Full length article

Total hip arthroplasty in patients 55 years or younger: Risk factors for poor midterm outcomes

Mohamad J. Halawi^{a,*}, David Brigati^a, William Messner^b, Peter J. Brooks^a^a Department of Orthopaedic Surgery, Cleveland Clinic, Cleveland, OH, United States^b Department of Quantitative Health Sciences, Cleveland Clinic, Cleveland, OH, United States

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ABSTRACT

Background: Total hip arthroplasty (THA) is increasingly performed in younger patients. The purpose of this study is to report on the midterm outcomes of primary cementless THA in patients 55 years and younger; and specifically to examine the risk factors for aseptic failure, all-cause revision, and mortality in this patient population.

Methods: Four hundred and twenty-six consecutive patients with minimum 5-year follow-up were retrospectively reviewed. Multivariate analyses were conducted to control for potential confounding factors identified by univariate analyses.

Results: Mean follow-up was 92.12 ± 30.9 months. The overall 5-year implant survival rate was 90.8% and the aseptic survival rate was 92.6%. Among the potential risk factors, only bearing surface had a significant relationship with aseptic revision ($P = 0.041$). Aseptic revisions occurred more frequently with metal-on-polyethylene articulation ($P = 0.012$). Higher Charlson comorbidity index (CCI) was a significant risk factor for all-cause complications ($P = 0.04$) while higher CCI and lower body mass index were significant risk factors for mortality ($P = 0.001$ and 0.006 respectively).

Conclusion: Bearing type was the only risk factor for revision surgery, particularly metal-on-polyethylene bearing. Patients with higher comorbidities were at increased risk for postoperative complications and mortality, while higher body weight appeared to have a protective effect against mortality. These findings should be considered before surgery for risk modification and management of patient expectations. While it appears that bearing couples other than metal-on-polyethylene are especially suitable for young patients, more studies are needed to determine the best bearing couple and to reduce the rates of postoperative complications in this patient population.

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1. Introduction

Total hip arthroplasty (THA) is a highly effective treatment for end-stage degenerative hip disease when nonsurgical management has failed. While this operation was initially intended for elderly, low demand patients, those undergoing THA today are increasingly younger, live longer, and have higher expectations.¹ As a result, arthroplasty surgeons are now faced with higher demands to provide longer lasting implant designs. There have been tremendous improvements in this regard including the advent of higher wear-resistant bearing surfaces, safer anesthetic and analgesic modalities, effective postoperative rehabilitation pathways, and improved preoperative risk stratification.^{2–4} The latter is very important. Understanding risk factors associated with poor

THA survival is not only important for risk reduction, but also for optimizing outcomes and modulating unrealistic expectations.

The burden of revision THA in young North American patients is unclear, but it is reported to be higher than older patients.^{5–7} Using data from the Finnish Arthroplasty Register, the 10-year revision rate in patients younger than 55 years who underwent THA for primary osteoarthritis (OA) is 94%.⁸ Numerous studies had examined the factors influencing THA survival. However, many of those studies were not specific to young patients, were based on Medicare and European Joint Registries data, excluded patients with diagnoses other than primary OA, included a mix of cemented and hybrid fixation, had small sample sizes, or predated modern THA bearings. As such, there is limited available data on the risk factors for revision THA in young patients.

The purpose of this study is to estimate the 5-year survival rate of modern cementless THA in patients 55 years or younger. In addition, the risk factors for aseptic revision, all-cause complications, and mortality are examined. Understanding the risk factors

* Corresponding author at: Department of Orthopaedic Surgery, Cleveland Clinic, 9500 Euclid Avenue, A40 Cleveland, OH, 44195, United States.

associated with poor midterm outcomes in young adults is important as orthopaedic surgeons are challenged with higher functional demands in an increasingly younger patient population.

