

## Case report

## Late fracture of an old-generation modular neck in a titanium alloy femoral stem of a cementless total hip arthroplasty



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## ABSTRACT

Neck-stem modularity gained recent popularity in hip arthroplasty for clinical advantages, and few complications have been reported. We describe an unusual two-stage failure of the bimodular neck of a cementless forged titanium alloy stem implanted 12 years before. The retrieved neck was forwarded to the manufacturer for metallurgical evaluation and failure analysis. Lengthening and bending of the superolateral aspect of the neck and double depression of the medial part prove that the prosthetic neck underwent a medial displacement and a varus rotation. The crack initiated from the superolateral corner of the fracture section, and the neck probably underwent two subsequent unstable configurations. The first horizontal part of the fracture occurred in the external surface as a result of physiological load carried on abnormal conditions of frictions. Due to increased oscillations, the end of the fracture section knocked against the inner aspect of the proximal hole of the stem, preventing further valgus displacement of the neck, which was moved forward. Consequently, the neck achieved a second unstable configuration, and the fracture propagated in the weaker direction creating a bent track. Finally, the neck broke unexpectedly as a result of the traumatic event. An incorrect placement into the femoral component during surgery was the initiation of the failure of the bimodular neck. The transitory but repeated interface motion between the neck and the stem induced a local surface irregularity acting as a starting point for crack propagation of fatigue fracture. Final failure followed a direct trauma.

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## 1. Introduction

Femoral component breakage is a well-documented complication following total hip arthroplasty (THA). The most common site is the middle or the proximal third of the stem and failure is usually due to fatigue,<sup>1,2</sup> but several cases of neck fracture have been observed.<sup>3–10</sup> The use of dual modular femoral components has become increasingly popular in recent years, and only few complications were described.<sup>11–19</sup>

We report an unusual two-stage fracture of the double-modular neck of a cementless forged titanium alloy femoral stem that was implanted 12 years before. To our knowledge, a two-stage late fracture of an old-generation bimodular neck in a primary THA with a well-fixed femoral stem has not been previously reported. The management of the fractured implant and the results of the failure analysis are detailed.

## 2. Case report

On May 2007, a 64-year-old farmer with BMI of 32.6 kg/m<sup>2</sup> was admitted to our institution affected with severe groin pain and was unable to bear weight after a right hip trauma following an accidental fall. Physical examination revealed a shortened, adducted and externally rotated right limb and any attempt of hip motion was painful. Conventional x-ray showed a fracture of the modular neck of the femoral stem and calcar osteolysis; the acetabular component was well positioned with evidence of osseous integration [Fig. 1]. The patient had undergone a right primary cementless THA for osteoarthritis in 1995, with the contralateral hip being replaced one year before. The acetabular component was a 52-mm PEG press-fit cup with a polyethylene (PE) liner. The femoral component was a SCL Contact fluted stem size 3 that was designed to accept a modular Morse-tapered neck, including a modular medium size neck and a 32-mm diameter, + 4 mm long alumina head (Lima-Lto, Villanova, Italy). Both stem and neck were made of titanium alloy (Ti6Al4V). Following operation, the patient had a complete functional recovery.

Revision surgery was conducted via an anterolateral approach. After excision of a wide scar tissue with macroscopic evidence of

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**Fig. 1.** Emergency radiograph demonstrating a fracture of the modular neck without evidence of prosthetic loosening.

metallosis, the prosthesis was exposed showing the fracture of the lateral third of the modular neck, which was easily removed. However, the distal part of the neck could not be extracted from the body of the implant as it was firmly embedded inside the stem. Both prosthetic components were well fixed to the bone and PE liner was found to be intact. A small window was performed on the lateral aspect of the subtrochanteric area in order to remove the residual part of the modular neck, but any attempt was unsuccessful, so that replacement of the stem required a trans-femoral approach.

