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Early femoral component migration: comparing the anterior and posterior approach to the hip

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Abstract

Purpose: Early femoral component migration is a useful indicator for identifying implants at risk of failure due to aseptic loosening. The goal of this retrospective study was to identify if anterior approach (AA) treated hips are at a higher risk of failure due to aseptic loosening caused by early migration compared to hips operated on using the traditional posterior approach (PA).

Methods: A total of 388 hips were included in this study, 139 AA and 249 PA treated hips. Femoral component migration was evaluated using EBRA-FCA and radiographs were assessed for radiolucency at latest follow-up. Preoperative and 2-year clinical outcomes were reported.

Results: The 1- and 2-year migration rates (mm/year), and total migration (mm) at 2-year follow-up were comparable between AA and PA hips, respectively: 0.52 versus 0.41, 0.18 versus 0.19, and 0.64 versus 0.63 (all $p > 0.05$). Though not statistically significant, a higher percentage of AA hips passed 2-year total migration thresholds that have been associated with aseptic loosening compared to PA hips: 25.4% versus 16.5% for 1.5 mm threshold, and 11.3% versus 4.1% for the 2.7 mm threshold. Migration was not associated with the presence of radiolucent lines. All clinical outcomes improved significantly between preoperative and 2-year follow-up.

Conclusions: There was no association between the AA and any significant increase in femoral component migration. A higher percentage of AA hips exceeded the migration thresholds associated aseptic loosening; however, these stems had no other indications of instability and therefore suggests that this may be a difference in migration pattern.

Keywords

Anterior approach, EBRA-FCA, femoral component migration, total hip arthroplasty

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Introduction

Rapid recovery programmes after total hip replacement have evolved tremendously over the last decade, significantly decreasing length of hospital stay for patients.[1] Surgical approaches such as the anterior approach (AA) for total hip arthroplasty (THA) have assisted with this rapid recovery.[2–4] However, there remain concerns surrounding the long-term success of THA using this approach, with several reports indicating higher risks of complications when compared to the traditional posterior approach (PA).[5–8]

The most prevalent concern with the AA is the high rate of early femoral-sided failures.[9–11] Eto et al.[10] found that failure due to aseptic loosening was more commonly associated with the AA, accounting for 30% of failures compared to 8% with the PA. Similar findings were made by Meneghini et al.[9] However, these papers do not account for surgeon experience and the associated learning curve of the AA.[9] Some authors have reported up to 50 operations are required

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before complication rates are comparable to a more traditional approach, while other authors suggest that the learning curve is not an issue for experienced arthroplasty surgeons.[2,12,13] Having said that, regardless of surgeon experience, femoral component preparation and insertion with the AA can be challenging and has led some surgeons to use shorter femoral components.[8] These femoral components have been associated with higher peri-prosthetic fracture especially in the elderly patient.[14] It is still unclear if this risk of higher femoral component failure with the AA is due to poor femoral bone quality, under sizing/malposition of the femoral component or implant design.

Early femoral component migration within the first two years of operation has proven to be a useful indicator for identifying implants at risk of failure due to aseptic loosening.[15] Determining if the early migration of femoral components implanted using the AA differs from traditional approaches could help identify if the cause for the increased number for femoral sides failures seen within the AA population is related to implant placement or sizing. Femoral component migration has been extensively studied using both prospective and retrospective techniques, allowing for a safe amount of early migration to be established.[16–19]

Ein-Bild-Roentgen-Analyse-femoral component analysis (EBRA-FCA) uses bony and prosthetic landmarks on standard pelvic radiographs to compute subsidence and is the current standard for retrospective migration analysis. This technique has been validated against radiostereometric analysis (RSA) with a specificity of 100% and a sensitivity of 78% for detection of migration over 1 mm.[16] Krismer et al.[17] found that revision for aseptic loosening of cemented and cementless stems could be predicted by EBRA-FCA with a sensitivity of 69%, specificity of 80%, and an accuracy of 79% by using a migration threshold of 1.5 mm during the first two years.[17] A later study by Streit et al.[15] found that a migration threshold of 2.7 mm at two years postoperatively could detect failure due aseptic loosening with a sensitivity of 56% and a specificity of 99%. The study considered a single cementless design. The 18-year survivorship for stems with little early distal migration (<2.7 mm) was 95% compared to 29% for stems with large amounts of early distal migration (>2.7 mm).[15]

The goal of this retrospective study was to identify if AA hips are at a higher risk of failure due to aseptic loosening caused by early migration compared to hips operated on using the traditional PA. The objectives of this study were therefore to: (1) determine early migration rates and total migration of the femoral components; (2) assess radiographic appearance; and (3) assess the short-term clinical outcomes in both cohorts.