2. Materials and methods

Institutional Review Board approval was obtained. Four hundred and twenty-six consecutive patients aged 55 years or younger who underwent primary cementless THA in our health care system and had a minimum 60 months follow-up were included. Exceptions to the minimum follow-up period were patients who experienced any of the three main study outcomes (aseptic revision, postoperative complications, and mortality) within the first 60 months. All procedures were performed by high-volume arthroplasty surgeons (defined as performing at least 50 THAs per year) to eliminate the potential confounding effect of surgeon experience. Exclusion criteria were non-elective procedures and procedures performed for tumors or fractures. Spinal anesthesia was used unless contraindicated. Following THA, patients underwent a standardized clinical pathway. Preoperative and postoperative X-rays were reviewed to confirm the correct procedure (THA) and no prior ipsilateral reconstructive surgery had been performed. The most common femoral implants used for THA were Citation (50.7%, Stryker, Kalamazoo, MI), Accolade TMZF (17.1%, Stryker, Kalamazoo, MI), Synergy (8.8%, Smith and Nephew, Memphis, TN), Corail (DePuy Synthes, Warsaw, IN), and S-ROM (4.9%, DePuy Synthes, Warsaw, IN). The most common acetabular implants were Trident (74%, Stryker, Kalamazoo, MI), Pinnacle (9.1%, DePuy Synthes, Warsaw, IN), and Reflection (8.8%, Smith and Nephew, Memphis, TN).

An electronic medical record chart review was performed to collect the following patient variables: age, gender, body mass index (BMI), Charlson Comorbidity Index (CCI), preoperative diagnosis, prior non-arthroplasty hip surgery, surgical approach, femoral head size, and bearing surface. Preoperative diagnoses were divided into six major categories: primary osteoarthritis (OA), inflammatory arthritis, avascular necrosis, developmental dysplasia of the hip (DDH), posttraumatic arthritis, and slipped capital femoral epiphysis (SCFE). Bearing surfaces included ceramic-on-ceramic, metal-on-metal, metal-on-polyethylene, and ceramic-on-polyethylene. The primary study outcomes were aseptic revision, all-cause revision, and mortality. Patients with missing five-year follow-up were contacted via telephone or email. Participation was voluntary and no financial compensation was provided. Complete follow-up was available on 84.3% of patients.

Results for continuous variables were described using means, standard deviations, medians, and/or interquartile ranges. Categorical variables were described using counts and percentages. Numerical variables were compared between groups using Wilcoxon's rank-sum test or Welch's two sample t-test. Categorical variables were compared between groups using Pearson's chi-squared test or Fisher's exact test. All multivariate modeling was performed using logistic regression. Variables were selected in a stepwise manner according to *P* values. Linear multiplicative interactions were tested for among the selected main effects and included where significant. All analyses were done using R software (R version 3.2.3 (2015-12-10), Vienna, Austria). All testing assumed a 5% level of significance.

3. Results

There were 426 consecutive patients in the study group. Mean age was 46.9 ± 7.1 years (range 19–55) and follow-up 92.1 ± 30.9 months (range 0–123.5). There were 42 patients (9.8%) who experienced one of the three primary outcomes before the

minimum 60 months required follow-up and were included in the analyses.

3.1. Aseptic revision

The 5-year rate of revision for any reason was 9.2% and for aseptic revisions was 7.4%. Among the potential risk factors, only bearing surface had a significant univariate relationship with aseptic revision ($P=0.04$). Table 1 describes the patient variables in the aseptic revision group compared to the control group. A logistic regression model was built according to the criteria described in the Methods section with bearing surface remaining as the only significant variable. The model (Table 2) showed that septic revisions occurred at different frequencies depending on the bearing surface. Specifically, in comparison to the ceramic-on-ceramic bearings (reference group), aseptic revisions were more frequently associated with metal-on-polyethylene bearings ($P=0.01$). Excluding THAs with metal-on-metal bearings, the most common cause of aseptic revision was loosening of the acetabular component (4.6%) followed by periprosthetic fractures (1.5%) followed by loosening of the femoral component (0.9%). Periprosthetic infection was the most common cause of revision in metal-on-metal bearings (4.9%).

3.2. All-Cause Complications

The 5-year rate of all-cause complications was 9.6%. Among the potential risk factors, only younger age had a significant relationship with the complications ($P=0.03$). Table 3 describes the patient variables in the complications group compared to the

Table 1
Potential risk factors for aseptic failure in the study group.