The diaphyseal canal was finally reamed and fitted with a tapered revision stem (Revision, Lima-Lto, Villanova, Italy), including a 200-mm long and 14-mm wide fluted distal part connected with a 60-mm long proximal component bearing a 32-mm short alumina head. The acetabular components were retained. At 8-year follow-up examination, the patient was pain-free with a Harris Hip Score of 92.

The retrieved double-modular neck was forwarded to the manufacturer for metallurgic evaluation and failure analysis.

The patient was informed that data from the case would be submitted for publication, and gave his consent.

### 3. Discussion

Neck breakage of the femoral component is a rare but well-known occurrence following THA.<sup>3,10</sup> Fracture through the neck of the stem may be due to several factors: defects of the welding of the neck to the prosthetic head, laser etching in a part subjected to high stresses leading to a fatigue failure, younger age, heavier weight, and lateralized stems which increase the offset of the head.<sup>1,2,7,8</sup>

Modular necks were designed to better optimize joint stability, leg length, and femoral offset.<sup>20</sup>

Taper-locking devices of modular hip prostheses have shown variability in fit, motion and pull-off strength. Repeated relative interface motion under load between the components in a modular femoral neck can induce fretting and crevice corrosion and, ultimately, component fracture.<sup>4,5,14</sup>

Sporer et al.<sup>11</sup> described an unusual case of disassociation of a modular femoral neck from its junction with a well-fixed prosthetic stem. Dangles and Altstetter<sup>13</sup> were the first to report a bimodular neck fracture at the neck-stem junction 3.5 years following implantation. Additional failures of modern interchangeable necks have been documented, highlighting the risks related to increased modularity in THA.<sup>12,14,19</sup> Grupp et al.<sup>14</sup> observed a fracture incidence of 1.4% in a large series of 5000 uncemented THAs with a titanium femoral neck.

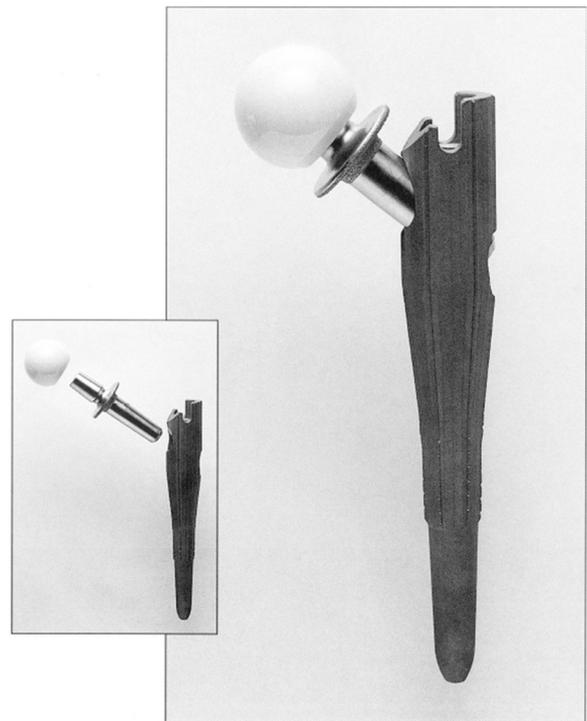
The SCL Contact is an evolution of the original SCL model stem [Fig. 2]. From 1982–1997, 7338 original SCL prostheses were implanted and about 30 failures of fatigue neck breakage due to laser etching are reported. From 1990 the etching was made in a neck zone without tension and this change eliminated any associated risk.

The fracture and modular connection surfaces of the retrieved component were evaluated using optical and scanning electron microscope at magnifications up to x500.