Patients and methods

Patients

This research ethics board approved study considered all patients who underwent primary THA at our institution between 01 January 2008 and 31 December 2013. Patients who had a PROFEMUR TL stem (MicroPort Inc., Arlington, TN, USA), a primary diagnosis of degenerative arthritis, and a metal-on-polyethylene head-liner combination were included in the study. The distribution of femoral component stem sizes was the same across AA and PA cohorts (p = 0.111). All patients were operated on by experienced surgeons, where 1 surgeon performed all AA surgeries and 2 surgeons performed all PA surgeries. A total of 352 patients (388 hips) were included, with 249 PA treated and 139 AA treated hips. Only 208 hips (120 PA, 88 AA) had 2-year follow-up that could be used for the migration analysis. During the migration analysis, exclusions were made if a patient had inadequate radiological follow-up. Inadequate follow-up was defined as any patient with <4 radiographs in the 5 years span following operation; 5 AA and 17 PA hips were excluded based on this criterion. An additional 12 AA and 6 PA hips were excluded by EBRA-FCA's internal standards of comparability between radiographs. A further 5 PA hips were excluded by the user because the landmarks could not be reliably placed on the radiographs. The resulting AA and PA group sizes for migration analysis were 71 and 97 hips, respectively. The original cohort of 388 hips was used to assess clinical outcomes between approaches. Study overview is depicted in Figure 1.

Demographics

The mean age of the total AA cohort, and AA hips with 2-year follow-up was significantly lower than the mean age of the corresponding PA groups ($p < 0.001$ and $p = 0.02$). This age difference was not present in the cohort used for the migration analysis. There were no other significant demographic findings (Table 1).

Surgical approach

A standard PA was performed with an incision length of 8–10 cm and repair of the short external rotators and posterior capsule. The AA was done using a positioning table as described by Matta et al.[20] with the following modifications: the positioning table was a Delacroix extension for the Maquet and utilised a posterior thigh bolster to elevate the femur rather than a femoral hook. Standard hip precautions were approach specific with no flexion past 90° with the PA and no extension combined with external rotation with the AA.

Migration analysis

Using the data provided from EBRA-FCA, the 1-year and 2-year subsidence rates were calculated as well as the total subsidence at 24 months. Instances of femoral components reaching a subsidence of greater than 1.5 mm or 2.7 mm at two year follow up were recorded. When interpolation was necessary, a linear relationship was assumed between data points.

