Case Report

Cementless Stem Stabilization after Intraoperative Fracture

A Radiostereometric Analysis

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Abstract We present the case of a patient with intraoperative femoral fracture during THA, which was repaired using cerclage fixation and insertion of an hydroxyapatite-coated cementless stem. The patient was evaluated postoperatively using radiostereometry during a 2-year course, and despite a large amount of subsidence and rotation, stabilization occurred and was maintained by 6 months. By evaluating the pattern of stem migration after intraoperative fracture, this case shows, even in the presence of instability, a successful clinical outcome can be achieved using an hydroxyapatite-coated cementless stem.

Introduction

Cementless stems rely on press-fit during insertion to achieve initial stability and osseointegration augmented for long-term stability [6, 14]. A well-recognized complication that limits initial stability is intraoperative fracture, which occurs most frequently during insertion of the femoral stem [2, 3, 11]. The tapered shape of cementless stems, in conjunction with the force required during impaction, contributes to this complication [11, 21].

When intraoperative fractures occur, they are usually incomplete or minimally displaced and often are treated using minor osteosynthesis such as cerclage fixation and changes to the postoperative management such as weight-bearing regimens to achieve stable fixation [3, 16]. When initial stability is achieved, a successful outcome can be achieved despite the presence of a fracture [17]. Despite the importance of this complication, the amount of migration occurring with such successful outcome is unknown.

We report the findings from a patient enrolled in a prospective clinical study examining the migration of cementless stems. In this patient, an intraoperative fracture occurred during stem insertion and subsequently was stabilized with cerclage wires. The serendipitous radiostereometric analysis (RSA) examination of this patient affords a unique measure of implant migration where a femoral component is implanted in a potentially unstable environment.

Case Report

A 78-year-old woman underwent primary THA as part of a clinical trial. Ethical approval was granted by the Repatriation General Hospital Research and Ethics Committee,

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Each author certifies that his or her institution approved the reporting of this case report, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

This work was performed at Repatriation General Hospital.

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Fig. 1 A postoperative radiograph shows an undisplaced proximal femoral fracture extending beyond the femoral component into the diaphyseal region.

and the patient provided informed consent for insertion of tantalum markers during surgery and subsequent RSA radiographs.

The patient received an hydroxyapatite-coated, standard offset, collarless, press-fit femoral stem (Corail[®]; Depuy Orthopaedics Inc, Warsaw, IN). Tantalum markers (1.0-mm diameter; RSA Biomedical, Umeå, Sweden) were attached to the proximal shoulder and distal tip of the femoral stem during manufacture and seven tantalum markers (0.8-mm diameter; RSA Biomedical) were inserted intraoperatively into the cancellous bone of the medial and lateral aspects of the femur using a tantalum marker injector (RSA Biomedical). During insertion of the stem, a proximal femoral fracture was sustained. The fracture was treated by removal of the implant, stabilization using one cerclage wire, and reinsertion of the component. The operating surgeon used one cerclage wire, believing the fracture was confined to the calcar region; however, the postoperative radiographs showed an undisplaced fracture extending beyond the femoral component into the diaphyseal region (Fig. 1). The patient was allowed restricted weightbearing for the initial 6 weeks postoperatively.

Table 1. Migration of the stem relative to the femoral bone with time

Followup	Rotations (degrees)			Translations (mm)		
	Anterior tilt	Retroversion	Valgus	Medial	Distal	Posterior
6 months	1.37	10.03	0.32	2.27	7.31	1.82
1 year	1.25	10.21	0.39	2.19	7.33	2.02
2 years	1.28	9.57	0.40	2.08	7.47	1.75

Simultaneous radiographic exposures (100 kV and 4 to 6 mAS) were taken, with the patient in a supine position, 4 days, 6 months, 1 year, and 2 years postoperatively. Bragdon et al. [5] and von Schewelov et al. [22] reported there is no difference between wear measurements made from standing and supine RSA radiographs. Each resultant pair of RSA radiographs was analyzed using UmRSA[®] software (v6.0; RSA Biomedical). Segment analysis was used to compare the translations and rotations of the two stem markers and the center of the femoral head relative to markers in the bone. Functionality was recorded using the Harris hip score [7] preoperatively and at 1 and 2 years after surgery.

