High Incidence of Migration with Poor Initial Fixation of the Accolade® Stem

Craig A. White MD, Sasha Carsen MD,
Kevin Rasuli BSc, Robert J. Feibel MD, FRCSC,
Paul R. Kim MD, FRCSC, Paul E. Beaulé MD, FRCSC

Published online: 2 November 2011
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Abstract

Background Numerous cementless femoral stem design variations are in clinical use. Because initial implant instability and micromotion are associated with aseptic loosening of the femoral component, migration analysis provides an early assessment of implant survivorship.

Questions/purposes We determined the (1) migration pattern of the Accolade® cementless femoral stem; (2) clinical factors predisposing to stem migration; (3) self-reported patient outcomes; and (4) our current rate of aseptic stem loosening.

Methods We retrospectively analyzed 81 femoral stems for aseptic migration using Ein-Bild-Roentgen-Analyse-femoral component analysis. Postoperatively, patients

completed the WOMAC and SF-12 questionnaires. We assessed radiographic factors potentially associated with subsidence: indices of bone shape and quality, canal fill of the implant, and radiographic signs of loosening. Minimum followup was 24 months (mean, 29 months; range, 24–48 months).

Results The average subsidence at 24 months was 1.3 mm (range, 0–1.5 mm). In the first 2 years, 36% of stems subsided more than 1.5 mm. Large stem size was associated with subsidence. Radiolucent lines (> 1.5 mm in three zones) were present in 10% of stems and associated with lower questionnaire scores. The 5-year survivorship for aseptic loosening of the 367 stems was 97% with revision as end point and 95% for radiographic failure.

Conclusions The high incidence of migration and stems with radiographic failure raises concerns about patient clinical function and long-term survivorship of this stem design. This migration pattern may be due to poor initial stability with a subsequent lack of osseointegration. Our results differ from radiographic findings and clinical durability of other similar cementless stem designs.

Level of Evidence Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

PRK is a consultant for Stryker Orthopaedics (Mahwah, NJ, USA). All remaining authors certify that they, or a member of their immediate family, have no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

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

C. A. White, S. Carsen, K. Rasuli, R. J. Feibel,
P. R. Kim, P. E. Beaulé (✉)
Adult Reconstruction, The Ottawa Hospital,
501 Smyth Road, Room W1646,
Ottawa, ON K1H 8L6, Canada
e-mail: pbeaule@ottawahospital.on.ca

Introduction

THA is a reproducible operation for the treatment of hip arthritis with long-term implant survival [1, 7, 33]. Although there is still ongoing debate concerning whether cemented or cementless femoral fixation is superior, both methods have documented implant survivorship of 99% due to aseptic stem loosening at 15 or more years of followup [9, 22]. During the last 10 to 15 years, numerous variations of femoral stem

designs have been introduced [22] and it is unclear whether all of these will have an equal survivorship. Thus, the importance of being able to predict the long-term durability of these stems at short-term followup is important.

In 1980, Loudon and Charnley [31] analyzed migration to show differing femoral implant designs had different migration patterns of failure. Later, Mjoberg et al. [36] hypothesized early implant instability and micromotion were associated with aseptic loosening of the femoral component. Similarly, Freeman and Plante-Bordeneuve [13] and Kobayashi et al. [25] demonstrated the subsidence of a femoral stem at 2 years could predict failure at long-term followup. The association between early implant stability and long-term survivorship is well established for a variety of stem designs [23, 28, 38, 43], with the gold standard in evaluating initial implant stability being radiostereometric analysis (RSA) [8, 39]. Another validated technique to measure implant migration is Ein-Bild-Roentgen-Analyse-femoral component analysis (EBRA-FCA) [3, 27], which also allows accurate measurement of femoral stem subsidence without the need for tantalum markers [4] and can be performed retrospectively using standard pelvic radiographs. EBRA-FCA has an accuracy of better than ± 1.5 mm (95% CI) when compared to RSA, a Cronbach alpha coefficient of 0.84 [3], a specificity of 100%, and sensitivity of 79% [3]. Using a cutoff value of 1.5 mm for femoral stem subsidence in the first 2 years, EBRA-FCA has a sensitivity of 69%, specificity of 80%, and accuracy of 79% in predicting implant failure [28].

