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Mid-term Outcomes of Short Stem Total Hip Arthroplasty in Younger versus Older than 60 Years: A Propensity Score-Matched Study

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Abstract

Purpose

To evaluate the influence of chronological age on the mid-term clinical outcomes and implant survivorship of cementless short-stem total hip arthroplasty (THA) by comparing patients aged over 60 years versus those aged 60 years and under.

Methods

A retrospective propensity score–matched study included 509 patients who underwent Metha® short-stem THA. Patients were stratified into two age groups (> 60 vs. ≤60 years). Patients were stratified into two age groups consisting of older (over 60 years) and younger (60 years and under) patients. After matching (1:4) for sex, BMI, ASA class, diagnosis, and Dorr femoral type, 76 older and 304 younger patients were analyzed with a minimum follow-up of five years. Outcomes included Harris Hip Score (HHS), Forgotten Joint Score (FJS), patient satisfaction, radiographic fixation, stem subsidence (> 3 mm), complications, and implant survivorship using Kaplan–Meier analysis.

Results

Baseline characteristics were well balanced after matching (SMD < 0.1). At five years, postoperative HHS (97.3 vs. 97.7; p = 0.16) and FJS (95.1 vs. 95.7; p = 0.31) were comparable between the older and the younger groups, with > 97% reporting high satisfaction. Radiographic fixation and subsidence rates were similar between groups. Intraoperative femoral fractures occurred more frequently in the older group (11.8% vs. 3.0%; p = 0.023). Five-year survivorship for revision for any reason was 97.4% in the older group and 98.7% in the younger group (p = 0.41).

Conclusion

Cementless short-stem THA demonstrated excellent mid-term outcomes and comparable survivorship across age groups. Although intraoperative femoral fractures were more frequent in older patients, overall outcomes were not compromised, suggesting that chronological age alone should not preclude metaphyseal-anchoring short stems when bone quality and femoral morphology are appropriate.

Introduction

Total hip arthroplasty (THA) is a highly successful orthopedics procedure that provides durable pain relief and functional improvement for patients with end-stage hip disease [1]. With increasing life expectancy and rising functional demands, indications for THA continue to expand, particularly among younger and more active patients [2]. Accordingly, preservation of proximal femoral bone stock,

reduction of stress shielding, and facilitation of future revision have become key considerations in femoral implant design.

Cementless short-stem femoral components were developed to address limitations of conventional stems, including metaphyseal–diaphyseal mismatch, stress shielding, postoperative thigh pain, periprosthetic fracture, and proximal bone loss [3, 4]. These implants achieve metaphyseal anchorage without diaphyseal engagement, enabling more anatomical reconstruction and physiological load transfer [3–6]. By preserving proximal bone stock and minimizing canal violation, short-stem THA may facilitate future revision surgery.

Encouraging mid- to long-term outcomes of cementless short-stem THA, including reliable osseointegration, low subsidence, favorable radiographic remodeling, and high patient satisfaction, have been reported, particularly in patients with good bone quality [5–8]. Consequently, short-stem designs have gained popularity as a bone-conserving option for primary THA in appropriately selected patients.

However, the role of cementless short-stem THA in elderly patients remains controversial. Advancing age is associated with reduced bone mineral density, altered femoral morphology, and a higher risk of intraoperative complications, potentially compromising metaphyseal fixation [9, 10]. Existing comparative studies are limited by baseline imbalances, making it difficult to isolate the independent effect of age on implant performance.

Therefore, this study aimed to compare the mid-term clinical outcomes, radiographic findings, complications, and implant survivorship between patients aged over 60 years and those aged 60 years and under, utilizing propensity score matching. We hypothesized that after matching for bone quality and femoral morphology, mid-term clinical outcomes and implant survivorship would be comparable between the older and younger patient groups.

Methods

A retrospective comparative cohort study was approved by the Institutional Review Board (IRB No. 154/2025), in accordance with the Declaration of Helsinki. All consecutive patients who underwent primary cementless short-stem THA using the Metha® femoral stem between November 2010 and December 2019 were reviewed. Inclusion criteria were age 18 years or older, preoperative femoral bone quality of Dorr type A or B [9], and a minimum follow-up of five years. Patients with incomplete records were excluded.