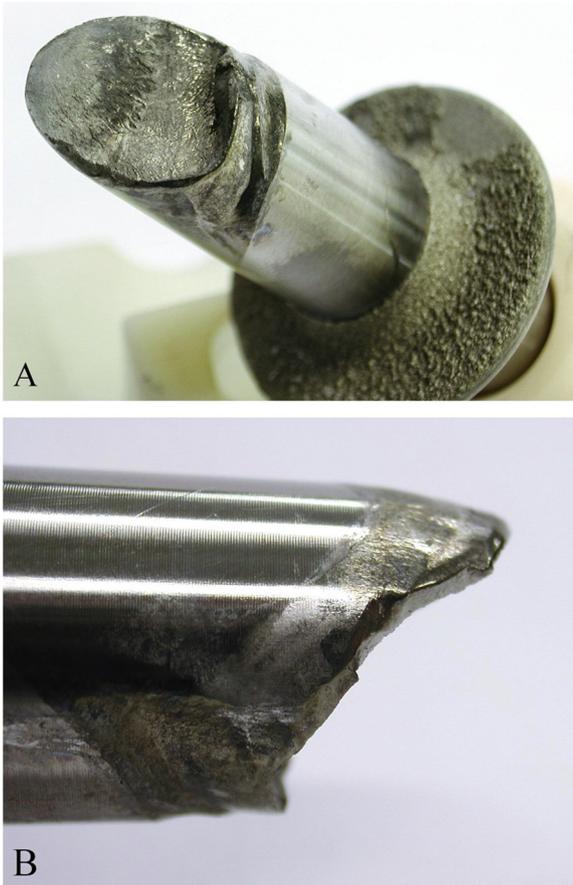
Analysis performed by the manufacturer revealed that the track of the fracture has an S-profile in the horizontal plane, with a convex surface ending in a bent area in the centre of the neck [Figs. 3a–b]. A concave surface originates from this bent area, joining inferiorly and acutely to an irregular spur. Although the presence of striation and wrinkles are indicative of material detachment, typical signs of fatigue fracture were not found.

Any possible relationship with the laser etching, which was located 4-mm away from the edge of the fracture section, was excluded consequently [Fig. 4].

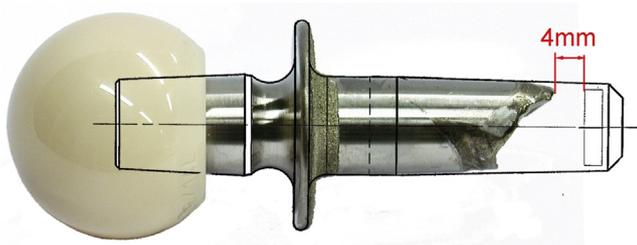
The initiation site from which the crack propagated was identified at the superolateral corner of the neck fracture, where no



**Fig. 2.** The SCL Contact fluted modular femoral stem.



**Fig. 3.** Photographs showing fracture surface of the retrieved femoral neck: (a) bent area separates the convex initiation site from the concave fatigue failure surface; (b) the final part of the crack acutely culminates in an irregular inferior spur.



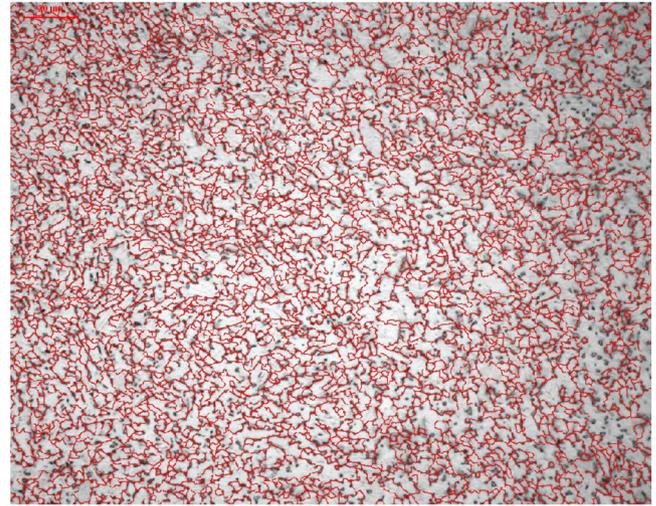
**Fig. 4.** The 4-mm distance with the edge of the fracture section excludes any relationship with the laser etching.

inclusions and material defects could be detected, as confirmed by metallographic examination [Fig. 5].

