

Neck fracture of the Exeter stem in 3 patients

A cause for concern?

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The patients

Patient 1 (Figure 1)

A 63-year-old woman (height 1.70 m, weight 92 kg, BMI 31) with developmental dysplasia of both hips underwent bilateral hybrid total hip replacement (THR) using the cemented Exeter V40 stem (offset 44 mm, size 3) and uncemented Trident PSL (Stryker) with alumina-on-alumina ceramic bearing (BioloX Forte; Ceramtec, Plochingen, Baden-Württemberg, Germany) at our hospital in 2004. A ceramic femoral head with a diameter of 36 mm and offset of +5 mm was used. Short-term functional outcome was excellent. 5 years and 3 months later, the patient tripped on a flat floor and fell down, and was unable to move her left leg due to severe pain. Plain radiographs revealed a neck fracture in the Exeter stem. She underwent revision surgery, during which both the remnant of the Exeter stem and the uncemented acetabular component were found to be well fixed. A posterior notch distal to the fracture line was seen in the stem, indicating neck-cup impingement. The fractured stem was removed and a new short (125-mm) Exeter Revision stem (offset 44 mm, size 0) was cemented

into the well-retained cemented mantle. The well-fixed cup was retained. However, both the ceramic liner and the femoral head were replaced with new ones that corresponded with the original liner and the head, both in diameter and in offset.

Patient 2 (Figure 2)

An 87-year-old man (height 1.78 m, weight 84 kg, BMI 27) underwent hybrid THR at our hospital in 2009, due to advanced osteonecrosis of the left femoral head. On the femoral side, a cemented Exeter V40 stem was used (offset 44 mm, size 2). A femoral head made of stainless steel (Orthinox; Stryker) with a diameter of 40 mm and offset of +8 mm was coupled with the Exeter stem. On the acetabular side, a press-fit cup (Trident) with highly crosslinked polyethylene liner (Trident X3 acetabular insert) was used. In August 2013, the patient bent forward to treat an ulcer in his lower limb. He had a feeling of subluxation, and the replaced hip became painful. Plain radiographs revealed a neck fracture of the Exeter stem. He underwent revision surgery, during which both the stem remnant and the cup were found to be well fixed. The fractured stem was removed and a short Exeter revision stem (offset 44

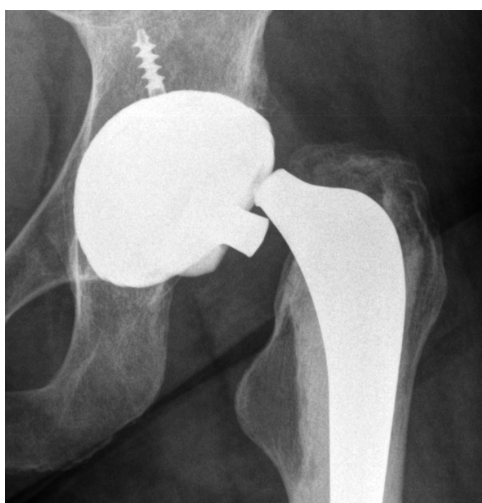


Figure 1. The left hip of patient 1, note the notch in the stem.

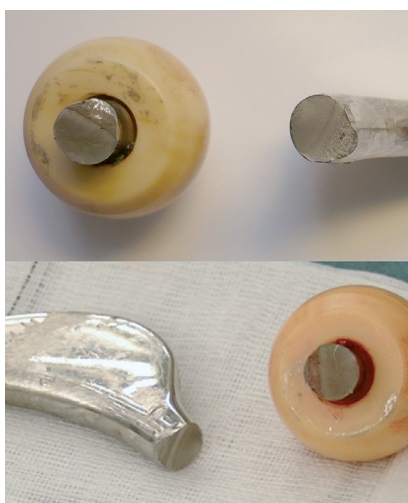


Figure 2. A. The left hip of patient 2.