Based on a previous study [11], the sample size was calculated to detect a minimal clinically important difference of 7 points in the Harris Hip Score (HHS), assuming a standard deviation of 15, an alpha level of 0.05, and 90% power. Accounting for a 10% attrition rate, the minimum required sample size was 65 patients in the older group (over 60 years) and 193 patients in the younger group (60 years and under).

Patients were stratified into two age groups consisting of older (over 60 years) and younger (60 years and under) patients [12, 13]. To reduce selection bias, propensity score matching was performed using a multivariable logistic regression model with age group as the dependent variable and sex, body mass index (BMI), ASA class, primary diagnosis, and Dorr type as covariates [9]. Matching was performed without replacement at a 1:4 ratio. Covariate balance was considered adequate when the standardized mean difference (SMD) was less than 0.10. After matching, 76 patients in the older group and 304 patients in the younger group were included.

All procedures used the Metha® cementless short-stem system (B. Braun Aesculap AG, Tuttlingen, Germany) and were performed by three experienced surgeons (YS, JS and TT) via a modified Hardinge approach. A cementless acetabular component with a polyethylene liner was implanted in all cases.

Patients were mobilized with full weight-bearing from postoperative day two and followed at regular intervals with standardized radiographs. Clinical outcomes included the Harris Hip Score (HHS), assessed preoperatively and at follow-up, and the Forgotten Joint Score (FJS) at final follow-up. Patient satisfaction was recorded using a four-point Likert scale [14]. Clinical data were collected by an independent assessor.

Radiographic evaluation assessed osseointegration using modified Gruen zones [15] (Fig. 1), stress shielding according to Engh's classification [16], and stem subsidence greater than 3 mm [17]. Stem subsidence was measured as the change in distance between the lateral shoulder of the femoral stem and the most prominent point of the greater trochanter on anteroposterior radiographs, comparing immediate postoperative and follow-up images. Two independent observers (PC and SA) reviewed all radiographs.

Postoperative complications (intraoperative femoral fracture, dislocation, periprosthetic joint infection, and revision) were recorded. Implant survivorship was analyzed using Kaplan–Meier methods with endpoints of revision for any reason and aseptic loosening.

Statistical Analysis

Statistical analyses were performed using Stata version 19 (StataCorp LLC, College Station, TX, USA). Analyses were conducted within the propensity score–matched cohort. Continuous outcomes were analyzed using linear regression, categorical outcomes using chi-square or Fisher's exact tests, and ordinal outcomes using ordinal logistic regression. Binary outcomes were analyzed using logistic regression, with effects reported as risk differences with 95% confidence intervals. Implant survivorship was evaluated using Kaplan–Meier analysis with log-rank testing. Inter- and intra-observer reliability for radiographic assessments was assessed using Cohen's kappa coefficient, with inter-observer agreement ranging from 0.87 to 1.00 and intra-observer agreement ranging from 0.84 to 1.00. A two-sided p-value of less than 0.05 was considered statistically significant.

Results

Baseline demographic and clinical characteristics were evaluated in unmatched and matched cohorts. In the unmatched cohort, 509 patients were included (76 in aged over 60 years and 433 in patients aged 60 years and under). Several baseline variables showed imbalance (SMD > 0.1), particularly ASA classification ($p = 0.004$), indicating a higher comorbidity burden in older patients (Table 1).