Lengthening and bending of the superolateral site and double depression of the medial part prove that the prosthetic neck underwent medial displacement and varus rotation [Fig. 6].

The propagation of the fracture line indicated that the neck probably have assumed two subsequent unstable configurations under physiological load.

The contact of the inferomedial aspect of the neck is likely to have occurred in two different periods, and both marks have required time to develop. If the neck gets contact with the calcar before the conical locking as a result of an incorrect coupling to the stem, an immediate stable configuration under load cannot be obtained, and the neck can move compared with the prosthetic stem.



**Fig. 5.** Scanning electron microscopy image of the fractured surface (x500) confirming the absence of material defects.

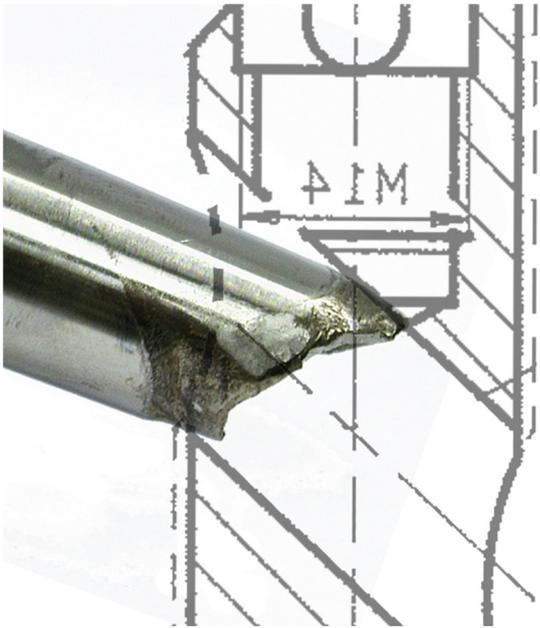


**Fig. 6.** The double depression detected in the medial part of the fracture section demonstrates medial displacement and varus rotation of the prosthetic neck as a result of an incorrect neck-stem coupling.

Improper surgical technique could result in an early stop with the calcar due both to the inclination of the resection plane and the level not corresponding to the minimum that the neck size should have required. The evidence of the medial mark demonstrates that initially an overload of the calcar prevented a stable matching between neck and stem, promoting a swing movement between varus and valgus in the inferomedial aspect of the neck.

Conversely, the creep scratch due to oscillations produced wear and superficial defects in the superolateral region, which propagated inside the neck leading to a lengthening deformation.

The first part of the fracture, proceeding horizontally across the neck, occurred in the external surface as a result of physiological load carried on abnormal conditions of frictions. The mode of contact between neck and stem changed as the crack propagated,



**Fig. 7.** Drawing illustrating the proposed model-mechanism for the failure of the bimodular neck.

also promoted by bone resorption of the calcar due to medial overload. These oscillations increased progressively, and the end of the fracture section impinged on the inner aspect of the proximal hole of the stem, preventing further valgus displacement of the neck, which was moved forward.

The neck achieved a new unstable configuration, more medial and varus [Fig. 7], and the fracture propagated in the weaker direction creating a bent track. Finally, although supported by the remaining calcar bone, the neck broke definitively as a result of the acute trauma.

To our knowledge, a two-stage late fracture of an old-generation bimodular neck in a primary THA with a well-fixed femoral stem has not been previously reported.

In conclusion, on the basis of our analysis data, age of prosthesis and patient activity, a combination of two factors appears to have contributed to the delayed but atypical fatigue failure of the double-modular neck. Initial crack propagation of fracture due to incorrect neck-stem coupling which occurred at primary surgery and final breakage secondary to direct trauma constitute the model mechanism for the failure.

It is advisable that modern modular double taper necks allow an easier disassembly, providing less invasive surgical revisions.

## Conflict of interest

None.

## Funding

None.