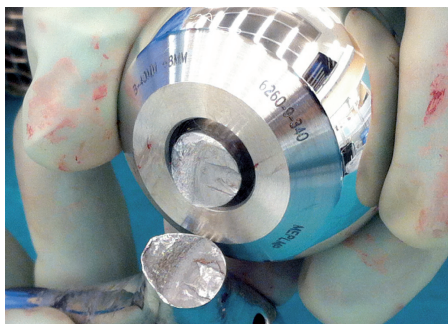


Figure 2. B. The fractured stem of patient 2.

mm, size 0) was cemented into the well-retained cement mantle. The damaged polyethylene liner was exchanged for an identical new one. Similarly, the femoral head was replaced with a new one that was identical to the one used in the primary THR.

Patient 3 (Figure 3)

A 76-year-old man (height 1.76 m, weight 120 kg, BMI 38) underwent primary THR on the right hip at another hospital in 2000. A cemented Exeter stem (V40) and an undisclosed cemented cup were used. Because of recurrent dislocations, the hip was revised in 2003 and the original femoral head was replaced with a 32-mm head made of stainless steel (+10 mm offset). However, after revision surgery the patient still experienced 3 more dislocations, which were treated with closed reduction. After the third dislocation in January 2012, a second reoperation was performed in February 2012. In this second revision, the original Exeter stem was revised to a new standard Exeter V40 stem (offset 44 mm, size 1). A CoCr femoral head with a diameter of 36 mm and an offset of +10 mm (LFIT; Stryker) was used. The cemented cup was also revised to a press-fit trabecular metal cup (Trabecular Metal Revision Shell; Zimmer, Warsaw, IN). A constrained polyethylene liner (Longevity Constrained Liner; Zimmer) was used on the acetabular side. Recovery after the second revision was uneventful. In November 2014, however, the patient had a feeling of subluxation in the revised hip while turning in standing position. This feeling was immediately followed by severe pain in the groin area. Plain radiographs revealed a fracture in the stem neck. The hip was again revised. Both components were found to be well fixed. An anterior notch distal to the fracture line was seen in the stem, indicating neck-cup impingement. The constrained liner was removed and a new constrained liner (Longevity) was cemented inside the trabecular metal shell. The fractured stem was removed and a new Exeter stem (offset 50 mm, size 1) was cemented after the old cement mantle had been thoroughly removed. A stainless steel femoral head with a diameter of 36 mm and an offset of +5 mm was used (Orthinox; Stryker). Recovery after the third revision was uneventful.



Figure 3. The right hip of patient 3, note the notch in the stem.



Prevalence of stem neck fracture in Exeter V40 stems

Contemporary Exeter V40 stems have been used continuously at our institution since September 2002. Until the end of May 2014, 2,521 stems had been implanted. Thus, in our cohort of patients with Exeter V40 stems the prevalence of stem neck fracture is 0.1%. All of our patients with neck fractures of the Exeter V40 stem had 36-mm or larger femoral heads. In 966 (37%) of the 2,521 implanted stems, we used 36-mm or larger femoral heads. Thus, the prevalence of neck fracture is 0.3% in this subgroup of patients.

Discussion

Femoral stem fracture is still a rare complication after THR. The Exeter stem (Stryker) is a cemented, collarless, and polished component made of stainless steel. The stem fracture rate was reported to be as high as 2% in the original Exeter series (Fowler et al. 1988). Later on, the surface finish was changed to matte, but due to an increasing rate of aseptic loosening, the matte finish was abandoned and changed back to polished finish (Røkkum et al. 1995, van Doorn 2002). After the introduction of the current Exeter stem concept (made from wrought stainless steel with a polished surface finish) in 1986, hardware fractures have been very rare (Røkkum et al. 1995, van Doorn 2002). After the acquisition of Howmedica by Stryker in 1998, the taper in the Exeter stem was modified and a new Exeter V40 stem concept was introduced in 2001. This Exeter V40 stem has a smaller taper with a reduction in both taper tip diameter (11.3 mm) and taper length (12.1 mm) compared to its precursor (tip diameter 14.3 mm, neck length 16.3 mm) (FDA 2001).

To date, only 1 study has published results with the modified Exeter V40 stem: no hardware fractures occurred in 1,000

patients (Fujita et al. 2012). Recently, a few papers have reported stem fractures in patients who were operated on with the current Exeter stem design (Exeter V40). Davies et al. (2013) reported 4 such cases, and in all of them the fracture had occurred in the mid-stem area. Van Doorn et al. (2002) also reported 1 case with a stem fracture in the same area. They did not state the stem specifications. However, 1 recent case report described a patient with a fracture in the neck of the Exeter stem (Hamlin and MacEachern 2014). To our knowledge, this is the only neck fracture of the Exeter stem that has been reported to date.