Table 1
Baseline demographic data (Unmatched vs. Matched 1:4)

	Age > 60 years	Age ≤ 60 years	SMD	P-value
Unmatched THA patients	76	433	-	0.56
N	65.91 ± 4.02	44.49 ± 9.36	0.07	0.56
Demographics (%)	22.15 ± 4.17	22.43 ± 3.82	0.07	0.12
Age (mean ± SD)	87.61 ± 19.84	89.58 ± 28.29	**0.19**	0.92
BMI (mean ± SD)	49 (64.5%)	238 (55.0%)	0.07	**0.004**
Follow-up (mean ± SD)	27 (35.5%)	195 (45.0%)	**0.47**	0.28
Sex n(%)	303 (70.0%)	303 (70.0%)	**0.14**	-
Male	61 (14.1%)	61 (14.1%)	-	0.54
Female	42 (9.7%)	42 (9.7%)	0.08	0.47
Diagnosis n(%)	27 (6.2%)	27 (6.2%)	0.09	0.70
ONFH	4 (5.3%)	92 (21.2%)	0.05	0.91
DDH	59 (77.6%)	276 (63.7%)	0.09	1.00
OA	13 (17.1%)	64 (14.8%)	0.00	0.91
NOF	21 (27.6%)	147 (33.9%)	0.02	
ASA classification n(%)	55 (72.4%)	286 (66.1%)		
1	76	304		
2	65.91 ± 4.02	44.44 ± 9.81		
3	22.15 ± 4.17	22.45 ± 3.68		
Dorr type n(%)	87.61 ± 19.84	85.19 ± 27.40		
A	49 (64.5%)	203 (66.8%)		
B	27 (35.5%)	101 (33.2%)		
Matched THA patients	303 (70.0%)	221 (72.7%)		
N	61 (14.1%)	35 (11.5%)		
Demographics (%)	42 (9.7%)	23 (7.6%)		

SMD, standardized mean difference; BMI, body mass index; ONFH, osteonecrosis of the femoral head; DDH, developmental dysplasia of the hip; OA, osteoarthritis; NOF, femoral neck fracture; ASA, American Society of Anesthesiologists.

P-values < 0.05 were considered statistically significant. Statistically significant values ($p < 0.05$) and SMD > 0.1 are shown in bold.

Age (mean ± SD)	27 (6.2%)	25 (8.2%)
BMI (mean ± SD)	4 (5.3%)	16 (5.3%)
Follow-up (mean ± SD)	59 (77.6%)	236 (77.6%)
Sex n(%)	13 (17.1%)	52 (17.1%)
Male	21 (27.6%)	82 (27.0%)
Female	55 (72.4%)	222 (73.0%)
Diagnosis n(%)		
ONFH		
DDH		
OA		
NOF		
ASA classification n(%)		
1		
2		
3		
Dorr type n(%)		
A		
B		

SMD, standardized mean difference; BMI, body mass index; ONFH, osteonecrosis of the femoral head; DDH, developmental dysplasia of the hip; OA, osteoarthritis; NOF, femoral neck fracture; ASA, American Society of Anesthesiologists.

P-values < 0.05 were considered statistically significant. Statistically significant values ($p < 0.05$) and SMD > 0.1 are shown in bold.

After propensity score matching (1:4), 76 patients in the older group were matched to 304 patients in the younger group. All baseline covariates were well balanced after matching, with SMD values below 0.1 (Table 1).

At a minimum 5-year follow-up, clinical outcomes were comparable between groups. Preoperative HHS did not differ significantly between the older and the younger groups (42.9 ± 7.9 vs. 41.8 ± 6.7; $p = 0.30$). At 5 years postoperatively, both groups demonstrated excellent functional outcomes, with similarly high HHS (97.3 ± 2.2 vs. 97.7 ± 1.6; $p = 0.16$) and FJS values (95.1 ± 4.5 vs. 95.7 ± 2.4; $p = 0.31$). Patient satisfaction was comparable, with more than 97% of patients in both groups reporting being very satisfied (Table 2).