## References

1. Woolson ST, Milbauer JP, Bobyn JD, Yue S, Maloney WJ. Fatigue fracture of a forged cobalt-chromium-molybdenum femoral component inserted with cement. A report of ten cases. *J Bone Jt Surg Am.* 1997;79:1842–1848.
2. Ong A, Wong KL, Lai M, Garino JP, Steinberg ME. Early failure of precoated femoral components in primary total hip arthroplasty. *J Bone Jt Surg Am.* 2002;84:786–792.
3. Burstein AH, Wright TM. Neck fractures of femoral prostheses. A report of two cases. *J Bone Jt Surg Am.* 1985;67:497–499.
4. Rand JA, Chao EY. Femoral implant neck fracture following total hip arthroplasty. A report of three cases. *Clin Orthop Relat Res.* 1987;221:255–259.
5. Gilbert JL, Buckley CA, Jacobs JJ, Bertin KC, Zernich MR. Intergranular corrosion-fatigue failure of cobalt-alloy femoral stems. A failure analysis of two implants. *J Bone Jt Surg Am.* 1994;76:110–115.
6. Artime V, Ramos JC, Fernandez-Medina JM, de Luis MC, Aguilera L. Fracture of the neck of a femoral component in a total hip arthroplasty: a case report. *Int Orthop.* 1997;21:56–58.
7. Lee EW, Kim HT. Early fatigue failures of cemented, forged, cobalt-chromium femoral stems at the neck-shoulder junction. *J Arthroplasty.* 2001;16:236–238.
8. Vatani N, Comando D, Acuna J, Prieto D, Caviglia H. Faulty design increases the risk of neck fracture in a hip prosthesis. *Acta Orthop Scand.* 2002;73:513–517.
9. Botti TP, Gent J, Martell JM, Manning DW. Trunion fracture of a fully porous-coated femoral stem. Case report. *J Arthroplasty.* 2005;20:943–945.
10. Jang B, Kanawati A, Brazil D, Bruce W. Laser etching causing fracture at the neck-shoulder junction of an uncemented femoral stem: a case report. *J Orthop.* 2013;(May (10)):95–98.
11. Sporer SM, Della Valle C, Jacobs J, Wimmer M. A case of disassociation of a modular femoral neck trunion after total hip arthroplasty. *J Arthroplasty.* 2006;21:918–921.
12. Atwood SA, Patten EW, Bozic KJ, Pruitt LA, Ries MD. Corrosion-induced fracture of a double-modular hip prosthesis. A case report. *J Bone Jt Surg Am.* 2010;92:1522–1525.
13. Dangles CJ, Altstetter CJ. Failure of the modular neck in a total hip arthroplasty. *J Arthroplasty.* 2010;25(1169):e5–e7.
14. Grupp TM, Weik T, Bloemer W, Knaebel HP. Modular titanium alloy neck adapter failures in hip replacement – failure mode analysis and influence of implant material. *BMC Musculoskeletal Dis.* 2010;(Jan (11)):3.
15. Wilson DAJ, Dunbar MJ, Amirault JD, Farhat Z. Early failure of a modular femoral neck total hip arthroplasty component. A case report. *J Bone Jt Surg Am.* 2010;92:1514–1517.
16. Wright CG, Sporer S, Urban R, Jacobs J. Fracture of a modular femoral neck after total hip arthroplasty. A case report. *J Bone Jt Surg Am.* 2010;92:1518–1521.
17. Ellman MB, Levine BR. Fracture of the modular femoral neck component in total hip arthroplasty. *J Arthroplasty.* 2013;28(196):e1–e5.
18. Skendzel JG, Blaha JD, Urquhart AG. Total hip arthroplasty modular neck failure. *J Arthroplasty.* 2011;26(338):e1–e4.
19. Sotereanos NG, Sauber TJ, Tupis TT. Modular neck fracture after primary total hip arthroplasty. *J Arthroplasty.* 2013;28(196):e7–e9.
20. Srinivasan A, Jung E, Levine BR. Modularity of the femoral component in total hip arthroplasty. *J Am Acad Orthop Surg.* 2012;20:214–222.