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Case study

Fractography of a neck failure in a double-modular hip implant

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ABSTRACT

The tapered joints of modular hip implants are prone to fretting and crevice-corrosion. This can lead to total failure in under a year, especially for heavier, more active implant recipients. In this study, fractography of a failed Profemur Z implant showed that a life limiting fatigue crack was nucleated on the anterolateral surface of the implant's neck. The fatigue crack nucleation area appeared to have both more fretting damage and a higher corrosion rate than on other surfaces of the neck.

1. Introduction

Double-modular hip implants consist of a neck that is separate from both the stem and the head – the three parts fit together via tapered joints. Several necks and heads of different geometries are available, allowing the surgeon to optimize the hip angle, hip offset and leg length during surgery. However, concerns exist about the stability of the tapered joints used to connect the neck to the head and stem [1,2]. Specifically, tapered joints are susceptible to fretting and crevice-corrosion, which may lead to loosening, release of toxic metal ions and mechanical failure.

A study that followed 5000 double-modular hip implants (Metha Short Hip Stem Prosthesis) between 2004 and 2008 found that 1.4% of the titanium necks failed after approximately two years [3]. Most of the failures were attributed to the formation of microcracks on the anterolateral surface (i.e., toward the front and outside of the body) of the neck due to fretting and corrosion inside the tapered joint between the neck and stem. This damage led to the formation of a fatigue crack, and ultimately, complete fracture of the neck. According to Ref. [3], risk factors for neck failure included being male, heavier, more active, and having a sharper hip angle.

Three additional case reports of neck failures have been published on the same model of hip implant as this study's (Wright Medical Technology's Profemur® Z) [4–6]. All three reports found neck fracture to be caused by a fatigue crack which originated inside the tapered joint on the anterolateral surface of the neck, identical to those of Ref. [3]. All three reports also suggest fretting and/or corrosion played a role in the neck failures. However, no clear fatigue crack nucleation site was shown, possibly because of damage incurred after neck failure. This study does show a clear nucleation site, and comes to similar conclusions for failure as these aforementioned studies.

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2. Experimental

The implant recipient was described as an active 47-year-old male, weighing 84 kg. The implant consisted of a size 3 Profemur® Z stem, 8 degree varus neck, and a -3.5 mm $\times$ 50 mm Conserve® Total Class-A head. Both the neck and stem were made of Ti–6Al–4V, and the head was made of a cobalt-chrome alloy. The neck of this implant failed after three years (implanted in 2006, failed and removed in 2009). Due to legal reasons, the parts were examined in the as-received condition (no cleaning, cutting, etc.) using a scanning electron microscope (JEOL 6100) in 2011.

3. Results

Fig. 1 shows optical photographs of both fracture surfaces, as well as a model of where fracture occurred in relation to the modular hip implant. After fracture, one piece of the neck remained inside the stem's female taper; the other piece remained

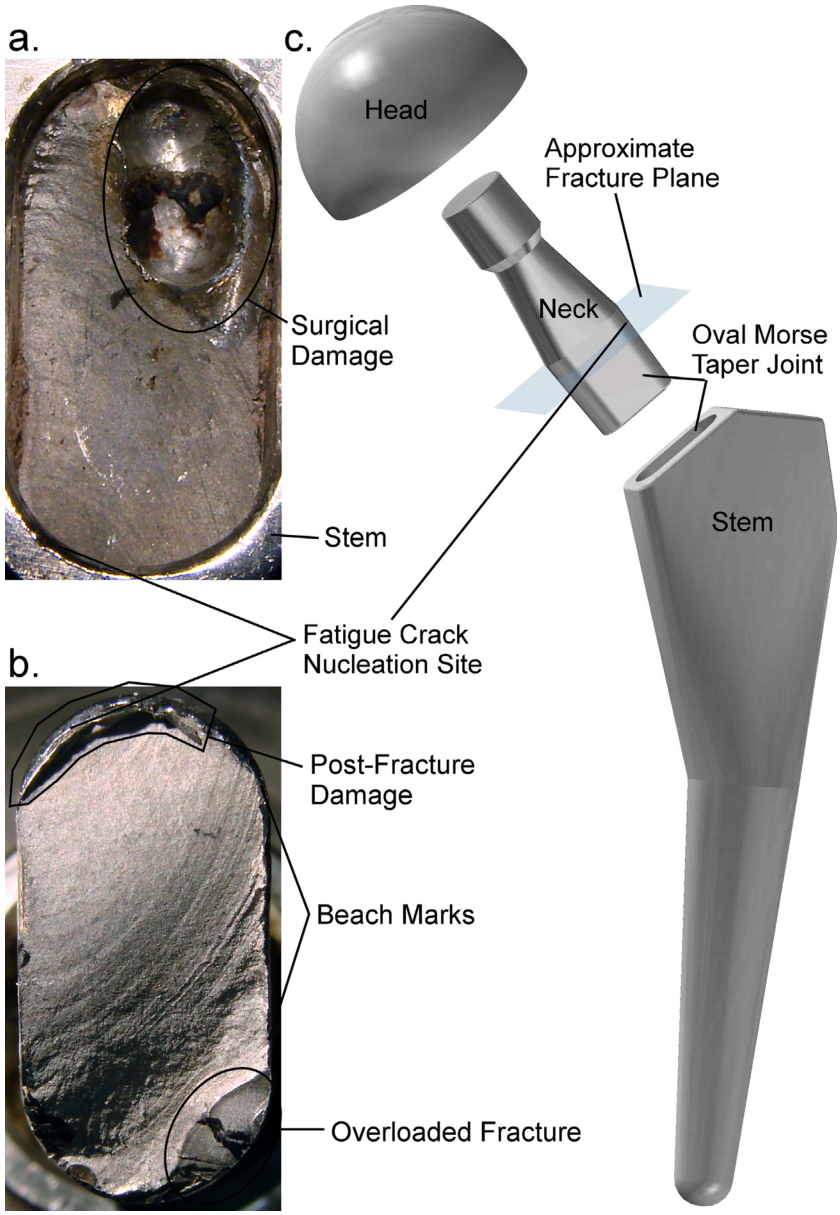

Fig. 1. (a) Optical photograph of the fracture surface of the neck that remained in the stem. The surgical damage was created by a tool used to remove the implant from the body. (b) Optical photograph of the fracture surface of the neck that remained attached to the head. Post-fracture damage occurred when the fractured neck slid across the inside of the stem's taper surface. (c) Exploded model of the modular hip implant, showing where neck fracture occurred. Both the neck and stem were made of Ti–6Al–4V.