Table 2
Clinical outcomes at minimum 5-year follow-up after 1:4 matched analysis

Parameter	Age > 60 years (n = 76)	Age ≤ 60 years (n = 304)	Mean difference (95% CI)	p-value
HHS (Pre-op) (Mean ± SD)	42.92 ± 7.94	41.75 ± 6.67	1.13 (− 1.03–3.29)	0.3038
HHS (5-year) (Mean ± SD)	97.32 ± 2.15	97.74 ± 1.60	−0.40 (− 0.95–0.15)	0.1582
FJS (5-year)	95.08 ± 4.53	95.69 ± 2.38	−0.56 (− 1.65–0.52)	0.3085
Patient satisfaction (hips) (%)	74 (97.4%)	297 (97.7%)		0.9546
- Very satisfied	2 (2.6%)	7 (2.3%)		
- Satisfied	0 (0%)	0 (0%)		
- Unsatisfied	0 (0%)	0 (0%)		
- Very unsatisfied				

HHS, Harris Hip Score; FJS, Forgotten Joint Score; CI, confidence interval.

Radiographic outcomes were similar between groups. Trabecular bone formation across modified Gruen zones and the distribution of stress shielding grades did not differ significantly between age groups. Femoral stem subsidence greater than 3 mm occurred in 2.6% of hips in the older group and 0.3% in the younger group, without a significant difference (p = 0.22) (Table 3). An illustrative case of postoperative stem subsidence with subsequent stabilization during follow-up is shown in Fig. 2.

Table 3
Radiographic outcomes and complications at minimum 5-year follow-up after 1:4 matched analysis

Parameter	Age > 60 years (n = 76)	Age ≤ 60 years (n = 304)	Risk Difference [95% CI]	p-value
Development of bone trabeculae (hips) (%)	54 (71.1%)	225 (74.0%)	−0.030 [− 0.153, 0.094]	0.6379
- Zone 1	63 (82.9%)	235 (77.3%)		0.3164
- Zone 2	14 (18.4%)	52 (17.1%)	0.056 [− 0.054, 0.166]	0.8081
- Zone 3	6 (7.9%)	46 (15.1%)	0.013 [− 0.093, 0.120]	0.0832
- Zone 4	4 (5.3%)	21 (6.9%)		0.6140
- Zone 5	74 (97.4%)	297 (97.7%)	−0.072 [− 0.154, 0.010]	0.8779
- Zone 6	71 (93.4%)	262 (86.2%)	−0.016 [− 0.081, 0.048]	0.0823
- Zone 7			−0.003 [− 0.045, 0.039]	
			0.072 [− 0.009, 0.154]	
Stress shielding of femur (hips) (%)	68 (89.5%)	257 (84.5%)		0.7274
- Grade 1	5 (6.6%)	30 (9.9%)		
- Grade 2				
Subsidence (> 3 mm) (hips) (%)	2 (2.6%)	1 (0.3%)	0.023 [− 0.014, 0.060]	0.2198
Complications (hips) (%)	9 (11.8%)	9 (3%)	**0.089** [0.012, 0.166]	**0.0236**
- Intraoperative fracture	2 (2.6%)	3 (1%)	0.016 [− 0.022, 0.054]	0.3948
- Dislocation	0 (0%)	0 (0%)	-	-
- Infection	2 (2.6%)	4 (1.3%)	-	0.5342
- Revision			0.013 [− 0.028, 0.055]	

CI, confidence interval. Risk difference represents the difference in proportions between the two groups (Age > 60 years minus Age ≤ 60 years).

P-values < 0.05 were considered statistically significant. Statistically significant values (p < 0.05) are shown in bold.

Regarding complications, intraoperative femoral fracture occurred more frequently in the older group than in the younger group (11.8% vs. 3.0%; risk difference 0.089, 95% CI 0.012–0.166; p = 0.023). Postoperative dislocation (2.6% vs. 1.0%; p = 0.39) and revision surgery (2.6% vs. 1.3%; p = 0.53) were

uncommon and did not differ significantly between groups. No periprosthetic joint infection occurred in either group during follow-up (Table 3).

Implant survivorship was high and comparable between age groups. Survival free from revision for any reason at both 60 and 120 months was 97.37% (95% CI 89.89–99.34) in the older group and 98.68% (95% CI 96.52–99.5) in the younger groups (log-rank p = 0.41). Survival free from aseptic loosening remained excellent in both groups, reaching 100% in the older group and 99.67% (95% CI, 97.68–99.95) in the younger group (log-rank p = 0.62). No aseptic loosening–related revisions occurred in the older group during follow-up (Fig. 3).