The Accolade[®] stem (Stryker Orthopaedics, Mahwah, NJ, USA), a tapered-wedge-type cementless design, was introduced to provide a more physiologic loading of bone by improving initial fixation with the hydroxyapatite (HA) coating and better stress transfer to the bone with the lower modulus of elasticity metal alloy TMZF[®] (Stryker) [30]. However, a higher incidence of subsidence has been reported particularly in male patients [20], as well as an association with the problem of squeaking with ceramic-on-ceramic bearings [41]. More importantly, it was the impression of one of us that some of the stems were subsiding early on, with some patients requiring revision surgery for aseptic loosening with no grossly identifiable surgical deficiencies. Consequently, concerns were raised as to the clinical performance of this stem in the short term with respect to patient function, its osteointegration, and its clinical survivorship. Because early implant instability and micromotion are known risk factors for aseptic loosening [36], combined with the well-established clinical performance of a variety of stems [21, 28, 38, 43], we undertook this study to quantify and assess the overall initial fixation of the Accolade[®] stem.

We raised four questions: (1) What is the early migration pattern of this stem? (2) What are the clinical/

radiographic factors predisposing to migration of this stem? (3) What is the clinical function of patients in our cohort? And (4) what is our current failure rate for aseptic loosening of the Accolade[®] stem?

Patients and Methods

All patients consented to be entered into the study after ethics approval at our institution. Between January 2005 and December 2006, 367 Accolade[®] cementless femoral stems were implanted in 344 patients by one of six surgeons at our center. From the original cohort of 344 patients, we included only patients with a preoperative diagnosis of osteoarthritis with no prior hip surgery and those with digitized radiographs (our institution introduced digital radiographs in December 2005), leaving us with 106 hips in 104 patients. Sixty patients had another diagnosis, 20 had had a prior hip surgery, and 181 patients did not have digitized radiographs. Among these exclusions, 17 patients had passed away. A further 16 hips were excluded because they had already undergone a subsequent surgery at the time of analysis, resulting in insufficient radiographs (Table 1). This left our final group of 90 of the 367 hips (25%). A total of 491 radiographs were analyzed, of which 17 were rejected by the EBRA-FCA software, leading to a further nine patients being excluded, leaving us with 81 patients (81 hips) with an average of 5.1 radiographs per patient. In the study group, there were 48 (59.3%) women and 33 (40.7%) men with a mean ($\pm$ SD) age of 69.9 years (± 11.6 years); this was comparable with the patients who were excluded (Table 2). There were 42 right hips and 39 left. The average BMI was 27.1 kg/m² (± 4.5 kg/m²).

All surgeries were performed by one of six surgeons (including authors PEB, RJF, PRK) using a Hardinge approach. The Accolade[®] stem was implanted with a broach-only insertion technique according to manufacturer recommendation. It has a proximal circumferential titanium plasma spray and HA coating to aid initial stability

Table 1. Patients excluded from EBRA-FCA due to subsequent surgery

Reason for revision	Number of patients
Aseptic stem loosening*	9
Cup exchange	4
Fracture requiring fixation	2
Infection	1
Total	16

* One additional patient underwent surgery for aseptic stem loosening and is not included in this table; this patient was included in the EBRA-FCA; EBRA-FCA = Ein-Bild-Roentgen-Analyse-femoral component analysis.

Table 2. Demographics of patient groups

Variable	Non-EBRA (n = 286)	EBRA (n = 81)	p value
Age (years)*	68.1 ± 14.2	69.9 ± 11.6	0.25
Sex (number)			
Women	177 (62.1%)	48 (59.3%)	0.53
Men	108 (37.9%)	33 (40.7%)	

* Values are expressed as mean ± SD; EBRA = Ein-Bild-Roentgen-Analyse.

and ingrowth. Patients were allowed to weightbear as tolerated using an assistive device (crutches or walker) immediately after surgery and followed standard hip precautions for the first 6 weeks. Routine clinical followup for patients included a 6-week and 4- to 6-month visit with radiographs and clinical examination and then yearly visits with clinical and radiographic examination and functional questionnaires (WOMAC [2] and SF-12 [45] physical and mental component summary scores).

One observer (CAW) evaluated all pre- and postoperative radiographs on a digitized system (Horizon Rad Station™ 11; McKesson Technologies, San Francisco, CA, USA). The EBRA-FCA method used 19 reference points on the femur and stem, and the images were calibrated using the known diameter of the prosthetic femoral head [3]. The tip of the greater trochanter and the shoulder of the stem were used to measure migration in the longitudinal direction. The software compared the distance between reference points to assess the films for comparability. It rejected 17 radiographs (nine patients) that were not within the appropriate confidence levels and required at least four comparable radiographs for analysis.

