

Anatomical Characterization of Long Bone Femur and Tibial Fractures and Associated Two-Year Risks of Non-Union – A US Database Analysis

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OBJECTIVES

- There is significant heterogeneity in the clinical presentation of patients with long-bone trauma.
- Our objective was to provide a detailed characterization of non-union risk for each fracture type.

METHODS

Study Design: Retrospective cohort analyses

Data Source: IBM® MarketScan® Commercial Claims and Encounters database

Study Population: All Patients with femur or tibia fractures treated in the inpatient setting and requiring surgical fracture repair, from Q4 2015 to Dec 31, 2021.

- **Index:** Defined as date of surgical intervention for fracture repair.

- **Exclusion criteria:** polytrauma, revision of prior trauma, continuous enrollment < 30 days and long-bone fracture site amputation at time of index surgery.

Study Duration: 2 years from index.

Outcomes: Non-union at 2 years post-index

Variables: Patient demographic and comorbid factors, fracture severity, soft tissue damage and location (for femoral fractures: neck, trochanter, shaft and condylar – for tibial fractures: condylar, other proximal (including physeal and Salter Harris), shaft, pilon and malleolus, other distal).

Statistical Analysis: Crude and adjusted rates of non-union at 1- and 2-years using Poisson regressions with log link; Risk ratio analysis for key variables; Kaplan Meier analysis for time to non-union.

RESULTS

- 26,274 Patients were identified, as shown in Table 1

Table 1: Clinical and demographic characteristics of patients with femoral and tibial fractures, by fracture anatomy.

Femoral Fractures	Trochanteric	Neck	Shaft	Condylar	Other Unspecified	Multiple
N	1,252	2,665	2,664	547	987	4,655
Gender: Male (vs Female)	598 (47.8%)	1,047 (39.3%)	1,745 (65.5%)	240 (43.9%)	477 (48.3%)	2,328 (50.0%)
Age (Mean (SD))	52.70 (13.66)	51.87 (13.86)	27.45 (19.25)	45.46 (18.02)	43.47 (20.07)	47.02 (17.93)
Elixhauser Index (Mean (SD))	1.96 (2.20)	2.00 (2.52)	0.70 (1.39)	1.59 (2.07)	2.14 (2.29)	1.69 (2.23)
Clinical Presentation						
Displaced Fracture	1,185 (94.6%)	949 (35.6%)	2,362 (88.7%)	518 (94.7%)	62 (6.3%)	4,455 (95.7%)
Comminuted Fracture	0 (0.0%)	0 (0.0%)	1,262 (47.4%)	0 (0.0%)	0 (0.0%)	1,037 (22.3%)
Fracture Gustilo Classification						
Closed	1,192 (95.2%)	2,550 (95.7%)	2,263 (84.9%)	413 (75.5%)	554 (56.1%)	4,116 (88.4%)
Open Type I or II	52 (4.2%)	99 (3.7%)	277 (10.4%)	97 (17.7%)	123 (12.5%)	386 (8.3%)
Open Type III	8 (0.6%)	16 (0.6%)	124 (4.7%)	37 (6.8%)	13 (1.3%)	153 (3.3%)
Unknown	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	297 (30.1%)	0 (0.0%)

Tibial Fractures	Condylar	Other Proximal	Shaft	Pilon and Malleolus	Other Distal	Other Unspecified	Multiple
N	1,258	146	1,692	2,832	299	162	7,115
Gender: Male (vs Female)	581 (46.2%)	107 (73.3%)	1,119 (66.1%)	1,100 (38.8%)	177 (59.2%)	98 (60.5%)	3,844 (54.0%)
Age (Mean (SD))	47.31 (13.20)	30.49 (20.18)	33.64 (16.48)	45.16 (14.70)	36.13 (18.91)	31.68 (20.96)	42.91 (15.49)
Elixhauser Index (Mean (SD))	1.15 (1.56)	1.10 (1.73)	0.65 (1.20)	1.25 (1.79)	1.02 (1.52)	1.42 (2.13)	1.01 (1.58)
Clinical Presentation							
Displaced Fracture	1,247 (99.1%)	51 (34.9%)	1,349 (79.7%)	2,809 (99.2%)	5 (1.7%)	77 (47.5%)	6,516 (91.6%)
Comminuted Fracture	0 (0.0%)	0 (0.0%)	812 (48.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2,697 (37.9%)
Fracture Gustilo Classification							
Closed	1,128 (89.7%)	119 (81.5%)	1,112 (65.7%)	2,163 (76.4%)	220 (73.6%)	89 (54.9%)	5,026 (70.6%)
Open Type I or II	112 (8.9%)	14 (9.6%)	377 (22.3%)	443 (15.6%)	49 (16.4%)	8 (4.9%)	1,265 (17.8%)
Open Type III	18 (1.4%)	13 (8.9%)	203 (12.0%)	226 (8.0%)	30 (10.0%)	1 (0.6%)	824 (11.6%)
Unknown	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	64 (39.5%)	0 (0.0%)