A total of six revision procedures occurred during the study period, including two patients in the older group and four patients in the younger group. In the older group one 62-year-old female underwent revision at 3 months due to femoral stem subsidence related to an undersized stem, which was treated with revision to a conventional femoral stem. Another 67-year-old male required acetabular component revision for recurrent dislocation at 12 months after the index surgery.

In the younger group, two revisions were performed for dislocation, including a 59-year-old male who underwent femoral head exchange at 7 months and a 51-year-old female who underwent femoral head exchange at 8 months after the primary procedure. One 56-year-old male sustained a periprosthetic femoral fracture requiring revision of the femoral stem at 50 months postoperatively. In addition, one 23-year-old female developed aseptic loosening of the acetabular component and underwent revision acetabular reconstruction using a Burch–Schneider cage at 58 months following the index surgery.

Discussion

The principal finding of this propensity score–matched study is that cementless short-stem THA demonstrated comparable mid-term clinical outcomes, radiographic fixation, and implant survivorship in patients aged over 60 years and 60 years and under. Despite a higher baseline comorbidity burden among older patients, functional recovery, radiographic fixation patterns, and survivorship at a minimum five-year follow-up were similar between age groups. These findings indicate that chronological age does not negatively affect mid-term implant outcomes if patients are properly selected for good femoral bone quality and proximal femoral morphology.

Clinical outcomes were favorable and comparable between age groups, with high patient-reported outcome scores and satisfaction. These findings are consistent with previous reports demonstrating satisfactory functional recovery following metaphyseal-anchoring short-stem THA in elderly populations across various designs [13, 18–21], as well as with studies specifically evaluating the Metha® short stem in comparable age groups [21]. Collectively, the available evidence supports the concept that postoperative functional recovery after short-stem THA is primarily determined by restoration of hip biomechanics and stable metaphyseal fixation rather than chronological age per se. The consistently high Forgotten Joint Scores observed across age strata further suggest low joint awareness and

satisfactory functional integration of the prosthetic hip, in keeping with prior patient-centered outcome data following Metha® short-stem THA [8].

Radiographically, the present cohort demonstrated reliable osseointegration and favorable mid-term remodeling, supporting durable metaphyseal fixation. Comparable fixation patterns with low rates of radiolucent lines and absence of progressive loosening have been reported for calcar-guided and metaphyseal-anchoring short stems in both younger and elderly cohorts [21, 23]. DXA-based analyses of the Metha® stem have shown region-specific periprosthetic bone remodeling with relative preservation of metaphyseal bone stock and limited proximal stress shielding, consistent with adaptive load transfer rather than mechanical compromise [22, 24]. Systematic reviews further indicate that periprosthetic remodeling after short-stem THA is broadly comparable to that observed with conventional stems, with design-dependent differences in proximal bone preservation [25]. Across different short-stem designs, remodeling patterns appear broadly comparable between age groups when adequate metaphyseal anchorage and bone quality are ensured, whereas compromised femoral morphology has been associated with less favorable remodeling and increased mechanical risk [13, 26]. These observations reinforce the importance of implanting short stems within the intended metaphyseal envelope.

Although overall complication rates after cementless short-stem THA are generally low, intraoperative femoral fracture remains the most clinically relevant adverse event, particularly in older patients. Large series and registry-based analyses identify increasing age and unfavorable proximal femoral morphology as risk factors for periprosthetic fracture after cementless THA, with stem design and fixation philosophy acting as important modifiers [27]. Surgical approach and broaching technique further influence fracture risk during stem insertion, particularly with tapered cementless designs [28, 29]. Contemporary observational data suggest that intraoperative fracture rates with short stems are generally low when metaphyseal anchorage is achieved and appropriate indications are applied [30]. In elderly cohorts, intraoperative fracture rates are not uniformly higher than in younger patients when metaphyseal anchorage is achieved; however, postoperative periprosthetic fractures are more frequent in patients with compromised bone quality, particularly in Dorr type C femora [13, 18, 21]. These findings underscore the importance of stringent preoperative assessment of femoral morphology and bone quality, meticulous broaching technique, and avoidance of short-stem implantation in severely compromised femora to mitigate fracture-related complications. While older patients experienced intraoperative femoral fractures more often, implant durability remained unaffected. Our recent study also found that promptly recognizing and treating intraoperative femoral fractures did not lead to worse outcomes or higher revision rates within a two-year follow-up period [31].