The examiner assessed the preoperative radiographs to quantify the canal index with respect to bone quality. For the canal index, we used the method described by Dorr et al. [11], measuring endosteal size at a point 10 cm below the lesser trochanter and at the midtrochanteric line. The mean canal index was 0.55 (range, 0.36–0.68). A total of 46 of 81 femurs (56.8%) were classified as champagne flute (canal index, 0.5–0.55), 33 were classified as normal (canal index, 0.56–0.75), and two were classified as stove pipe (canal index, > 0.76). The canal-calcus index was also calculated as a ratio of the endosteal size at a point 10 cm below the calcus to the endosteal size at the midpoint of the lesser trochanter [37]. We used this as a measure of canal morphology, with a mean value of 0.54 (range, 0.39–0.79).

We assessed postoperative radiographs obtained within 6 weeks of surgery to quantify the canal fill of the prosthesis using the method of Kim and Kim [23] and the varus/valgus stem position. We examined the radiographs at latest followup for signs of loosening using the method of Engh et al. [12] and considered stems with radiolucent

lines of greater than 1.5 mm in at least three radiographic zones of Gruen et al. [14] radiographically loose.

We summarized patient demographics as means and SDs for continuous variables and as frequencies and percentages for categorical variables. To show the progression to 1.5 mm of subsidence over time using obtained EBRA-FCA values (Objective 1), a Kaplan-Meier curve was used. We calculated best-fit curves for each stem without constraining to zero as described by Freeman and Plante-Bordeneuve [13]. Briefly, we fitted a regression line for each stem using all subsidence values to predict 24-month subsidence. After this, we classified patients by whether we expected greater than 1.5 mm of subsidence at 24 months. This also allowed us to perform subgroup analyses of demographic (age, BMI, sex, operative side) and clinical (canal index, canal-calcus index, implantation factors, stem offset, stem size, operating surgeon) variables, based on subsidence group (subsidence ≤ 1.5 mm versus > 1.5 mm) (Objective 2). Using subsidence group as the outcome variable, continuous variables (canal index, canal-calcus index) were analyzed using Student's t-tests, and categorical variables (stem offset, stem size, operating surgeon) were assessed using chi-square analyses. In addition, univariate logistic regression models were used to obtain univariate odds ratios for these categorical variables. Multivariate logistic regression analyses were not performed due to sample size limitations. WOMAC and SF-12 scores were analyzed using Student's t-tests for differences in the following three pairs of groups: (1) subsidence (≤ 1.5 mm versus > 1.5 mm), (2) pedestal (yes versus no), and (3) the presence of radiolucencies (yes versus no) (Objective 3). Finally, to assess Accolade® stem survivorship (Objective 4), we used a Kaplan-Meier curve, with corresponding 95% CIs with revision and radiographic failure as end points for aseptic loosening. All statistical analyses were performed using SPSS® for Windows® Version 16.0 (SPSS Inc, Chicago, IL, USA).

Results

The average subsidence at 24 months was 1.36 mm (± 2.2 mm; range, 0–11.5 mm) at a mean radiographic followup of 29.4 months (range, 13–50 months). In total, 29 of the 81 stems (36%) had subsided more than 1.5 mm at 2 years (Fig. 1). In comparing our two subsidence groups (≤ 1.5 mm versus > 1.5 mm), we found no differences in patient demographic data (Table 3) but did find larger implants more likely ($p = 0.008$) to migrate, with an odds ratio for stems Size 4 or greater of 3.7. Patients with subsided stems had a smaller ($p = 0.02$) canal index compared to those with nonsubsided stems: 52.5 (± 6.4) versus 56.4 (± 7), with an odds ratio of 1.09 for migration with a smaller canal index.

Fig. 1 A Kaplan-Meier curve of subsidence over time shows the number of stems reaching the end point of 1.5 mm of migration over time. At 2 years, 29 of the 81 stems (36%) had subsided more than 1.5 mm. Bars = 95% CIs; circles = censored observations.

