INTRODUCTION:
The Profemur-Z modular total hip replacement (Wright Medical Technology, Inc., Arlington, TN) is a primary total hip replacement system that offers surgeons the ability to alter the length and version of the femoral neck after the femoral stem has been implanted. The versatility is achieved through a double Morse taper modular neck component used to bridge the femoral stem and femoral head. These components have been in use for a number of years, but in the past year, at our center, a number of these components have failed catastrophically at the modular neck. The purpose of this study was to investigate the early catastrophic failure of a Profemur-Z modular total hip arthroplasty component.

METHODS:
A 62 year old male, height 181 cm, weight 84 kg, BMI 25.6, presented to the emergency room with a non-functional hip. The patient reported he had been walking normally when his hip collapsed underneath him. Radiographic investigations showed a fracture of the distal femoral neck of the femoral component (Figure 1). Revision surgery was performed and a Profemur-Z with a fractured, long, retroverted, modular neck component was retrieved during the procedure. The fractured neck and the stem were inspected visually, with light microscopy then with scanning electron microscopy (SEM). Energy dispersive X-ray spectroscopy (EDS) was performed to analyze the chemical composition of the modular neck around the fracture. The findings from the investigations were used in conjunction with finite element analysis (FEA) to develop an analytical model of the fractured component to assess the likelihood of reoccurrence.

RESULTS:
The results of the investigations revealed a damage pattern consistent with fatigue failure (Figure 2). There was substantial surface damage in the area where the failure originated (Figure 3). The most likely source of this surface damage was interfacial contact during engagement of the Morse taper. The surface damage results in a magnification of the stresses at the surface of the material of at least 300%. The stress in a long retroverted neck component during normal patient ambulation was found with the FEA to be 270 MPa (Figure 4). The stress in the component was compared with the known maximum fatigue stresses in Ti6Al4V alloy (the material the Profemur-Z is made from). The fatigue stress limit for Ti6Al4V alloy is 510 MPa undamaged and 240 MPa with surface damage. The stress in the component was found to exceed the materials fatigue strength when the surface had undergone damaged.

DISCUSSION:
Modular necks for total hip arthroplasty offer the surgeon a variety of options for altering the offset and version of the component after the femoral stem has been inserted. However, any advantage these modular components may offer is negated if they compromise the mechanical strength of the prosthesis.
The Profemur-Z component uses a Morse taper for both the proximal and distal interfaces of a modular neck. At the proximal junction, the Morse taper lies at the center of rotation of the hip. At the distal end of the neck, the long moment arm of the applied force produces a bending moment. In cases that use long necks with offset heads, the moment arm, is relatively large, and has the effect of providing substantial bending stresses to the distal end of the neck. This bending stress in conjunction with the surface damage produced upon engagement of the taper results in high focal stresses in the modular components.

CONCLUSIONS:
The findings of this study demonstrate that this design of modular neck total hip arthroplasty component is at a relatively high risk of early catastrophic failure. It is likely that more components of this design in similar patients will also fail prematurely.