In the present propensity score–matched cohort, Kaplan–Meier analyses demonstrated no material between-group differences in survival free from revision for any reason and no increase in aseptic loosening in older patients at mid-term follow-up, indicating comparable implant durability across age strata when appropriate selection criteria are applied. These findings are concordant with matched comparative studies and registry-based analyses reporting comparable mid-term revision risk between short and conventional cementless stems [32, 33], as well as with prospective multicenter series

demonstrating high mid-term survivorship of calcar-guided short stems [34]. Longer-term series and systematic reviews further support the durability of modern metaphyseal-anchoring designs, with high long-term survivorship and low rates of aseptic loosening reported across designs and indications [7, 35, 36]. Together, these data provide external validity for the survivorship outcomes observed in the present matched cohort.

From a clinical standpoint, the present findings suggest that chronological age alone should not be considered a contraindication to cementless short-stem THA. Patient selection should prioritize femoral morphology, bone quality, and meticulous surgical technique. In appropriately selected older patients, short-stem designs represent a reasonable bone-preserving option that can achieve durable fixation and patient-perceived benefit comparable to younger cohorts at mid-term follow-up. However, these findings should not be extrapolated to patients with severely compromised femoral bone stock, in whom conventional or cemented fixation strategies may remain more appropriate.

Several limitations warrant consideration. The retrospective design introduces potential residual confounding despite the use of propensity score matching. The single-center setting and use of a single implant design may limit generalizability to other institutions or stem geometries. Although mid-term follow-up is clinically informative, longer-term surveillance is required to confirm durability, particularly with respect to late aseptic loosening and periprosthetic fracture. Finally, radiographic assessments were based on plain radiographs rather than quantitative imaging modalities, which may limit sensitivity for detecting subtle periprosthetic bone remodeling.

Conclusion

Cementless short-stem THA provided excellent mid-term functional recovery and radiographic fixation, with high patient satisfaction and comparable survivorship across age groups; although intraoperative femoral fractures were more frequent in older patients, this did not compromise implant durability, supporting the view that chronological age alone should not preclude the use of metaphyseal-anchoring short stems when bone quality and femoral morphology are appropriate.

Declarations

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Author Contribution

Y.S. conceived and designed the study. S.A., P.C., and J.S. collected the data. T.T. performed the statistical analysis, interpreted the data, and drafted the manuscript. R.S. critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Figures