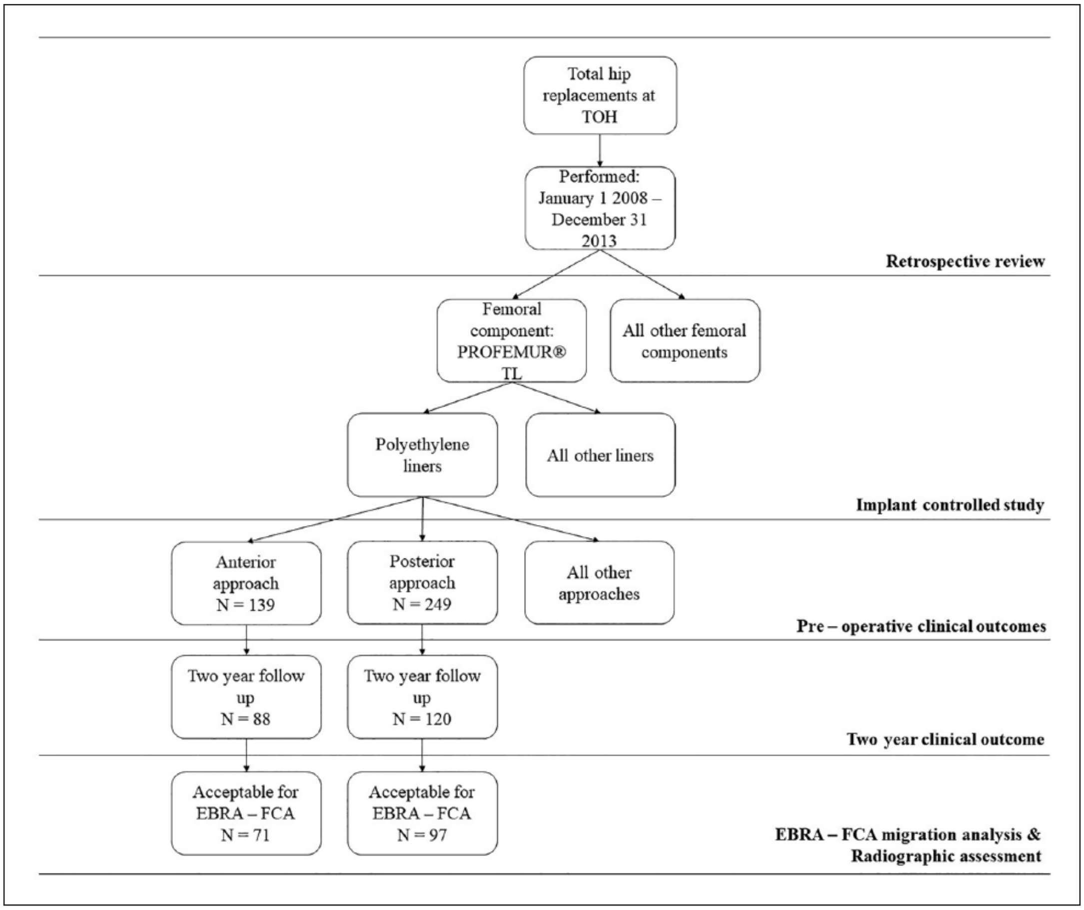

Figure 1. Study overview, including sample size for each analysis.

Table 1. Distribution of demographics for anterior and posterior approach groups.

	Total Cohort (n = 388)		Hips with 2 years of radiological follow-up (n = 208)		Hips acceptable for migration analysis (n = 168)	
	AA	PA	AA	PA	AA	PA
Hips	139 (36%)	249 (64%)	88 (42%)	120 (58%)	71 (42%)	97 (58%)
Male	73 (53%)	114 (46%)	44 (50%)	47 (39%)	35 (49%)	36 (37%)
Female	66 (48%)	135 (54%)	44 (50%)	73 (61%)	36 (51%)	61 (63%)
Age (years)	64 (26–94)*	69 (40–90)*	65 (26–94)*	68 (40–90)*	65 (43–94)	68 (40–90)
BMI (kg/m^2)	28.9 (25.1–31.2)	29.4 (25.9–33.2)	28.4 (25.0–31.1)	28.2 (25.9–33.2)	28.3 (24.5–31.1)	28.3 (26.2–33.4)
Follow-up duration (months)	-	-	-	-	38 (26–49)	42 (35–48)

AA, anterior approach; PA, posterior approach.
*indicates significant difference between groups ($p < 0.05$).

Preoperative and postoperative radiographic assessment

Preoperative radiographs were assessed to quantify bone quality with respect to the canal flare index and the cortical index. The canal flare index was used to characterise canal morphology using the methods described by Nobel et al.[21] and is a ratio between the intercortical width of the femur at a point 2 cm proximal to the mid lesser trochanter line and the intercortical width 10 cm distal to the mid lesser trochanter line. Canal shapes were characterised as normal, stovepipe, or champagne fluted using this index. Cortical index was measured using the methods described by Dorr et al.[22] and is the ratio of the femoral diaphysis

Table 2. Subsidence findings for anterior and posterior approach groups.

	AA	PA
1-year migration rate (mm/year)	0.52 (0.14–1.08)	0.41 (0.12–0.74)
2-year migration rate (mm/year)	0.18 (–0.02–0.42)	0.19 (0.06–0.40)
Subsidence at 24 months (mm)	0.64 (0.24–1.53)	0.63 (0.26–1.18)
Hips to subside 1.5 mm in <2 years	18 (25.4%)	16 (16.5%)
Hips to subside 2.7 mm in <2 years	8 (11.3%)	4 (4.1%)

AA, anterior approach; PA, posterior approach.

width minus the medullary canal width divided by the femoral diaphysis width 10 cm distal to the mid lesser trochanter line. This ratio reflects the cortex thickness.

