Orthopaedic Research* 36.6 (2018): 1630-1636.

43. Mroczkowski ML., *et al*. "Effect of impact assembly on the fret- ting corrosion of modular hip tapers". *Journal of Orthopaedic Research* 24 (2006): 271-279.

44. Vail TP. "Complications: metal-on-metal articulations-design and technique related factors," in Proceedings of the Hip Society Meeting, Chicago, Ill, USA (2013).

45. Rehmer A., *et al*. "Influence of assembly procedure and material combination on the strength of the taper connection at the head-neck junction of modular hip endoprostheses". *Clinical Biomechanics* 27 (2012): 77-83.

46. Milosev L., *et al*. "Extensive metallosis and necrosis in failed prostheses with cemented titanium-alloy stems and ceramic heads". *Journal Bone Joint Surg British* 82 (2000): 352-357.

47. Meneghini RM., *et al*. "Evaluation and treatment of painful total hip arthroplasties with modular metal taper junctions". *Orthopedics* 35 (2012): 386-391.

48. Willmann G. "Ceramic femoral head retrieval data". *Clinical Orthopaedics and Related Research* 379 (2000): 22-28.

49. Hannouche D., *et al*. "Is there a risk in placing a ceramic head on a pre- viously implanted trunion?" *Clinical Orthopaedics and Related Research* 468 (2010): 3322-3327.

50. Wight CM., *et al*. "Evidence based recommendations for reducing head-neck taper connection fretting corrosion in hip replacement prostheses". *HIP International* 27.6 (2017): 523-531.

**Volume 13 Issue 5 May 2022**