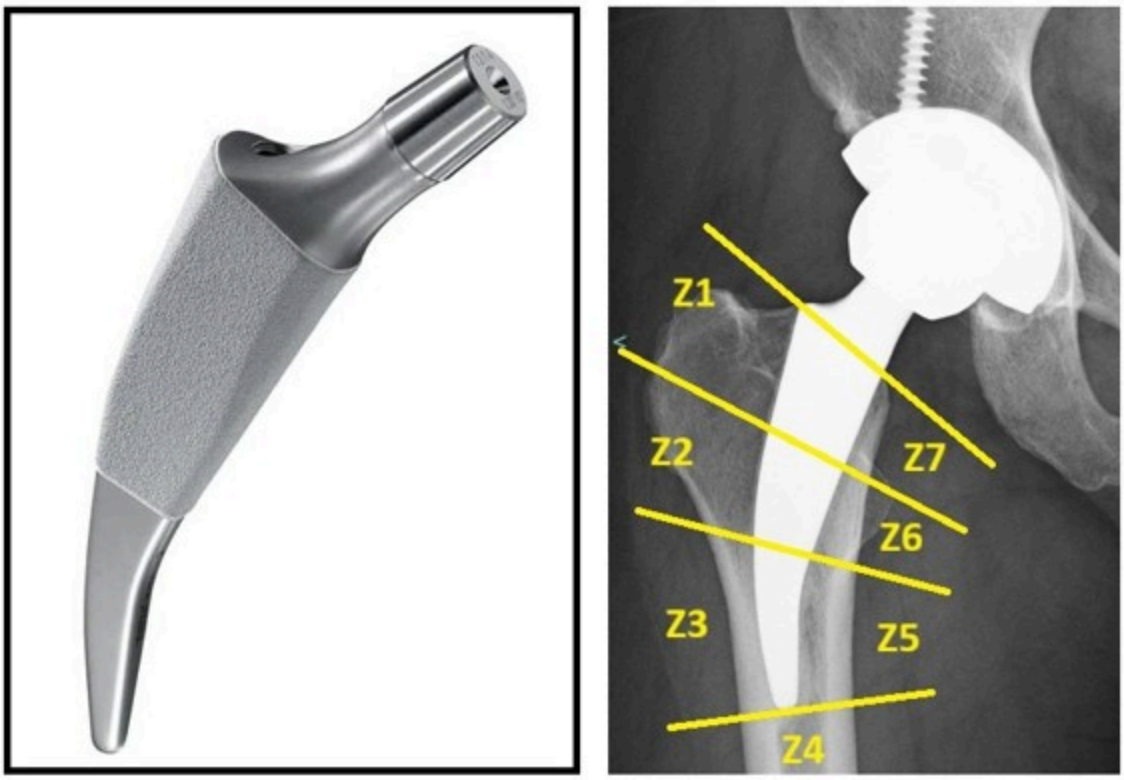


Figure 1

Metha® short femoral stem and modified Gruen zones used for radiographic evaluation.

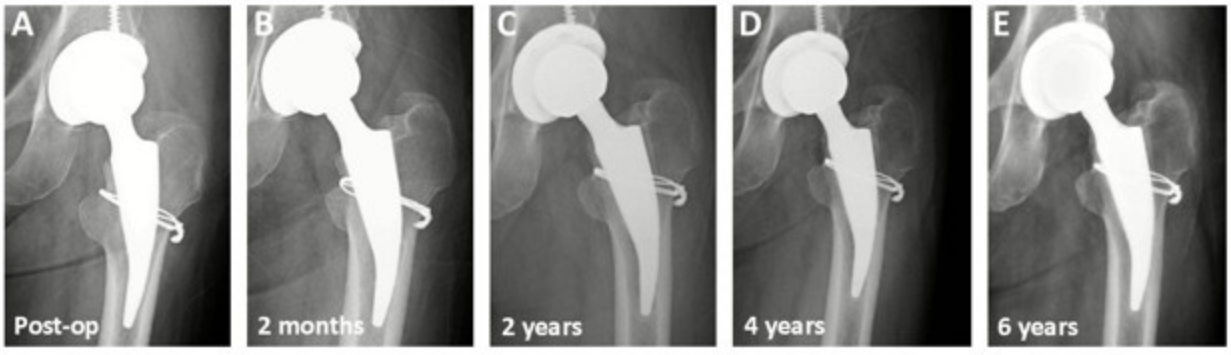


Figure 2

Radiographic example of femoral stem subsidence and subsequent stabilization in a patient aged >60 years after cementless short-stem total hip arthroplasty.
(A) Immediate postoperative radiograph.
(B) Two-month follow-up showing approximately 5 mm of stem subsidence.
(C–E) Follow-up radiographs at 2, 4, and 6 years demonstrating no further migration.