Table 3. Demographics/surgical variables based on subsidence

Variable	Subsided	Unsubsided	p value
Demographics			
Age (years)*	69 ± 11.3	70.4 ± 11.7	0.62
BMI (kg/m ²)*	26.9 ± 3.6	27.1 ± 5	0.82
Sex (number)			
Male	12 (44.4%)	21 (38.9%)	0.63
Female	15 (55.6%)	33 (61.1%)	
Side (number)			
Right	17 (63%)	25 (46.3%)	0.16
Left	10 (37%)	29 (53.7%)	
Canal index*	52.5 ± 6.4	56.4 ± 7	0.02
Canal-calcaneal index*	56.6 ± 8.5	53.7 ± 7.4	0.11
Implantation factors			
Stem fill index*	79.8 ± 7.5	78.1 ± 10.6	0.44
Varus (−), valgus (+)*	−0.48 ± 2	−0.47 ± 1.6	0.98
Stem offset (number)			
127	11 (40.7%)	26 (49.1%)	0.48
132	16 (59.3%)	27 (50.9%)	
Stem size (number)			
≤ 4 (< 125 mm)	8 (29.6%)	33 (61.1%)	0.008
> 4	19 (70.4%)	21 (38.9%)	
Cases by surgeon (number)			
Surgeon A	12 (44.4%)	20 (37%)	0.39
Surgeon B	5 (18.5%)	17 (31.5%)	
Surgeon C	7 (25.9%)	15 (27.8%)	
Surgeon D	3 (11.1%)	2 (3.7%)	

* Values are expressed as mean ± SD.

Fifteen of the 81 patients had pedestal formation at the tip of the stem, with seven showing subsidence of more than 1.5 mm, with an odds ratio of migration with pedestal formation of 2.01 (range, 0.64–6.31). Eight of the 81 patients had radiolucencies of greater than 1.5 mm in more than three radiographic zones around the stem. Three of the eight patients subsided more than 1.5 mm, whereas 24 of the 73 patients without radiolucencies subsided. The presence of radiolucencies of greater than 1.5 mm in at least three radiographic zones was not associated with subsidence, with an odds ratio of 1.23. There were no differences in WOMAC or SF-12 scores according to subsidence or pedestal formation (Table 4). However, when compared to those without radiolucencies, patients with radiolucencies scored worse on all domains of the WOMAC (Table 4).

For the overall clinical series of 367 hips, a query of our database showed 10 stems had gone on to revision surgery for aseptic loosening of the femoral component at a mean time of 26.7 months (range, 0.5–60.5 months), with 17 patients having died. Thus, the 5-year survivorship for the Accolade[®] stem due to aseptic loosening was 97% (95% CI, 95.6%–98.4%) with revision as end point and 95% (95% CI, 93.3%–96.7%) with radiographic failure (eight stems with radiolucencies of > 1.5 mm in more than three zones) as end point.

Discussion

As with any new implant design, a critical evaluation of its early clinical performance is important to identify possible

Table 4. Clinical outcomes based on radiographic parameters

Outcome	Subsided	Unsubsided	p value	Pedestal	No pedestal	p value	Radiolucencies	No radiolucencies	p value
WOMAC (points)									
Total	86.0	79.4	0.29	77.0 ± 27.2	82.4 ± 16.8	0.48	72.0 ± 25.0	82.3 ± 18.3	0.3
Pain	89.6 ± 13.4	82.0 ± 22.0	0.14	73.9 ± 25.1	83.5 ± 20.3	0.16	58.8 ± 22.4	84.5 ± 19.6	0.002
Stiffness	81.7 ± 19.5	82.0 ± 18.9	0.43	66.7 ± 30.8	77.3 ± 21.4	0.16	51.8 ± 31.8	78.2 ± 20.9	0.004
Function	85.6 ± 14.2	77.1 ± 21.2	0.14	72.1 ± 27.4	79.0 ± 20.9	0.34	55.9 ± 28.9	80.4 ± 19.9	0.005
SF-12 (points)									
Physical component summary	42.3 ± 13.0	36.2 ± 10.1	0.08	42.2 ± 11.7	38.1 ± 11.3	0.28	34.8 ± 8.9	39.3 ± 11.6	0.36
Mental component summary	55.9 ± 4.8	53.9 ± 10.7	0.39	51.1 ± 12.5	54.2 ± 9.2	0.34	47.5 ± 9.4	54.3 ± 9.7	0.11

* Values are expressed as mean ± SD.