- The cumulative hazard over 2 years for non-union following femur and tibial fractures, by fracture anatomy, is shown in Figures 1 and 2. Excluding patients with undefined anatomy, or fractures at multiple sites:

- the cumulative hazard for nonunion following femoral condylar, shaft, trochanteric or neck fractures was 9.8% (7.0%-12.6%), 9.0% (7.8%-10.2%), 6.9% (5.3%-8.5%) and 6.0% (4.9%-7.0%), respectively.
- the cumulative hazard for nonunion following tibial shaft, distal, pilon or malleolus, condyle and proximal fracture was 10.8% (9.2%-12.3%), 8.1% (4.7%-11.4%), 5.2% (4.3%-6.1%), 2.4% (1.5%-3.3%) and 2.2% (0.0%-4.6%), respectively.

- Risks for nonunion were elevated in cases involving shaft fractures, and fractures with significant soft tissue damage (Gustilo III) as seen in Figures 3 and 4. Comorbidities increased risk of nonunion, but to a lesser extent than anatomical location or tissue damage.

Figure 1: Cumulative hazard with confidence intervals of non-union in patients following femoral fracture, by anatomy.

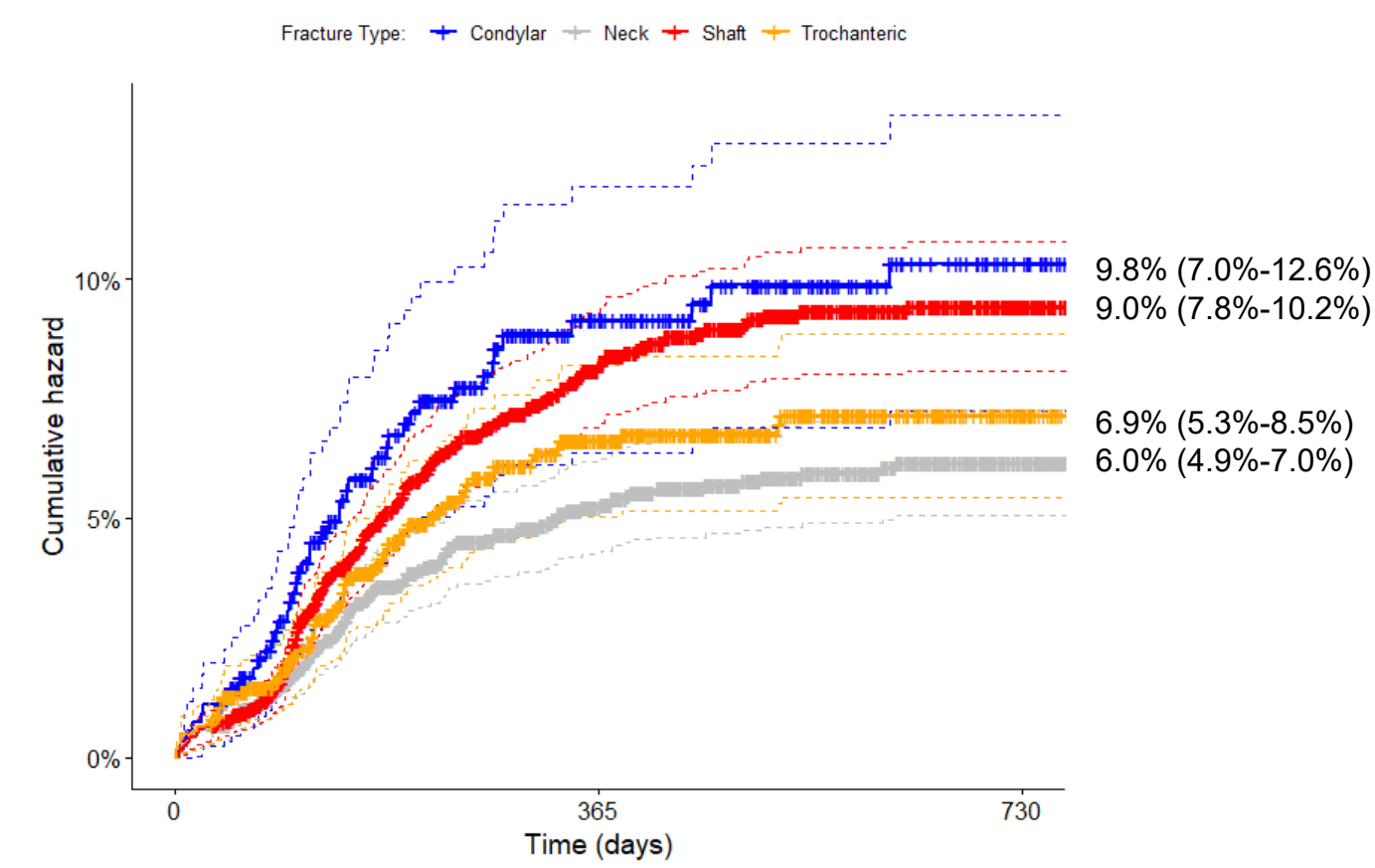


Figure 2: Cumulative hazard with confidence intervals of non-union in patients following tibial fracture, by anatomy.

