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ORIGINAL STUDY

Is there a place for conservative treatment of a Vancouver B2 fracture around a cemented polished tapered stem?

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Revision of the unstable stem of a total hip replacement following a peri-prosthetic fracture of the femur is a complex procedure with a high complication rate. With this study we aim to describe the radiologic findings of a specific fracture around polished tapered cemented stems and we present the results of a two-stage treatment plan for non-displaced Vancouver type B2 fractures.

Eight male patients with a cemented polished, tapered stem presented after a fall. Standard radiographs did not show any direct signs of a fracture. CT scans showed a complex burst fracture with cement mantle cracks in all cases. Partial weight bearing with 2 crutches was initiated for at least 6 weeks. A cement-in-cement revision was conducted at 3 months in case the patient was not pain free.

After 3 months of weight bearing as tolerated, none of the fractures had displaced any further, neither had the stem further subsided. Five patients were pain free and did not require surgical intervention. One patient underwent a cement-in-cement stem revision because of persistent pain.

Normal radiographs of a post-traumatic and painful polished tapered stem do not exclude a Vancouver type B2 fracture and should be followed by a CT-scan. Cement cracks, eccentric gaps and subsidence are highly suspicious signs for a non-displaced fracture pattern. Conservative treatment remains an option for these fractures and can be followed by a cement-in-cement stem revision after fracture healing, if this is still required.

Level of evidence: IV, retrospective series

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Keywords : total hip replacement ; periprosthetic fracture ; Vancouver B2 ; cemented revision.

INTRODUCTION

The assessment and treatment of periprosthetic fractures of the femur following a total hip arthroplasty (THA) remains a challenge. The incidence is rising, not only because of the rising numbers of primary THA but also due to a greater susceptibility to falls in the aging population *(12,17)*. Fracture location, stem stability and bone stock are the 3 most important parameters in the Vancouver classification which guides the surgeon in the decision making process *(8)*. Revision with a long-stemmed prosthesis is recommended in case the stem is loose (i.e. Vancouver type B2 and B3 fractures). Early reports suggested the use of

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cemented revision stems *(5,8,16)* whereas more recent data have favored the use of uncemented stems *(1,2,14,19,22,23)*. However, debate remains about the best treatment option *(6)* because not only conservative treatment *(1,3,15)* but also revision surgery has been documented with high complication rates *(18)*. Reduction of the complexity of the revision surgery is likely to minimize the associated co-morbidity and complication rate of the procedure.

Cemented tapered stems with a polished surface have been suggested to be associated with a higher incidence of periprosthetic fractures although this has not been supported in a survey of the Swedish Arthroplasty registry *(4,18,20)*. In our practice of over 3.000 cemented Exeter stems (Stryker, Kalamazoo, Michigan) implanted over the past 17 years, we noted a specific fracture pattern that was associated with these stems. We treated these fractures with immediate stem revision. However, based on our clinical experience, we changed our treatment plan to a two-stage treatment regime with initial partial weight bearing as tolerated in order to support fracture healing prior to the revision procedure.

With this study we aim *(1)* to describe the radiologic findings of this specific fracture pattern around polished tapered cemented stems and (2) to present our experiences of a two-stage treatment plan for these non-displaced Vancouver type B2 fractures.

METHODS

A 62-year old female with end-stage osteoarthritis of the right hip was treated in January 2009 with a primary total hip arthroplasty (THA). A cemented Exeter stem (V40, Stryker, Kalamazoo, Michigan) was used in combination with a cementless Trilogy socket with a polyethylene liner (Zimmer, Warsaw). Her follow-up clinic at 6 weeks was normal. Six weeks later, she slipped and fell on her right hip. She was in pain and used crutches for 3 months. She then presented at our clinic because of persistent pain in the groin and upper thigh region. Antero-posterior and lateral radiographic views of the hip revealed a healed Vancouver type B2 fracture of the calcar around a subsided stem (Figure 1). The patient was treated successfully with a straightforward cement-in-cement stem revision. She was completely pain free with normal radiographs 2 year following the procedure.