Postoperatively hips were assessed for canal fill at first follow-up and loosening at latest follow-up. Canal fill was measured at three locations along the diaphysis; at the mid point of the lesser trochanter, distal extremity of the stem, and a midway between these two locations. Radiographs were assessed at the latest follow-up for signs of loosening. Stems were considered radiographically loose if they had radiolucent lines >1.5 mm in at least three radiographic zones as described by Gruen et al.[18,23] Radiographic assessment was only performed on patients that were included in the migration analysis.

Clinical outcome

Clinical functional scores were gathered preoperatively and then yearly using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), 12-Item Short Form Health Survey (SF-12), Harris Hip Score (HHS) and University of California at Los Angeles (UCLA) activity scale. Only preoperative and 2-year clinical function scores were reported.

Statistics

Data normality was tested using a Shapiro Wilk test, all normally distributed data is represented by the mean and range, non-normally distributed data is represented by the median and interquartile range. Means were compared using a Student's t-test for normally distributed data, or a Mann-Whitney U-test for non-normally distributed data. A chi-square or Fisher's exact test was used when assessing categorical variables. Confidence level was set to 0.05 for all tests. A post hoc power analysis showed that the study was sufficiently powered to detect differences of 1 mm between groups in terms of 1-year and 2-year migration rates, and total migration at 24 months. This effect size was chosen based on the detection limit of EBRA-FCA.

Results

Femoral component migration

The mean 1-year and 2-year migration rates showed no significant differences between the AA and PA groups ($p = 0.13$ and $p = 0.43$ respectively). Similarly, the average subsidence at 24 months did not show any significant differences between groups ($p = 0.49$). A higher percentage of AA hips reached a total subsidence of 1.5 and 2.7 mm in less than two years compared to PA hips, these differences were not significant ($p = 0.16$ and $p = 0.08$ respectively). Femoral component migration results are summarised in Table 2.

Preoperative and postoperative radiographic assessment

Preoperatively the canal flare index was used to classify the morphology of the femoral canal, the distribution of champagne flute, normal, and stove pipe morphologies was the same between cohorts. The median canal flare index was 3.26 (2.96–3.82) and 3.22 (2.95–3.62) for AA and PA groups respectively ($p = 0.166$). The median cortical index for the AA and PA groups was also similar between cohorts, 0.56 (0.52–0.62) versus 0.56 (0.53–0.59) respectively ($p = 0.436$). Postoperatively there were significant differences between proximal and distal canal fill for AA and PA groups ($p = 0.030$ and $p = 0.014$ respectively). The proximal and distal canal fill was significantly lower for the AA group, 0.76 (0.70–0.84) versus 0.80 (0.76–0.84) and 0.71 (0.62–0.77)) versus 0.76 (0.63–0.85) respectively. There was, however, no linear correlation between migration and proximal or distal canal fill ($r = 0.026$, $p = 0.740$ and $r = -0.087$, $p = 0.272$ respectively). No hips included in the migration analysis were considered radiographically loose. Radiographic assessment is summarised in Table 3.

Clinical outcomes

Both groups demonstrated significant improvements between the preoperative and postoperative clinical scores excluding SF-12 mental for both groups (AA $p = 0.25$, PA $p = 0.06$). Only the Harris Hip preoperative score showed a significant difference between groups ($p = 0.01$), the PA group was significantly lower than the AA group. There were no significant differences between approaches for any of the clinical outcomes scores at two years (Table 4).

Discussion

The introduction of a new surgical technique is often associated with higher complication rates; this is likely due to

Table 3. Preoperative and postoperative radiographic assessment.

	AA	PA
Preoperative		
Canal flare index	3.26 (2.96–3.82)	3.22 (2.95–3.62)
Stove pipe	28.7%	28.9%
Normal	70.0%	70.1%
Champagne	1.3%	1.0%
Cortical index	0.56 (0.52–0.62)	0.56 (0.52–0.59)
Postoperative		
Canal fill		
Proximal	0.76 (0.70–0.84)*	0.80 (0.75–0.84)*
Middle	0.92 (0.86–0.97)	0.94 (0.88–0.97)
Distal	0.71 (0.62–0.77)*	0.76 (0.63–0.85)*
Radiographic loosening	0%	0%

*indicates significant difference between groups ($p < 0.05$).

Table 4. Clinical outcome scores for anterior and posterior approach groups.