	Control Group	Aseptic Revision Group	P-Value
N	350 (92.59%)	28 (7.41%)	
Age (years)	49 (43.25, 52)*	45.5 (39.5, 49.75)*	0.052 ^W
Sex			
Male	187 (53.43%)	16 (57.14%)	0.86 ^C
Female	163 (46.57%)	12 (42.86%)	
Body mass index	30.41 $\pm$ 7.54	29.04 $\pm$ 6.54	0.33 ^T
Charlson Comorbidity Index	2 (1, 2)*	2 (1, 2)*	0.15 ^W
Preoperative diagnosis			
Primary osteoarthritis	178 (50.86%)	10 (35.71%)	0.26 ^F
Avascular necrosis	83 (23.71%)	6 (21.43%)	
Dysplasia	47 (13.43%)	7 (25.0%)	
SCFE	18 (5.14%)	1 (3.57%)	
Posttraumatic arthritis	13 (3.71%)	1 (3.57%)	
Inflammatory arthritis	11 (3.14%)	1 (3.57%)	
Approach			
Posterolateral	170 (48.57%)	12 (42.86%)	0.84 ^C
Anterolateral	114 (32.57%)	10 (35.71%)	
Direct lateral	66 (18.86%)	6 (21.43%)	
Prior ipsilateral non-arthroplasty hip surgery			
No	313 (89.43%)	22 (78.57%)	0.15 ^C
Yes	37 (10.57%)	6 (21.43%)	
Head size	32 (32, 36)*	32 (32, 36)*	0.84 ^W
Articulation			
Ceramic on ceramic	169 (49.71%)	9 (33.33%)	0.041 ^F
Ceramic on polyethylene	44 (12.94%)	5 (18.52%)	
Metal on metal	79 (23.24%)	4 (14.81%)	
Metal on polyethylene	48 (14.12%)	9 (33.33%)	

*: Median [25th percentile, 75th percentile]; C: Pearson's Chi-squared test; F: Fisher's exact test for count data; T: Welch two sample t-test; W: Wilcoxon rank sum test with continuity correction.

Table 2

Logistic regression model for aseptic revision.

Bearing surface	P Value	Odds Ratio (95% Confidence Interval)
Ceramic on ceramic	Reference	Reference
Ceramic on polyethylene	0.193	2.13 (0.629–6.51)
Metal on metal	0.935	0.951 (0.252–3.02)
Metal on polyethylene	0.012	3.52 (1.31–9.5)

control group. From a multivariate perspective, both age and CCI were selected for inclusion in the logistic regression model according to the criteria outlined in the Methods section (Table 4). Controlling for CCI, complications tended to occur in younger patients ($P=0.005$). Controlling for age, complications tended to occur in patients with higher CCIs ($P=0.02$). The most common complications were superficial wound infections (1.6%) followed by instability (1.1%).

3.3. Mortality

The 5-year mortality rate was 5.9%. Among the potential risk factors, only higher CCI and lower BMI had a significant univariate relationship with mortality ($P=0.001$ and 0.006 respectively; Table 5). These variables (along with their interaction) were also the only two selected for inclusion in the multivariable logistic regression model. In this model, the interaction between BMI and CCI ($P=0.006$) showed a somewhat complex relationship with mortality. The risk of death was highest when both CCI was high and BMI was low; and the risk was relatively low if the two variables didn't exhibit this exact “high-low” pattern. Most deaths

Table 3

Potential risk factors for complications in the study group.

