Increased Body Mass Index but Not Stem Canal Fill is Associated with Stem Subsidence >5 mm of Modular Fluted Tapered Stems in Aseptic Revision Total Hip Arthroplasty

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INTRODUCTION: The modular fluted tapered (MFT) stem has become the workhorse in aseptic revision total hip arthroplasty (rTHA). While aseptic loosening remains a leading cause of rTHA failure, risk factors of stem subsidence in the revision setting are lacking. The aim of this study was to report the occurrence of stem subsidence in a large cohort of aseptic rTHAs utilizing MFT stems and to determine factors associated with stem subsidence >5 mm.

METHODS: A retrospective cohort study of 256 patients who underwent aseptic rTHA with one of two MFT stem designs between June 1, 2015 and March 31, 2024 was performed (Figure 1). Patients with retained MFT stems or who underwent revision of a Girdlestone at the time of aseptic rTHA were excluded. Patient demographics, operative details, and clinical information were collected via a validated, prospective data collection system at our institution. Radiographic outcomes included stem subsidence, cortical bone index (CBI), modular body canal fill, and femoral stem canal fill and were collected by analyzing anteroposterior radiographs of the hip. Outcomes were not captured for patients that required reoperation or re-revision of the hip with the stem of interest. Stem subsidence was calculated as the difference between measurements obtained from the latest available radiograph and the immediate postoperative radiograph at the time of aseptic rTHA. Measurements at three locations that related the femoral construct to bony landmarks on the femur were collected and then averaged to obtain stem subsidence. Subsidence >5 mm was considered clinically significant. The CBI, modular body canal fill, and femoral stem canal fill were collected by analyzing radiographs obtained immediately after aseptic rTHA. The CBI was calculated as the inner medullary canal dimension divided by the width of the femur measured at 100 mm distal to the lesser trochanter. Modular body canal fill was calculated as the modular body width divided by the modular body width plus the medial and lateral gaps between the modular body and inner canal cortex measured at 10 mm proximal to the modular junction. Stem canal fill was calculated similarly to modular body canal fill; however, stem width was used for all measurements, and measurements at 50, 100, and 150 mm distal to the modular junction were collected. Continuous variables were presented as means ± standard deviations (SD) or medians with interquartile ranges (IQR). Categorical variables were presented as counts with percentages. Student's *t*-tests, Wilcoxon-rank sum, *Chi*-square, or Fisher's Exact tests were used to assess differences between patients with and without stem subsidence >5 mm. A multivariable logistic regression modeled factors associated with stem subsidence >5 mm. An alpha value of 0.05 was considered statistically significant. The mean radiographic follow-up was 2.9 ± 2.5 years. Data analysis was performed using the SAS Software (Version 9.4, Cary, North Carolina).

RESULTS: Among the 256 patients who underwent aseptic rTHA with MFT stems, the mean stem subsidence was 3.2 ± 3.4 mm [range, 0.17 – 37.2]. A total of 42 patients (16.4%) experienced stem subsidence >5 mm. No patient required re-revision of the MFT stem for aseptic loosening. Patients who experienced stem subsidence of >5 mm differed significantly from those who did not in several ways (Table 1). The proportion of patients with uncemented or cemented stems, osteosynthesis, or hip resurfacings differed between cohorts (P=0.046). A larger proportion of patients who experienced subsidence had overall construct lengths of 230 to 335 mm (69 vs. 47.1%, P=0.01). Patients with stem subsidence also had lower mean stem canal fill at 50 mm (0.826 vs. 0.860, P=0.04) and 100 mm (0.785 vs. 0.818, P=0.02) distal to the modular junction (Table 2). In a multivariable analysis, body mass index (BMI) was associated with stem subsidence >5 mm, such that for every 1 kg/m^2 increase in BMI, the odds of subsidence >5 mm increased by 5.5% (95% CI: 1.004 – 1.11, P=0.03), after controlling for patient sex and stem canal fill at 50 and 100 mm distal to the modular junction (Table 3).

DISCUSSION AND CONCLUSION: To the best of our knowledge, this is the largest study to evaluate stem subsidence of MFT stems in aseptic rTHA. The results suggest that a mean femoral stem canal fill of 76% across the stem's length is adequate for overall construct stability. In this study, neither patient sex nor femoral stem canal fill was associated with clinically significant stem subsidence. However, an increased BMI was associated with an increased odds of stem subsidence >5 mm. More cautious weight-bearing protocols after aseptic rTHA with an MFT stem may be warranted in patients with elevated BMIs.

