Distal Femoral Replacement for Oncologic Versus Non-Oncologic Indications: Comparative Outcomes and Predictors of Failure

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Significance & Hypothesis: Distal femoral replacement (DFR) is a limb-salvage option originally developed for oncologic resection but increasingly applied to complex non-oncologic reconstruction. Whether outcomes and failure modes differ between these populations—and which preoperative factors drive failure—remains incompletely characterized. We hypothesized that non-oncologic DFR recipients, despite absent tumor burden, would experience equivalent or worse implant survival due to a higher cumulative burden of prior surgery, retained hardware, and prior infection.

Innovation: This is among the largest single-institution comparisons of oncologic versus non-oncologic DFR and the first to our knowledge to isolate the independent effect of surgical indication from prior surgical burden using multivariable survival modeling.

Approach (Materials & Methods): We performed a retrospective cohort study of 321 consecutive DFRs (204 oncologic, 117 non-oncologic) performed at a single tertiary center. Baseline demographics, comorbidities, prior surgical history, operative characteristics, and Henderson modes of failure (I–V) were extracted from the electronic health record. Groups were compared using Mann–Whitney U, χ^2, or Fisher exact tests. Revision-free, amputation-free, and overall survival were estimated with Kaplan–Meier curves and compared using the log-rank test. Univariable and multivariable Cox proportional hazards models were used to identify predictors of all-cause revision.

Results: Median follow-up was 42 months (oncologic) versus 29 months (non-oncologic). Non-oncologic patients were older (65 vs 58 y, $p<0.001$), had higher BMI and ASA scores, and carried a markedly greater burden of prior ipsilateral surgery (90.6% vs 33.3%), prior hardware removal (88.0% vs 29.4%), and prior infection (29.1% vs 2.0%; all $p<0.001$). All-cause revision rates did not differ (34.2% vs 30.4%, $p=0.56$), nor did individual Henderson I–IV failure modes or amputation rates (~6% both groups). Intuitively, tumor progression occurred only in oncologic patients (5.4%, $p=0.009$), and all-cause mortality was also higher in this group (41.2% vs 27.4%, $p=0.018$).

On Kaplan–Meier analysis, oncologic patients had superior 5-year revision-free survival (65.9% vs 51.7%; log-rank $p=0.043$; unadjusted HR 0.66, 95% CI 0.44–0.99). On univariable Cox analysis, any prior surgery (HR 1.98, 1.31–2.99), prior hardware removal (HR 1.78, 1.19–2.66), prior infection (HR 2.00, 1.21–3.30), and secondary-trauma/failed-arthroplasty sub-indication were significant predictors of revision. In a multivariable model including indication, age, prior hardware removal, and prior infection, prior hardware removal remained independently associated with revision (adjusted HR 1.64, 1.00–2.68, $p=0.048$), whereas oncologic indication itself was no longer protective (adjusted HR 1.23, $p=0.49$).

Discussion & Impact: Contrary to the common perception that oncologic DFR carries worse outcomes, non-oncologic DFR patients experienced similar absolute complication rates but inferior revision-free survival, driven not by the absence of tumor but by accumulated surgical trauma and prior hardware. Prior hardware removal emerged as the single independent predictor of revision. These findings argue against framing non-oncologic DFR as a uniformly "safer" use of the implant and support preoperative counseling that weights surgical history as heavily as indication.

Table 1. Baseline demographic, comorbidity, and operative characteristics by indication.

Variable	Oncologic (n=204)	Non-oncologic (n=117)	p-value
Age at surgery, median [IQR], y	58 [44–68]	65 [57–71]	<0.001
Sex, n (%)			<0.001
Female	104 (51.0)	84 (71.8)	
Male	100 (49.0)	33 (28.2)	
BMI, median [IQR], kg/m²	27 [24–32]	31 [26–36]	<0.001
ASA score, median [IQR]	3 [2–3]	3 [3–3]	<0.001
Diabetes, n (%)	24 (11.8)	41 (35.0)	<0.001
Chronic kidney disease, n (%)	11 (5.4)	15 (12.8)	0.033
Current smoker, n (%)	25 (12.3)	7 (6.0)	0.13
Any prior ipsilateral surgery, n (%)	68 (33.3)	106 (90.6)	<0.001
Removal of prior hardware, n (%)	60 (29.4)	103 (88.0)	<0.001
Prior native/implant infection, n (%)	4 (2.0)	34 (29.1)	<0.001
Operative time, median [IQR], min	240 [196–285]	217 [174–268]	0.016
Length of stay, median [IQR], d	4 [3–5]	5 [3–6]	0.013
Median follow-up [IQR], mo	42 [18–91]	29 [5–66]	0.002