Based on this experience, we initiated a two-stage treatment plan for non-displaced periprosthetic fractures of the femur. Between August 2009 and August 2015, eight male patients with a cemented polished, tapered stem presented at

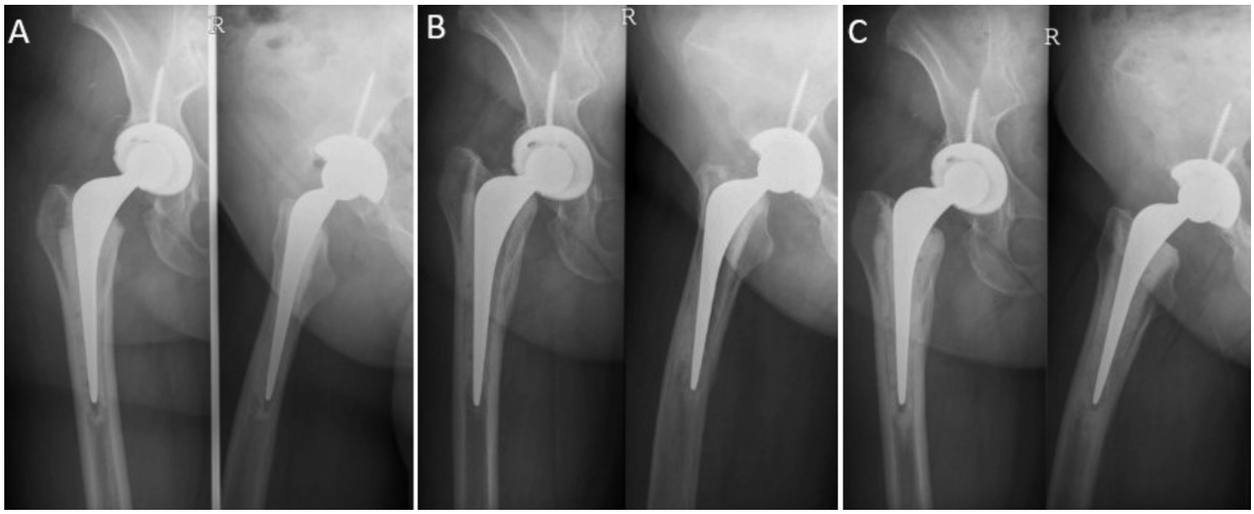

Fig. 1. — (a) The 6w post-operative radiograph of the primary THA is normal. (b) The radiograph 4 months following the fall reveals a healed Vancouver type B2 fracture of the calcar with subsidence of the stem. (c) The 2-year post-operative radiograph of the cement-in-cement revision shows a nicely healed fracture and a stable stem

Table I. — Overview of the patient characteristics

Gender/ age	Primary THA stem	Time to fall (months)	Time to healing (months)	Symptoms	Treatment	Follow-up since fall (months)
M, 67	Exeter	6	3	pain, shortening	Conservative	74
M, 66	CPT	18	3	pain	Gluteus Medius repair at 17 months and revision due to MoM related problems after 5 years.	75
M, 70 (Fig. 2)	Exeter	123	2	no complaints	Conservative	67
M, 41	CPT	39	3	slight pain	Conservative	73
M, 77	Exeter	36	2	no complaints	Conservative	67
M, 50	Exeter	168	3	slight pain	At 39 months cup revision due to progressive loosening. In-cement revision of stem because of instability.	68
M, 78	Exeter	5	2	External rotation and shortening	At 34 months cement-in-cement revision	45
M, 64	Taperfit	7	2	Slight pain	Conservative	11

our outpatient clinic within one week following a fall from a standing height (Table I). All patients presented with pain in the thigh and groin region. Standard antero-posterior and lateral radiographic views of the hip did not show any direct signs of a periprosthetic fracture. Indirect signs such as a cement mantle crack at the shoulder of the stem (n=3/8) and/or subsidence of the stem of <5 mm (n=6/8) and an eccentric linear gap between the stem and the cement mantle (n=1/8) were present in all eight cases (Figure 2). CT scans of the proximal femur showed a complex burst fracture pattern with cement mantle cracks in all cases. There were no displaced fracture fragments in any of the cases. Patients were explained that the treatment plan consisted of 2 stages with the intention to revise the stem after healing in case the pain would persist. Partial weight bearing as tolerated with 2 crutches was initiated for at least 6 weeks. Explanations about avoidance of torsional movements such as