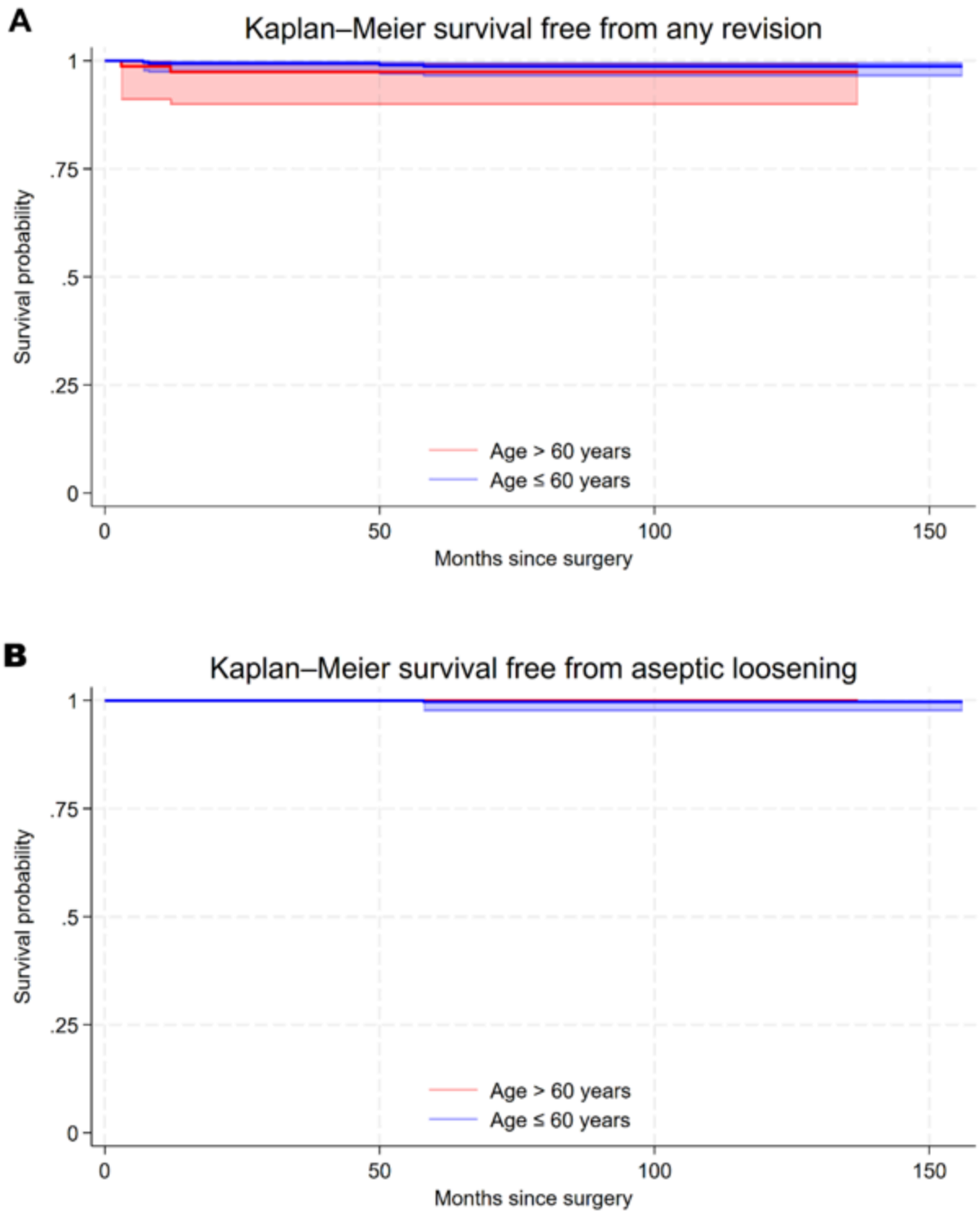


Figure 3

Kaplan–Meier survival curves comparing patients aged > 60 years and ≤ 60 years. (Matched)
(A) Survival free from any revision. At 60 and 120 months, implant survival was 97.37 % (95 % CI, 89.89–99.34) for patients aged > 60 years and 98.68 % (95 % CI, 96.52–99.50) for those aged ≤ 60 years (*log-rank p = 0.41*).
(B) Survival free from revision due to aseptic loosening. The corresponding survival rates were 100 % and 99.67 % (95 % CI, 97.68–99.95) at both 60 and 120 months (*log-rank p = 0.62*).
Shaded areas indicate 95 % confidence intervals.