	AA	PA
Harris Hip Score		
Preoperative	51.7 (33.0–67.1)*	45.1 (34.7–55)*
2-year	84.7 (73.7–97.9)	81.4 (72.6–91.3)
UCLA		
Preoperative	4 (2–6)	4 (3–6)
2-year	6 (4–8)	4 (4–6)
WOMAC		
Preoperative	45.0 (28.2–58.8)	40.5 (31.0–45.0)
2-year	94.2 (77.1–100.0)	91.4 (77.5–96.3)
SF-12		
Preoperative mental	53.8 (41.0–62.0)	51.1 (39.8–59.8)
2-year mental	56.2 (49.2–61.8)	56.4 (51.4–60.1)
Preoperative physical	31.3 (26.0–36.0)	29.2 (22.5–35.2)
2-year physical	46.9 (32.9–54.8)	46.4 (36.5–54.4)

AA, anterior approach; PA, posterior approach; UCLA, University of California at Los Angeles activity scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; SF-12, 12-Item Short Form Health Survey.
*indicates significant difference between groups ($p < 0.05$).

an associated learning curve and has been reported for the AA by several authors.[2,12,13,24] In addition, many studies have raised concerns about higher rates of femoral sided failures with the AA.[9–11] Although, it remains unclear as to why the AA would be associated with higher femoral component failure, one hypothesis is that under sizing of the femoral component, due to a variety of reasons (varus positioning, poor exposure, poor templating), makes the stem susceptible to early migration and concomitant loosening and peri-prosthetic fracture.[8] These concerns would likely translate to an increase in early migration and can be evaluated in an implant-controlled study. When comparing hips that received the same femoral component, we demonstrated that the early migration characteristics (total migration and rate of migration) did not significantly differ between the AA and PA. Similarly, the AA did not have any increased instances of radiographic loosening and had comparable clinical outcomes to PA treated hips in this short-term follow-up study.

Having said that, although not statistically significant, there was a greater percentage of AA femoral components that passed the 1.5- and 2.7-mm migration thresholds in the first two years postoperatively. None of these hips had radiolucencies or inferior clinical outcomes, therefore it cannot be concluded that these hips are at risk of failure due to aseptic loosening. This could be due to the lower proximal and distal canal fill of the anterior cohort although it is not clear that the statistical differences translate to a clinically significant amount that would lead to increased migration. It is also possible that the AA is more commonly characterised by a Type 2 migration pattern where there is initial subsidence and subsequent stabilisation.[17] It has been established that the AA allows a more rapid recovery compared to the PA and therefore the early loading of the hip could be influencing the migration pattern.[25] The AA surgeon in this study had extensive experience with the approach and the results may not translate to new surgeons or experienced surgeons adopting the AA into their practice. The results of this study demonstrate that early migration is not a concern when the procedure is performed by an experienced AA surgeon. Further studies would need to be done to establish if surgeon experience influences early migration. Both approaches showed similar improvements in clinical outcome scores at 2-year follow-up, indicating that the AA achieves similar outcomes as the PA. The preoperative HHS did show differences between approaches, this could be explained by the significantly lower age of the AA group used for clinical outcome analysis. This difference was not present at 2-year follow-up.

This study has some limitations that are inherent retrospective studies. First, the migration analyses required exclusion of 220 of the original 388 cases (57%).The loss of patients due to EBRA-FCA's internal comparability algorithm was 20% for this study, this is consistent with other reports in the literature of 3–37%.[15,18,26] Although stems were standardised across cases, the acetabular cup, liner type, head diameter, and stem size were not. By controlling for femoral implant, we isolate for the effects of approach, and eliminate the potential confounding femoral component design factors, which have been shown to affect component migration and migration patterns.[17] The migration thresholds used in this study may not accurately represent the true threshold of migration leading to revision of the PROFEMUR TL specifically; long-term data would be needed to establish this. However, by using two thresholds, we can capture any significant deviations between the AA and PA cohorts, allowing us to establish if a risk of long-term failure due to aseptic loosening exists for the AA when compared to the traditional PA.

In conclusion, there was no association between the AA and any significant increase in femoral component migration. We did find that a higher percentage of AA hips exceeded the migration thresholds associated with aseptic loosening, these stems had no indications of instability based on radiolucencies suggesting that this may be a difference in migration pattern. Longer term follow-up studies are recommended to verify this hypothesis. Further studies are also recommended to determine if surgeon experience can influence early femoral component migration with the AA.

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