Clinically, the patient recovered well from surgery and progressed to full weightbearing by 6 weeks postoperatively. Radiographically, the fracture remained undisplaced, the femoral component appeared stable, and no femoral radiolucencies were observed. The RSA measurements at 6 months showed substantial subsidence (7.3 mm) and rotation to retroversion (10.0°). Between 6 months and 2 years, subsidence and rotation stabilized (the degree of stabilization was within published levels of precision for the RSA technique, ie, 138 μ m translation depending on axis [4], and 0.66°, 1.14°, and 0.12° rotation in the x, y, and z axes, respectively [19]) (Table 1). Measures of functionality followed a pattern similar to the migration. The majority of the patient's improvement in functional outcome occurred within the first year, followed by a smaller increase in functional score between the first and second years (Harris hip scores: 35 preoperatively, 83 at 1 year, and 91 at 2 years).

Discussion

Early femoral stem subsidence reportedly predicts long-term failure [8, 10]. Subsidence greater than 1 mm within the first 2 years is considered a major concern, and when the mean subsidence in a population is between 1 and 2 mm, the risk of clinical failure after 5 to 10 years is estimated to be between 25% to 50% [9]. Despite this, several well-functioning cementless femoral stems show some degree of early migration, predominantly in the form

of subsidence and rotation to retroversion [18, 19], most likely owing to stem impaction associated with loading during weightbearing [20].

The design of the stem and close apposition of implant and bone are primarily responsible for initial stability of the stem [6]. The aim of treatment for intraoperative femoral fractures is to create an environment that closely matches the intact bone in terms of initial stability. The treatment method depends on the severity and location of the fracture and stability of the prosthesis. Minor cracks in conjunction with a stable implant often are managed with cerclage wiring or other minor technique modifications that achieve continued stability [1, 3, 13]. However, when monitoring a patient's outcome, the ability to detect instability attributable to early stem migration using conventional radiography is limited. Malchau et al. [12] suggested stem migration is detectable only if it exceeds 5 to 7 mm when using bony landmarks and conventional radiography. Therefore, when evaluating stability after fracture repair during the early postoperative phase, the use of conventional radiography may underestimate the amount of instability occurring between the implant and bone. The use of RSA during postoperative evaluation of this patient enabled us to detect a large amount of initial subsidence, indicating early postoperative stem instability despite cerclage fixation, and provided an accurate measure of subsequent implant restabilization.

Our patient experienced marked subsidence and rotation to retroversion within the first 6 postoperative months. From the data we obtained, it is not possible to determine how soon after fracture fixation stabilization occurred, as there were no measurements made before 6 months. It also is not possible to determine the exact amount of total subsidence as any subsidence that occurred before the initial postoperative reference examination at 4 days is excluded. However, Strom et al. [19] reported there is little micromotion within the first postoperative week and reference measurements taken within 1 week of surgery seem sufficient. Therefore, it is likely early stabilization was achieved, as reported for other cementless stems [19]. Late stem subsidence related to injury was reported in one case during study of the effect of early weightbearing on stem migration [20]. This patient experienced 2.7 mm subsidence and 12.8° retroversion after falling on the hip before a 2-year RSA examination. No fracture could be detected and the stem restabilized by 3 years [20].

We acknowledge the short followup of 2 years. Although it is recognized early stem micromotion is an indicator of later loosening [8, 9], the results seen with our patient alone do not necessarily ensure stability will be maintained during a 5- to 10-year period. The 5-year RSA measurements for our patient will provide a more accurate prediction of long-term success. Another limitation of this

study is the absence of a precision calculation. However, it is likely the precision will be similar to those reported in another study (between 68 µm and 138 µm depending on axis) [4] owing to similarity in the spatial distribution of the markers on the stem and in the bone.

Instability after cerclage fixation has been seen in animal studies. A study of micromotion and bone ingrowth into porous-coated canine femoral stems showed a deleterious effect of fracture despite cerclage wiring, resulting in an increase in stem micromotion and a reduction in bone ingrowth in comparison to unfractured femurs [15]. Micromotion at the bone implant interface is known to promote fibrous tissue formation, resulting in poor bone anchorage. Although stem design is known to affect initial stability, surface finish contributes substantially to osseointegration and long-term stability [6].

Our case presented a unique opportunity to observe initial stem micromotion occurring after cerclage fixation of an intraoperative fracture during THA. The findings show, despite a large amount of initial subsidence and retroversion, implant stability was achieved by 6 months and subsequently maintained. This unique observation of a stabilizing pattern of migration after fracture emphasizes the importance of interpreting the pattern of migration using RSA after insertion of cementless components, where initial subsidence and retroversion may be attributed to mechanical compaction in the host bone. The migration pattern subsequent to an initial period of osseous integration is likely to be a more important predictor of long-term stability than the initial migration measurement alone.

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