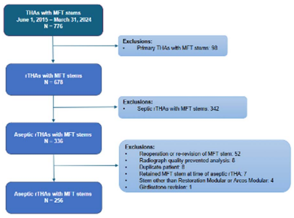
THAs with MFT stems
June 1, 2015 – March 31, 2024
N = 776
Exclusions:
• Primary THAs with MFT stems: 98
rTHAs with MFT stems
N = 678
Exclusions:
• Septic rTHAs with MFT stems: 342
Aseptic rTHAs with MFT stems
N = 336
Exclusions:
• Reoperation or re-revision of MFT stem: 52
• Radiograph quality prevented analysis: 8
• Duplicate patient: 8
• Retained MFT stem at time of aseptic rTHA: 7
• Stem other than Restoration Modular or Arcos Modular: 4
• Girdlestone revision: 1
Aseptic rTHAs with MFT stems
N = 256

Table 1: Patient demographics, operative details, and clinical data

Characteristic	No Subsidence >5mm	Number	Subsidence >5mm	Number	*P*-value
Age (years), mean ±SD [range]	69.6 ± 11.1 [34 – 95]	214	70.4 ± 10.5 [38 – 86]	42	0.671
Sex, N (%)		214		42	0.992
Women	117 (54.7)		23 (54.8)		
Men	97 (45.3)		19 (45.2)		
Body mass index (kg/m²), median (IQR)	28.8 (24.4; 32.3)	214	30.6 (26.6; 33.7)	42	0.069^
Race, N (%)		214		42	0.141
White	180 (84.1)		39 (92.9)		
Non-white/other/declined/unavailable	34 (15.9)		3 (7.1)		
Smoking status, N (%)		214		42	0.060*
Never	105 (49.1)		12 (28.6)		
Quit >6 months	86 (40.2)		24 (57.1)		
Quit <6 months	4 (1.9)		0 (0)		
Current	19 (8.9)		6 (14.3)		
Charlson Comorbidity Index, N (%)		209		42	0.188
0	108 (51.7)		16 (38.1)		
1	36 (17.2)		13 (31)		
2	23 (11)		4 (9.5)		
3+	42 (20.1)		9 (21.4)		
Insurance, N (%)		186		34	0.797
Medicare/Medicaid	144 (77.4)		27 (79.4)		
Commercial/self/work's comp/other	42 (22.6)		7 (20.6)		
Type of implant revised at rTHA		214		42	**0.046**
Uncemented stem	181 (84.6)		29 (69.1)		
Cemented stem	23 (10.8)		8 (19.1)		
Osteosynthesis/hip resurfacing	10 (4.7)		5 (11.9)		
Indication for rTHA, N (%)		214		42	0.396
Aseptic Loosening	99 (46.3)		15 (35.7)		
Periprosthetic fracture	80 (37.4)		17 (40.5)		
Catastrophic trunnion failure/metallosis	17 (7.9)		5 (11.9)		
Posttraumatic arthritis	6 (2.8)		4 (9.5)		
Instability	4 (1.9)		1 (2.4)		
Femoral stem fracture	4 (1.9)		0 (0)		
Leg length discrepancy	3 (1.4)		0 (0)		
Component malposition	1 (0.47)		0 (0)		
Operative limb, N (%)		214		42	0.550
Right	127 (59.4)		27 (64.3)		
Left	87 (40.7)		15 (35.7)		
Operative approach, N (%)		214		42	0.477*
Posterolateral	166 (77.6)		29 (69.1)		
Direct lateral	30 (14)		9 (21.4)		
Anterolateral	10 (4.7)		3 (7.1)		
Direct anterior	8 (3.7)		1 (2.4)		
Paprosky classification, N (%)		214		42	0.280*
Type I	4 (1.9)		0 (0)		
Type II	84 (39.3)		11 (26.2)		
Type III	114 (53.3)		27 (64.3)		
Type IV	12 (5.6)		4 (9.5)		
Femoral stem design		214		42	0.157
Restoration Modular	128 (59.8)		30 (71.4)		
Arcos Modular	86 (40.2)		12 (28.6)		
Femoral stem length (mm), N (%)					
Restoration Modular		128		30	**0.036**
115	0 (0)		1 (3.3)		
155	91 (71.1)		15 (50)		
195	32 (25)		13 (43.3)		
235	5 (3.9)		1 (3.3)		
Arcos Modular		85		12	0.598*
150	70 (82.4)		9 (75)		
190	12 (14.1)		3 (25)		
250	3 (3.5)		0 (0)		
Proximal body length (mm), N (%)					
Restoration Modular		128		30	0.335*
70	64 (50)		11 (36.7)		
80	51 (39.8)		14 (46.7)		
90	8 (6.3)		2 (6.7)		
100	5 (3.9)		3 (10)		
Arcos Modular		81		12	0.529*
50	18 (22.2)		2 (16.7)		
60	39 (48.2)		7 (58.3)		
70	22 (27.2)		2 (16.7)		
80	2 (2.5)		1 (8.3)		
Overall construct length (mm), N (%)		208		42	**0.010**
195 – 225	110 (52.9)		13 (31)		
230 - 335	98 (47.1)		29 (69)		
Femoral head polarity, N (%)		214		42	0.426
Unipolar	161 (75.2)		34 (81)		
Bipolar	53 (24.8)		8 (19)		
Femoral head size, N (%)		214		42	0.788
≥ 36 mm	122 (57)		23 (54.8)		
< 36 mm	92 (43)		19 (45.2)		
Trochanteric osteotomy, N (%)		214		42	0.563*
No	195 (91.1)		37 (88.1)		
Yes	19 (8.9)		5 (11.9)		
Structural bone graft, N (%)		214		42	0.477*
No	200 (93.3)		41 (97.6)		
Yes	14 (6.5)		1 (2.4)		
Length of stay (days), median (IQR)	3 (2;5)	214	4 (2;5)	42	0.082^
Discharge disposition, N (%)		214		42	0.263
Home/home health	117 (54.7)		19 (45.2)		
Other	97 (45.3)		23 (54.8)		
Readmission within 90 days of rTHA		214		42	1.0*
No	200 (93.5)		39 (92.9)		
Yes	14 (6.5)		3 (7.1)		
Mortality over follow-up period, N (%)		214		42	0.593*
No	191 (89.3)		36 (85.7)		
Yes	23 (10.8)		6 (14.3)		