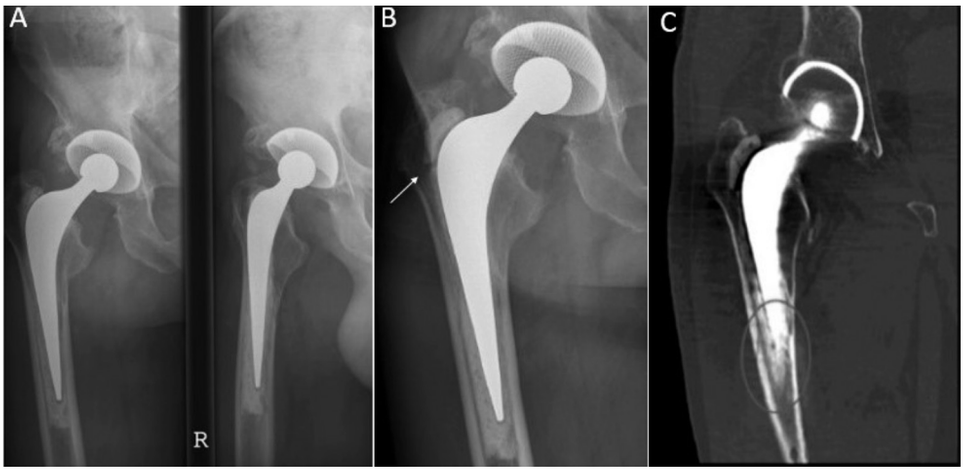

Fig. 2. — (a) This 70-year-old male patient had a normal radiograph 10 years following his primary THA. (b) Five months later he presented with a painful thigh and groin following a fall. No fracture lines were visible on the radiograph but the stem had subsided and a cement crack at the shoulder of the stem was noted (arrow). (c) The suspected undisplaced peri-prosthetic fracture was confirmed on the CT-scan. The radiograph remained unchanged and the patient is completely pain free at 4 years of follow-up

chair rise and stair ascent/descent were done. It was stressed that these movements put high loads on the implant. In addition, physiotherapy support was provided. Patients were meticulously followed with 3-week intervals with radiographic assessments. One crutch was discarded after minimally 6 weeks and when the pain had subsided. At 3 to 4 months, a cement-in-cement revision was conducted in case the patient was not pain free. These procedures were conducted in a similar way to any other cement-in-cement revision procedure. Loose cement fragments were removed but no attempts were made to remove the well-fixed cement mantle. The post-operative rehabilitation was similar to a primary THA.

RESULTS

All patients sustained a low impact trauma due to a fall from standing height at a mean of 50 months (range 5 to 168 months) following a primary THA. Mean follow-up after sustaining the fracture was 60 months (range 11 to 75 months). Five fractures occurred around an Exeter stem (Stryker, Kalamazoo, Michigan), 2 around a CPT stem (Zimmer, Warsaw, Indiana) and 1 around a Taperfit Stem (Corin, Cirencester, United Kingdom). After 3 months of weight bearing as tolerated, none of the fractures had displaced any further in comparison to the first radiograph after the fall, neither had the stem further subsided. Five patients were pain free after conservative treatment and did not require surgical intervention. One patient demonstrated a difficult gait with fixed external rotation due to subsidence of the stem. An uncomplicated cement-in-cement revision was performed 34 months after the fall. One patient had a known loosening of the cup at the time of the fracture. Initial treatment was conservative and the patient was asymptomatic 1 year after the fall. Progressive loosening of the cup was seen after 2 and 3 years and a revision of the acetabular component was planned at 39 months after the fall. During the revision procedure the stem was stable but a cement-in-cement revision was performed because of insufficient stability after revision of the acetabular component. Fifteen months after surgery the patient was completely pain free. One patient remained symptomatic after healing of the fracture. No further subsidence of the stem was seen at 17 months after the fall. A straightforward cement-in-cement revision was planned. However, during surgery the stem was found to be stable but a large Gluteus Medius tendon tear was discovered which was repaired with trans-osseous non-resorbable sutures. The femoral stem was not exchanged. Both patients that underwent a cement-in-cement revision showed normal radiographs with a well-fixed stem and without signs of aseptic loosening at 30 and 11 months of follow-up.

DISCUSSION

The patient population is aging and the number of primary THA procedures is increasing. Consequently, the orthopedic surgeon will be more frequently confronted with periprosthetic fractures. The accumulated incidence was 0.4% for primary and 2.1% for revision THA in a survey of the Swedish Hip Registry *(17)*. Vancouver type B fractures represent the most common fracture pattern and are located around or at the tip of the stem *(7,17)*. These fractures are classified as B2 fractures when the stem is loose and the bone stock is not compromised. Most frequently these fractures are obvious on standard radiographs. However, we report a specific non-displaced burst-type fracture in polished tapered stems, which can be easily missed on standard radiographs. These non-displaced fractures can be classified as Vancouver type B2 fractures since the stem is by definition loose in polished tapered stems. Radiographic findings such as cement mantle cracks, an eccentric linear gap between the stem and the cement mantle or subsidence into the centralizer are highly suspicious for complex burst fractures around polished cemented stems *(11)*. This specific fracture pattern can be explained by the "plug and feather" concept of a polished, tapered stem (the plug) that is driven into the cement mantle (the feather) during the impact. The "plug and feather"-technique was first described by the Egyptians and was commonly used in pre-industrial New England to split large rocks in a controlled way *(9)*. The plug