	Control Group	All-Cause Complications	P-Value
N	321 (81.06%)	75 (18.94%)	
Age (years)	49 (44, 52)*	46 (42, 52)*	0.017 ^W
Sex			
Male	184 (54.28%)	19 (46.34%)	0.43 ^C
Female	155 (45.72%)	22 (53.66%)	
Body mass index	30.27 ± 7.43	31.3 ± 8.18	0.45 ^T
Charlson Comorbidity Index	2 (1, 2)*	2 (1, 3)*	0.52 ^W
Preoperative diagnosis			
Primary osteoarthritis	170 (50.15%)	17 (41.46%)	0.42 ^F
Avascular necrosis	77 (22.71%)	15 (36.59%)	
Dysplasia	50 (14.75%)	4 (9.76%) 2	
SCFE	19 (5.6%)	(4.88%) 1	
Posttraumatic arthritis	13 (3.83%)	(2.44%)	
Inflammatory arthritis	10 (2.95%)	2 (4.88%)	
Approach			
Posterolateral	164 (48.38%)	21 (51.22%)	0.78 ^C
Anterolateral	110 (32.45%)	14 (34.15%)	
Direct lateral	65 (19.17%)	6 (14.63%)	
Prior ipsilateral non-arthroplasty hip surgery			
No	300 (88.5%)	37 (90.24%)	>0.99 ^C
Yes	39 (11.5%)	4 (9.76%)	
Head size	32 (32, 36)*	32 (32, 36)*	0.87 ^W
Articulation			
Ceramic on ceramic	159 (48.33%)	22 (55.0%)	0.093 ^C
Ceramic on polyethylene	45 (13.68%)	5 (12.5%)	
Metal on metal	75 (22.8%)	8 (20.0%)	
Metal on polyethylene	50 (15.2%)	5 (12.5%)	

*: Median [25th percentile, 75th percentile]; ^C: Pearson's Chi-squared test; ^F: Fisher's exact test for count data; ^W: Wilcoxon rank sum test with continuity correction; ^T: Welch two sample *t*-test.

Table 4

Multivariable logistic regression model for all-cause complications.

Risk factor	P Value	Odds Ratio (95% Confidence Interval)
Age	0.005	0.939 (0.899–0.982)
Charlson comorbidity index	0.021	1.31 (1.03–1.66)

occurred after 90 days from surgery (74%). The majority of deaths were cancer-related followed by congestive heart failure and pneumonia. The average postoperative time of death was 27.5 months.

4. Discussion

Unlike elderly patients, the indications for THA in young, active patients include a spectrum of etiologies. This is important to note as previous studies on THA outcomes in young patients excluded diagnoses other than primary OA. In this study, primary OA accounted for only 49.7% of the preoperative diagnoses. Other major indications were avascular necrosis of the femoral head (23.7%), hip dysplasia (14.3%), SCFE (5.5%), posttraumatic arthritis (3.7%), and inflammatory arthritis (3.1%). The relatively lower prevalence of inflammatory arthritis in our patient cohort contrasts with earlier reports in which juvenile idiopathic arthritis (JIA) was the most common indication for THA.^{9–12} This is likely explained by the advent of disease-modifying antirheumatic drugs (DMARDs) in recent years, which have dramatically improved the prognosis of JIA. In a recent systematic review of THA patients 30 years or younger, Adelani et al.¹² found THAs performed more recently were less likely to be secondary to JIA.

A few studies have reported on the outcomes of primary cementless THA in young patients. In a retrospective review of 221

Table 5

Potential risk factors for mortality in the study group.

	Alive	Deceased	P-Value
N	367 (94.10%)	23 (5.90%)	
Age (years)	49 (43, 52)*	50 (46.5, 52.5)*	0.57 ^W
Sex			
Male	199 (54.22%)	11 (47.83%)	0.70 ^C
Female	168 (45.78%)	12 (52.17%)	
Body mass index	30.37 ± 7.53	25.38 ± 7.26	0.006 ^T
Charlson Comorbidity Index	2 (1, 2)*	3 (2, 3)*	0.001 ^W
Preoperative diagnosis			
Primary osteoarthritis	183 (49.86%)	13 (56.52%)	0.062 ^F
Avascular necrosis	85 (23.16%)	3 (13.04%)	
Dysplasia	54 (14.71%)	2 (8.7%) 1	
SCFE	20 (5.45%)	(4.35%)	
Posttraumatic arthritis	11 (3.00%)	4 (17.39%)	
Inflammatory arthritis	14 (3.81%)	0 (0.0%)	
Approach			
Posterolateral	179 (48.77%)	15 (65.22%)	0.13 ^C
Anterolateral	118 (32.15%)	3 (13.04%)	
Direct lateral	70 (19.07%)	5 (21.74%)	
Prior ipsilateral non-arthroplasty hip surgery			
No	327 (89.1%)	22 (95.65%)	0.49 ^F
Yes	40 (10.9%)	1 (4.35%)	
Head size	32 (32, 36)*	32 (32, 36)*	0.099 ^W
Articulation			
Ceramic on ceramic	171 (48.03%)	13 (56.52%)	0.23 ^F
Ceramic on polyethylene	49 (13.76%)	2 (8.7%)	
Metal on metal	82 (23.03%)	2 (8.7%)	
Metal on polyethylene	54 (15.17%)	6 (26.09%)	

