Hardware Removal Due to Infection after Open Reduction and Internal Fixation: Trends and Predictors

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Introduction

- As operative techniques and implant device designs improve, open reduction with internal fixation (ORIF) is evolving as the preferred method of treatment for many fractures.
- Internal fixation has been shown to maintain reduction, provide stability that predictably allows for bony union, and lead to earlier return to function after injury.
- Hardware removal due to infection is one of the major causes of failure following ORIF.
- The aim of this study was to determine trends and predictors of infection-related hardware removal following ORIF of extremities using a nationally representative database.

Methods

- Data from the Nationwide Inpatient Sample from 2006 to 2017 was analyzed to determine the trend and predicting factors of hardware removal due to infection after ORIF.
- The regressions included interaction terms between calendar year and site of implant/removal so that statistical comparisons could be made between different bones and the femur (used as reference due to its relatively high rate of fracture).
- Trends per 100,000 were calculated for ORIF, infection, hardware removal, and hardware removal due to infection.
- Logistic regression and Wilcoxon Rank-Sum Test were used to control for patient and hospital variables and compare septic and aseptic groups, and to estimate the contribution of patient and hospital factors to the probability that a patient visit was for the removal of hardware.

Results

- Highest rate of hardware removal related to infection: tarsal (6.86%), tibial (4.35%) and carpal (4.17%) fractures.
- Infection related removals increased in all fractures except radial/ulnar fractures.
- Predictors of infection related hardware removal: Tarsal fractures (OR=1.05, 95% CI: 1.03-1.08), tibial fractures (OR=1.04, 95% CI: 1.03-1.06), diabetes mellitus (OR=2.73, 95% CI: 2.36-2.94), liver disease (OR=2.03, 95% CI: 1.74- 2.35), and rheumatoid arthritis (OR=2.05, 95% CI: 1.98-2.28)
- Females were less likely to undergo removal due to infection (OR= 0.59, 95% CI: 0.57-0.64 P<0.001).
- Infection-related hardware removals had significantly higher total charges and length of stay compared to aseptic removals

Figure 1: Hardware Location, Hardware Removal, Infection-Related Removal

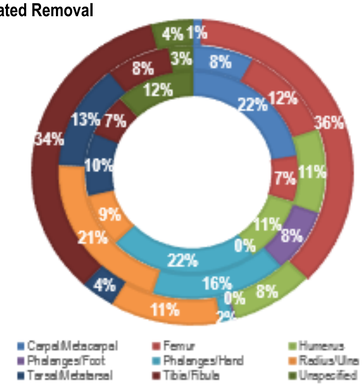


Figure 2: Hardware Removals due to Infection by Fracture Location

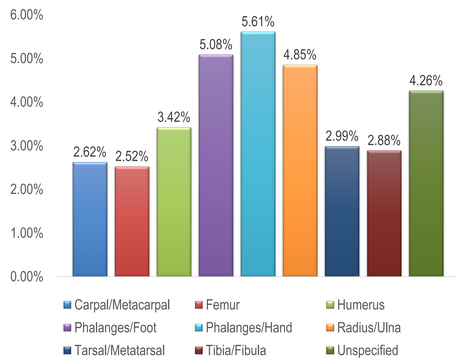


Figure 3: Odds Ratios for Predictive Factors of Infection-Related Hardware Removal