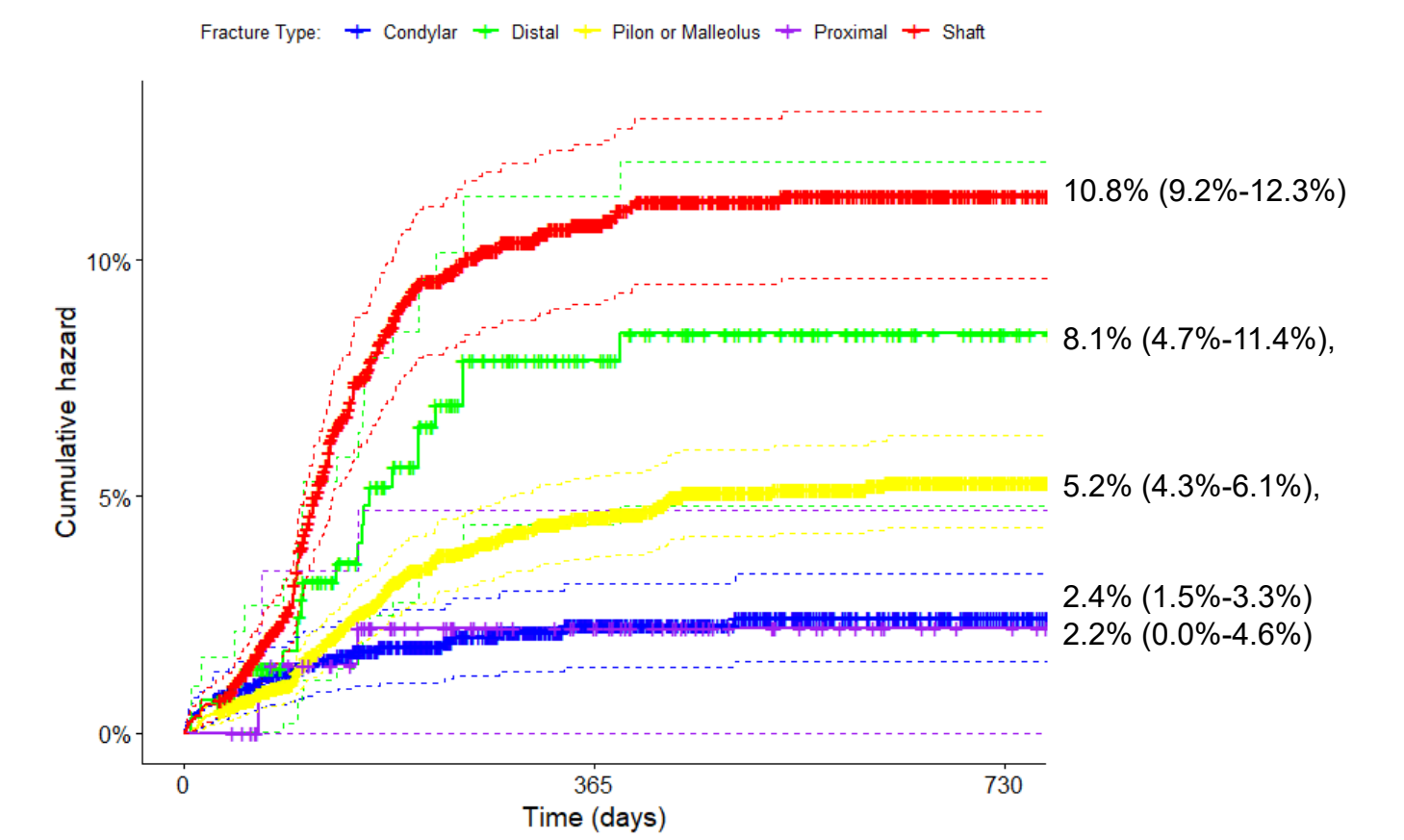


Figure 3: Risk ratios for non-union following femoral fracture.

Variable	Estimate, p value
Age Group	Reference
55 To 64	Reference
Under 19	0.30 (0.22, 0.41) <0.001
19 To 25	0.64 (0.48, 0.84) 0.002
26 To 34	1.13 (0.84, 1.49) 0.398
35 To 44	0.94 (0.72, 1.22) 0.673
45 To 54	1.34 (1.12, 1.59) 0.001
Condylar Fracture	1.81 (1.33, 2.43) <0.001
Shaft Fracture	2.36 (1.81, 3.04) <0.001
Trochanteric Fracture	1.26 (0.95, 1.65) 0.098
Neck Fracture	1.30 (0.98, 1.70) 0.059
Fractures at Multiple Femoral Sites	0.71 (0.51, 0.98) 0.035
Other Femoral Fractures	1.39 (0.90, 2.10) 0.125
Obesity	1.36 (1.08, 1.69) 0.008
Fracture Type	Reference
Closed	Reference
Gustilo I-II	1.34 (1.06, 1.66) 0.011
Gustilo III	1.96 (1.45, 2.58) <0.001
Displaced Fracture	1.31 (1.05, 1.65) 0.018
Elixhauser Comorbidity Index	Reference
0: No Comorbidities	Reference
1 or 2	1.24 (1.05, 1.47) 0.013
3 or 4	1.49 (1.20, 1.84) <0.001
5 or Greater	1.21 (0.92, 1.57) 0.166

Figure 4: Risk ratios for non-union following tibial fracture.

Variable	Estimate, p value
Age Group	Reference
55 To 64	Reference
Under 19	0.49 (0.38, 0.64) <0.001