is driven between 2 feathers and a non-displaced crack will appear between the insertion sites. As a result, the rock can easily be divided (Figure 3). Similarly, a femur can fracture due to a minor impact without fracture fragment displacement and with a well-preserved soft tissue sleeve attached to the fracture fragments an injury mechanism already reported by Sarvilinna et al *(21)*. Polished tapered stems use a 'force-closed' or 'loaded-taper' design principle and high rates of periprosthetic fractures have been reported of these stems compared to the 'shape-closed' or 'composite-beam' type cemented stems *(4,20)*. All patients in this series had a polished tapered stem based on the 'loaded-taper' principle.

Initial conservative treatment does not disrupt this soft tissue sleeve and would allow for fracture healing in case the fracture does not displace any further. Based on our experience, the soft tissue sleeve appeared stable enough to keep the fracture fragments in place when only partial weight bearing as tolerated is allowed.

Revision surgery of an unstable implant following a periprosthetic fracture is mandatory because open reduction and internal fixation is very likely to fail *(18)*. Most authors recommend revision to a long stem that bypasses the fracture site by at least 2 shaft diameters. This has been reported with a high complication rate and a combined non-union, re-fracture and revision rate of 12-20% *(2,5,6,8,10,18,24,25)*. Therefore, we believe that cement-in-cement revision might be a good alternative because this is generally accepted as a safe and relatively easy procedure *(13)*.

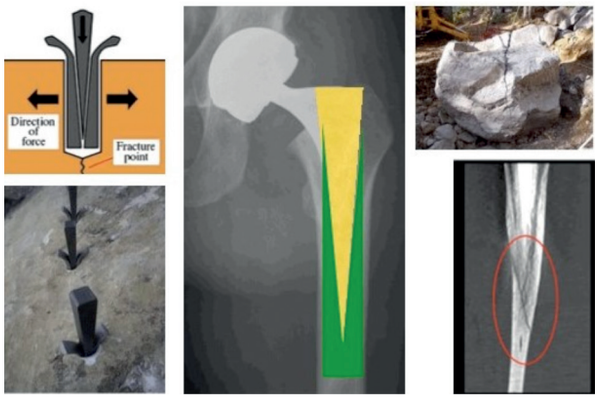

Fig. 3. — The wedge-and-feather system consists of a wedge that is driven between 2 feathers to fracture a rock in a very controlled way (red circle). This can be translated to a wedge tapered cemented stem (yellow arrow) that is driven into the cement mantle (green triangles). As a result the cortex will burst or crack in a complex fracture pattern. The stem is thus deemed unstable.

The polished stem can easily be removed and exchanged by a stem with the same offset but one or 2 sizes smaller. This stem is thus cemented into the pre-existing cement mantle. However, this treatment option can only be considered in case the bone around the cement mantle is stable enough to resist the pressure induced by the cementing technique and the introduction of the stem. As a consequence, only healed and non-displaced fractures are deemed suitable for this treatment modality. All stems had normal radiographic findings. Unexpectedly, 5 out of 8 patients were completely pain free after healing of the fracture and did so far not require any further surgery, although they had some stem subsidence.

We acknowledge that the follow-up term is short. However, we do not feel that these results should be any different from a "regular" cement-in-cement revision, which is generally accepted as a reliable revision technique of polished cemented stems *(13)*. Such a procedure is significantly less complex and traumatic than any other stem revision procedure with opening of the soft tissue sleeve. This is in accordance to Grammatopoulos' findings and recommendations *(11)*. We also acknowledge that our patient population is small but nevertheless remains significant because these fractures are rare. Even more, all patients with the described clinical and radiographic signs were diagnosed with a non-displaced Vancouver type B2 fracture after CT-scan was obtained.

In conclusion, normal radiographs of a post-traumatic and painful THA with a polished tapered, cemented stem do not exclude a Vancouver type B2 fracture and should be followed by a CT-scan. Cement cracks, eccentric linear gaps and subsidence of the stem are highly suspicious radiographic signs for a non-displaced fracture pattern. These fractures can initially be treated conservatively followed by a cement-in-cement stem revision, if required. Although our experience is limited and the follow-up term short, we have found this treatment plan to

be very safe and reliable and it can save frail and elderly patients from complex revision surgery.

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