^Wilcoxon-rank sum test
*Fisher's Exact test

Table 2: Radiographic outcomes

Radiographic Outcome	No Subsidence >5mm	Number	Subsidence >5mm	Number	*P*-value
Preoperative cortical bone index, mean ± SD [range]	0.571 ± 0.103 [0.332 – 0.959]	213	0.569 ± 0.095 [0.430 – 0.765]	42	0.925
Body canal fill, mean ± SD [range]	0.900 ± 0.050 [0.713 – 1.0]	212	0.894 ± 0.083 [0.635 – 1.0]	42	0.638
Stem canal fill, mean ± SD [range]					
50 mm distal to the junction	0.860 ± 0.077 [0.614 – 1.0]	213	0.826 ± 0.098 [0.598 – 1.0]	42	**0.038**
100 mm distal to the junction	0.818 ± 0.080 [0.546 – 0.975]	213	0.785 ± 0.096 [0.568 – 0.967]	42	**0.018**
150 mm distal to the junction	0.692 ± 0.119 [0.392 – 1.0]	212	0.674 ± 0.142 [0.419 – 0.893]	41	0.390
All locations	0.787 ± 0.074 [0.518 – 0.948]	213	0.761 ± 0.094 [0.552 – 0.937]	42	0.106

Table 3: Factors associated with the odds of stem subsidence >5 mm

Factor	Number of Patients	Number with Subsidence >5mm	Odds Ratio	95% CI	*P*-value
Sex					
Male	116	19	1.095	0.55 - 2.19	0.798
Female	140	23	Ref.		
Body mass index, per 1 kg/m² increase	256	42	1.055	1.004 - 1.11	**0.032**
Stem canal fill at 50 mm distal to the junction	255	42	0.030	0.00 - 5.22	0.182
Stem canal fill at 100 mm distal to the junction	255	42	0.080	0.00 - 13.46	0.334