implant-related problems and ease of surgical technique. How one best assesses initial implant performance can vary from survivorship analysis to an assessment of clinical function and/or radiographic review or a combination thereof. Unless a major design flaw is present, survivorship analysis will take many years before suboptimal component performance is identified. Initial implant fixation is one of the key elements for a successful THA [21, 35]. Consequently, migration analysis presents an early objective assessment of the predicted medium- to long-term performance and minimizes the risk of unexpectedly higher rates of later failure with early identification of at-risk components [10, 13, 25, 28, 29]. Having observed some early revisions for aseptic loosening of the Accolade® stem at our center, we set out to investigate the potential causes by evaluating initial implant stability using migration analysis. Using the technique of EBRA-FCA, we determined (1) the quality of the initial stability of the Accolade® stem; (2) any identifiable patient or implant factors associated with poor implant stability; (3) patient-reported function; and (4) the current failure rate for aseptic loosening of this stem both with radiographic and revision as end points.

We acknowledge limitations with our study. First, the study was retrospective, requiring us to exclude all but 81 of the original 367 cases (78%). Thus, the study would be prone to substantial selection bias. Although this may be of major concern, great care was taken to ensure our sample was well-defined. We excluded patients in which the primary diagnosis was not osteoarthritis ($n = 60$) and those who had undergone a previous hip surgery ($n = 20$). After this, the remaining exclusions were based on the use of EBRA-FCA, factors beyond our control. These exclusions were 181 patients due to a lack of digitized radiographs, 16 due to a subsequent surgery resulting in an insufficient series of radiographs, and nine where radiographs were rejected by the EBRA-FCA software. The demographics of excluded patients were not different from those included in

the migration analysis (Table 2). Our experience highlights some of the concerns to be considered in future investigations using EBRA-FCA; however, of all the publications on migration analysis (RSA and/or EBRA-FCA), our clinical series is one of the largest in regard to the number of patients evaluated [15, 21, 28]. As with any clinical analysis, a larger number of subsided stems (outcome of interest) would have allowed for a more robust logistic regression analysis. Consequently, because of the relatively low number of events (ie, migrated stems), a multivariate regression analysis could not be performed to clearly establish whether stem size or bone quality were independent risk factors for subsidence. Second, there is a concern about predicting revision surgery based on early implant migration owing to the possibility of secondary stabilization (ie, migration followed by stabilization) [28]. In regard to overall predictability, an RSA study may have been more definitive because of its greater specificity and precision. However, with the EBRA-FCA technique, we were able to study a greater number of stems, permitting us to evaluate several clinical variables and their impact on the risk of migration. Third, as stated above, because of the overall low number of events (stems with > 1.5 mm of migration) and the large number of clinical variables evaluated, we did not perform a multivariable analysis and it is possible the study was underpowered to determine the clinical importance of some of the variables. Finally, we did not perform post hoc corrections for the multiple comparisons in the univariate analysis. This could lead to interpreting differences when there were none.

Using EBRA-FCA, our migration analysis of this particular titanium alloy tapered stem showed a large proportion of patients (29 of 81 [36%]) with more than 1.5 mm of migration. Our findings of poor initial stability of the Accolade® stem were also noted by Jacobs and Christensen [20] who, using a manual radiographic method of migration measurement, also reported a high overall subsidence rate of 1.3 mm,

with 13 of 130 stems migrating more than 3 mm at 1 year. Using a lower threshold of 1.5 mm, 29 of 81 stems in our study were considered to have substantial migration, with 14 of the stems having more than 3 mm of migration. Other groups have used EBRA-FCA to study femoral component migration (Table 5), with our overall rate of migration observed with the Accolade[®] stem higher than other stem designs [6, 15, 29]. In particular, both Radl et al. [38] and Kroell et al. [29] showed early migration assessed with EBRA-FCA predicted poor long-term clinical performance when greater than 1.5 mm, mirroring the earlier work of Kobayashi et al. [26] and Donnelly et al. [10]. However, we must be careful in the interpretation of any migration study in regard to what represents the true threshold of migration leading to revision. Some implants may go on to secondary stabilization despite a lack of initial stability; longer followup of this series will be important to clarify this issue. Krismer et al. [28] noted, in a study of three different stem types utilizing EBRA-FCA, 45 of 158 stems (29%) had subsided more than 1 mm during the first 2 years, but after 5 years, 33 of those showed no further apparent migration.