*: Median [25th percentile, 75th percentile]; ^C: Pearson's Chi-squared test; ^F: Fisher's exact test for count data; ^W: Wilcoxon rank sum test with continuity correction; ^T: Welch two sample *t*-test.

patients 50 years or younger who underwent cementless THA with polyethylene bearings, Kearns et al.¹³ found a 96.3% 5-year all-cause survival rate with loosening of acetabular component identified as the most common reason for revision. Compared with ceramic-on-polyethylene bearings, THAs with metal (cobalt-chrome)-on-polyethylene bearings had a higher revision risk. Consistent with previous studies,^{14–16} aseptic loosening, of the acetabular component was the most common mechanism of aseptic failure in our study cohort. Among the four possible bearings we reviewed (ceramic-on-ceramic, metal-on-metal, ceramic-on-polyethylene, and metal-on-polyethylene), the lowest revision rate occurred in the ceramic-on-ceramic bearing and highest in the metal-on-polyethylene bearing as previously reported.^{17,18}

Other studies investigated the role of patient-related variables as risk factors for revision THA. In a systematic review of 86 papers, Prokopetz et al.⁵ found younger age, male gender, higher CCI, diagnosis of avascular necrosis, low surgeon volume, and larger femoral heads to be predictive of aseptic loosening. That study was limited by numerous confounding factors related to the heterogeneity of the included papers. In the present study, however, only younger age and higher CCI had a significant relationship with all-cause complications, which included aseptic revision surgery. Young age may indicate higher postoperative expectations and activity levels, which may lead to increased bearing surface wear or component loosening. In a series of 1,535 primary cemented THAs, Flugsrud et al.¹⁹ found patients with high activity level were at increased risk to develop aseptic loosening of the acetabular component.

The third outcome in this study was postoperative mortality. Previous reports based on the Danish and Norwegian Arthroplasty Registers demonstrated increased mortality rates among younger patients after THA with an 8-year mortality rate as high as 25%.^{20,21} In this study, the 5-year mortality rate was much lower at 5.9%. The majority of deaths were cancer-related followed by congestive heart failure and pneumonia. While our finding that increased CCI carried a higher mortality risk is self-explanatory, the relationship between lower BMI and mortality was not expected. Interestingly, on review of literature, several population-based studies demonstrated that higher BMI had a protective effect in THA patients.^{22,23}

The primary limitation of this study is its retrospective design, which resulted in multiple implants and surgeons to be included. Potential confounding effect related to surgeon experience was minimized by including only procedures performed by high-volume arthroplasty surgeons. Additionally, we assessed the effect of surgical approach, which was not statistically significant. The prostheses implanted in this study remain in use. Another limitation is our list of potential risk factors was not all-inclusive (e.g., preoperative activity level was not assessed). Those factors were not consistently available in the charts and hence were not analyzed. Nonetheless, we believe this study has several strengths. Most of our findings are consistent with previous reports. To our knowledge, this is the largest North American series of THAs in patients 55 years or younger. We investigated a wide array of patient and surgical factors. By reviewing individual patient charts, we had the advantage of assessing factors that are sometimes either not routinely collected in large-scale databases or mistakenly included (e.g., a hip resurfacing that is reported as THA in the database).

In summary, the 5-year THA all-cause revision rate in patients 55 years or younger was 9.2% and the aseptic revision rate was 7.4%.

Bearing type was the only risk factor for revision surgery, particularly metal-on-polyethylene bearing. Younger patients and those with more comorbidities were at increased risk for postoperative complications and mortality, while higher body weight appeared to have a protective effect against mortality. These findings should be considered before surgery for risk modification and management of patient expectations. While it appears that bearing couples other than metal-on-polyethylene are especially suitable for young patients, more studies are needed to determine the best bearing couple and to reduce the rates of postoperative complications in this patient population.

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