19 To 25	0.64 (0.50, 0.82) <0.001
26 To 34	0.69 (0.53, 0.88) 0.004
35 To 44	1.07 (0.88, 1.28) 0.503
45 To 54	1.10 (0.93, 1.30) 0.263
Obesity	1.07 (0.85, 1.34) 0.564
Elixhauser Category	Reference
0: No Comorbidities	Reference
1 or 2	1.09 (0.94, 1.26) 0.234
3 or 4	1.25 (0.98, 1.56) 0.062
5 or Greater	1.58 (1.17, 2.10) 0.002
Fracture Type	Reference
Closed	Reference
Gustilo I-II	1.68 (1.43, 1.96) <0.001
Gustilo III	3.33 (2.85, 3.87) <0.001
Comminuted Fractures	1.43 (1.24, 1.65) <0.001
Distal Fractures	1.24 (0.95, 1.61) 0.109
Pilon or Malleolus Fractures	1.10 (0.85, 1.41) 0.470
Proximal Fractures	1.18 (0.95, 1.46) 0.121
Condylar Fracture	0.73 (0.57, 0.94) 0.015
Shaft Fracture	1.95 (1.47, 2.57) <0.001
Multiple Tibial Fracture Locations	0.92 (0.70, 1.22) 0.560
Other Tibial Fractures	2.47 (1.22, 4.51) 0.006

CONCLUSIONS

- The highest risk for nonunion, whether for femoral or tibial fractures, was observed in patients with segmental/comminuted fractures with significant soft tissue damage (Gustilo III fractures). Shaft fractures were also at increased nonunion risk compared to fractures in other anatomical locations.