When looking at which clinical/radiographic factors were predictive of migration, we noted larger stems migrated

more, as well as those implanted in patients with better bone quality (ie, low canal index). However, only 24% (11 of 46) of stems greater than Size 4 were implanted in bone of the champagne flute style. Although they did not objectively quantify the bone quality of their patients, Jacobs and Christensen [20] reported males who also tend to have better quality bone (Dorr A canals) were at higher risk of migration with the Accolade[®] stem. Perhaps the most interesting finding of our series was the fact that larger stems had a higher risk of migration (odds ratio, 3.7), which may be explained by differing behavioral characteristics of the stem in the larger sizes. Although this stem used the basic principle of blade-type geometry and HA coating, it was made of a different metal alloy (TMZF[®]), which has a 25% lower modulus of elasticity compared to standard titanium alloy [44]; consequently, the stem may be too flexible in the larger sizes, permitting sufficient micromotion to prevent osseointegration [5, 18]. Other reasons for subsidence could be poor bone quality, undersizing of the femoral component, poor implant positioning, or mismatch between the native femur and the actual component. A component that wedges in distally in the canal before obtaining proximal fixation may not have enough overall stability for osseointegration

Table 5. Cementless femoral stem migration studies using EBRA-FCA

Study	Stem type	Number of hips	Followup (years unless stated)*	Subsidence at 2 years (mm)*	Number reaching 1.5 mm at 2 years	Failures (aseptic)
Hamadouche et al. [15]	Cementless anatomic tapered titanium HA	23	8.66 ± 1.52	0.84 ± 1.72 (0–7.96)	9	1 stem
	Cementless anatomic tapered titanium GB	24		1.62 ± 2.15 (0–7.42)	13	2 stems
Ince et al. [19]	Cementless titanium straight, proximal plasma spray	29	84 months (12–132)	0.29	1	None
Klestil et al. [24]	Cementless titanium straight	23	24 months	4.2 ± 1.5	7	None
Mazoochian et al. [32]	Cementless titanium, proximal fix	10	84 months	1.16 ± 0.73 (0.6–2.9)	0	None
Radl et al. [38]	Cementless various	AVN 22	6.1 (2–11)	1.5 (0–8.8)	Not reported	5
		OA 45	5.9 (4–8)	0.6 (–2.8–0.7)		2
Krismer et al. [28]	Cemented Müller cobalt-chrome	57	128 (109–141) months	0.5 (0.1–1.0)	7	8
	Cementless porous-coated anatomic	98		0.5 (0.0–1.4)	22	10
	Cementless titanium straight	41		0.4 (0.0–1.2)	10	3
Kroell et al. [29]	Cemented	49 20	8.7 ± 5.4	2.2 ± 0.7	All revisions had subsided at 2 years	Only revised stems were studied
	Cementless	20	10.7 ± 4.9	2.2 ± 1.8		
Current study	Cementless tapered	81	29.4 ± 8.2	1.36 ± 2.2	29 (35.8%)	1

* Values are expressed as mean ± SD, with range in parentheses; EBRA-FCA = Ein-Bild-Röntgen-Analyse-femoral component analysis; HA = hydroxyapatite; AVN = avascular necrosis; OA = osteoarthritis.

and undergo subsequent migration. Minor stem design changes having a negative impact on clinical performance is not unfamiliar, with an example being the introduction of a matte finish on the Exeter™ stem [34].

One aspect of this study that does not require longer clinical followup is the high percentage of patients with radiographic evidence of loosening with poor clinical outcome scores. Although we did not observe these stems migrating, they were obviously exhibiting some lack of stability, which may be rotational [40]. Previous reported studies have suggested a positive predictive value of 50% for failure in patients with radiographic loosening [25]. We found the Accolade® stem demonstrated poor initial fixation in more than 1/3 of our patients, with continued progression of migration being a concern for its overall long-term clinical performance, especially for larger stems. In addition, 10% of patients had poor clinical scores associated with radiolucencies.

Although other surveillance techniques are being proposed for the early observation of new implant designs [16], the gold standard for survivorship continues to be a well-performed, long-term clinical followup. In that regard, the failure rate at short-term followup for the Accolade® stem is 5% with aseptic loosening (revisions plus radiographic failure) as end point and 3% for revisions. This is in sharp contrast to other tapered-wedge designs, which have been reported to have 99% survivorship at 10 years of followup [9, 17, 42]. And although further analysis will determine whether secondary stabilization of the Accolade® stem can be achieved for this patient cohort, the overall clinical performance of this stem at short-term followup was disappointing due to poor initial fixation and migration.

Acknowledgment We thank Mr. Steve Doucette for his assistance with analysis of our data and for preparing the figure and tables for this manuscript.

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