Continuous variables are summarized as mean ± standard deviation or median (interquartile range) and compared using Welch's t-test or Mann–Whitney U test, respectively. Categorical variables are summarized as counts (percentages) and compared using Fisher exact test. ASA, American Society of Anesthesiologists; BMI, body mass index; F/U, follow-up; IQR, interquartile range; SD, standard deviation.

Table 2. Major complications, Henderson modes of failure, and survival outcomes by indication.

Outcome	Oncologic (n=204)	Non-oncologic (n=117)	Effect (95% CI)	p
All-cause revision, n (%)	62 (30.4)	40 (34.2)	OR 0.84 (0.52–1.36)	0.56
Revision-free survival (KM)				0.043
2-year	78.5%	70.6%	HR 0.66 (0.44–0.99)	
5-year	65.9%	51.7%		
Henderson I — Soft tissue failure, n (%)	10 (4.9)	5 (4.3)	OR 1.15 (0.38–3.46)	1.00
Henderson II — Aseptic loosening, n (%)	13 (6.4)	10 (8.5)	OR 0.73 (0.31–1.72)	0.62
Henderson III — Structural failure, n (%)	23 (11.3)	18 (15.4)	OR 0.70 (0.36–1.36)	0.37
Henderson IV — Deep infection, n (%)	19 (9.3)	18 (15.4)	OR 0.56 (0.28–1.13)	0.14
Henderson V — Tumor progression, n (%)	11 (5.4)	0 (0.0)	—	0.009
Amputation, n (%)	12 (5.9)	7 (6.0)	OR 0.98 (0.38–2.57)	1.00
Implant retention at last f/u, n (%)	168 (82.4)	97 (82.9)	OR 0.96 (0.53–1.76)	1.00
Mortality, n (%)	84 (41.2)	32 (27.4)	OR 1.86 (1.14–3.04)	0.018

HR = hazard ratio (Cox proportional hazards); OR = odds ratio; KM = Kaplan–Meier; CI = confidence interval. Henderson classification per Henderson et al. JBJS Am 2011. Comparisons by Fisher exact test (categorical) or Mann–Whitney U (continuous) unless otherwise indicated. Survival comparisons by log-rank test.

Table 3. Univariable and multivariable Cox proportional hazards models for all-cause revision surgery.

Covariate	Univariable HR (95% CI)	p	Multivariable aHR (95% CI)	p
Oncologic indication (vs non-oncologic)	0.66 (0.44–0.99)	0.043	1.23 (0.69–2.21)	0.49
Age at surgery (per year)	1.01 (1.00–1.02)	0.063	1.01 (0.99–1.02)	0.26
Removal of prior hardware (yes vs no)	1.78 (1.19–2.66)	0.005	1.64 (1.00–2.67)	0.048
Prior native/implant infection (yes vs no)	2.00 (1.21–3.30)	0.007	1.64 (0.90–2.98)	0.10
Any prior ipsilateral surgery (yes vs no)	1.98 (1.31–2.99)	0.001	—	—
BMI (per kg/m²)	1.03 (1.01–1.05)	0.015	—	—
ASA score (per point)	1.46 (1.03–2.06)	0.033	—	—

Multivariable model (n=321, 102 revision events) included oncologic indication, age, removal of prior hardware, and prior infection as pre-specified covariates. Any prior surgery, BMI, and ASA score were assessed univariably but excluded from the adjusted model due to collinearity with prior hardware removal. aHR = adjusted hazard ratio.