The weights of our patients were 92 kg, 84 kg, and 120 kg. These are lower values than those of the patients reported by Davies et al. (2013). In that study, the 4 patients with stem fractures weighed 102 kg, 98 kg, 110 kg, and 111 kg. Moreover, 2 patients had morbid obesity (BMI > 40). Extremely high strain is conveyed via the neck to the body of the stem in these patients. This may lead to stress fatigue, and eventually to fracture in the mid-stem. Patients with small stem sizes are also more susceptible to fracture of the stem, due to lower failure loads. This was also discussed by Davies et al. (2013), as all their patients had a small stem size.

A recent paper by Hamlin and MacEachern (2014) described 1 patient with fractured neck, after THR with the Exeter V40 stem. This patient was morbidly obese, weighing 141 kg, and therefore quite different to those described in our report. Our results suggest that the absence of stem neck fractures in the current literature may be a consequence of using larger femoral head diameters. In previous years, the femoral head size used with the Exeter stem has mainly varied between 22 mm and 28 mm. During the last few years, there has been a shift to larger head sizes. This allows larger jump distance and therefore a lower risk of dislocation would be expected (Sariali et al. 2009). All our patients had 36-mm or larger femoral heads. Most importantly, they all had additional horizontal offset enabled by the larger femoral head. Larger head size does not directly increase the leverage arm in the neck, since a 40-mm femoral head still has the same center of rotation as the traditional 26-mm femoral head. However, larger head sizes have more offset options than smaller head sizes (such as +8 mm and +12 mm) that allow medialization of the center of rotation and thus increase the total horizontal offset of the femoral component. This eventually increases the leverage arm by which the body weight levers against the neck area. In fact, Stryker recalled a 26-mm LFIT femoral head with +16 mm offset due to increased risk of neck fracture in obese patients who had been operated on with Accolade TMZF stems with V40 taper (FDA 2008). However, higher stress is present in the neck area regardless of the mechanism that leads to larger offset. The addition to leverage caused by a femoral head with additional offset is roughly the same as moving from an Exeter stem with 44 mm offset to one with 50 mm offset. In the latter case, however, the larger strain present in the neck due to increased leverage is carried by a monoblock steel

neck, which may tolerate stress fatigue well. In contrast, especially if improperly implanted, the outer edge of the taper-bore contact area in a larger femoral head with additional offset may cause peak strain to the neck more proximally than to a femoral head without additional offset. As can be seen in the retrieved implants (Figures 1, 2B, and 3), the fracture lines were quite proximal in our patients. In addition, notches indicating impingement were present in 2 of the 3 stems. There were no fracture lines originating from these. These notches may, however, be an effect of the stress distribution in the neck. Lastly, larger head sizes also have a higher degree of friction than small head sizes, which opposes the principle of Charnley's low-friction arthroplasty (Wroblewski et al. 2009). Increasing friction could increase the fatigue stress in the neck, contributing to neck fracture. We assume that these mechanical differences between small heads and large heads with high offset may have contributed to the neck fractures in our patients.

Retrieval studies have shown that increased leverage is associated with increased material loss in the taper junction with large-diameter metal-on-metal THRs (Langton et al. 2012). Due to better stability, there has been an increasing trend to use head sizes larger than 28 mm with cemented stems also. In previous reports, stem fractures have been associated with heavy weight. Our findings raise the concern that increased leverage caused by additional offset in larger head sizes may be associated with an increased risk of stem fractures. Future studies should assess this association in order to determine whether there may be a subgroup of patients with an increased risk of neck fracture, and whether it is safe to use large heads with maximum offset with the stem in question.

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FDA. US Food and Drug Administration 2001. 510(k) Premarket Notification K011623: EXETER HIP SYSTEM WITH V40 TAPER. http://www.accessdata.fda.gov/cdrh_docs/pdf/K011623.pdf

FDA. US Food and Drug Administration 2008. Class 2 Recall: LFIT COCR V40 Femoral Head; xxLong (16mm) Neck Length 26mm Diameter. <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfres/res.cfm?id=68194>

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