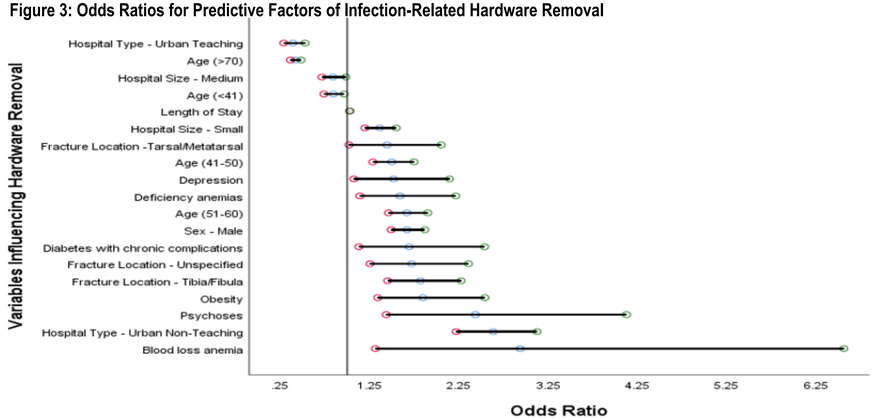
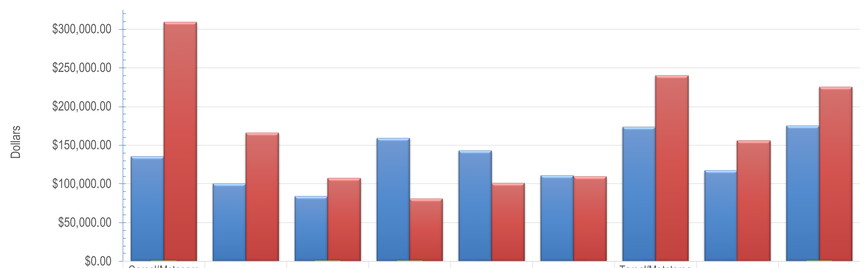


Figure 4: Average Hospital Charge For Septic and Aseptic Hardware Removal



	Carpal/Metacarpal	Femur	Humerus	Phalanges/Foot	Phalanges/Hand	Radius/Ulna	Tarsal/Metatarsal	Tibia/Fibula	Unspecified
Aseptic Hardware Removal	$135,388.91	$100,352.35	$83,823.29	$158,929.34	$142,969.46	$110,644.38	$173,560.04	$117,260.13	$175,065.21
Septic Hardwar Removal	$308,972.50	$165,980.15	$107,457.12	$80,766.33	$100,960.67	$109,363.37	$239,982.57	$155,530.15	$225,357.96
P-Value	0.1258	0.0001	0.4028	0.1176	0.0013	0.0001	0.0001	0.0001	0.4313

Discussion

- Recent studies have found the overall rate of ORIF, hardware removal, and infection-related hardware removal to be decreasing
- Hardware removal is common after ORIF, and is seen in 6%-27% of patients
- Infection is one of the most common complications related to hardware implantation and ORIF
- Higher rates of infection related complications with hardware are more commonly seen in lower extremity fractures, specifically the proximal tibia and ankle

Table 1: Predictors of Infection-Related Hardware Removal

Predictors of Hardware Removal	Odds Ratio	95% CI	P-Value
Blood loss anemia	2.94	1.32 - 6.56	<0.001
Hospital Type - Urban Non-Teaching	2.63	2.22 - 3.12	<.0001
Psychoses	2.43	1.44 - 4.13	<0.001
Obesity	1.85	1.34 - 2.54	<0.001
Fracture Location - Tibia/Fibula	1.82	1.45 - 2.28	<.0001
Fracture Location - Unspecified	1.72	1.25 - 2.36	<0.001
Diabetes with chronic complications	1.69	1.13 - 2.54	<0.05
Sex - Male	1.67	1.49 - 1.87	<.0001
Age (51-60)	1.67	1.46 - 1.9	<.0001
Deficiency anemias	1.59	1.14 - 2.22	<0.01
Depression	1.52	1.07 - 2.15	<0.05
Age (41-50)	1.50	1.29 - 1.75	<.0001
Fracture Location -Tarsal/Metatarsal	1.45	1.02 - 2.05	<0.05
Hospital Size - Small	1.36	1.2 - 1.55	<.0001
Length of Stay	1.03	1.03 - 1.03	<.0001
Age (<41)	0.85	0.74 - 0.97	<0.05
Hospital Size - Medium	0.84	0.72 - 0.98	<0.05
Age (>70)	0.42	0.36 - 0.48	<.0001
Hospital Type - Urban Teaching	0.39	0.29 - 0.53	<.0001

- Risks for infection are higher in patients with complex medical comorbidities, and disorder that can disrupt wound healing
- Diabetes mellitus, liver disease, and rheumatic disease are well documented risk factors for hardware infection
- Female gender has been postulated to be a protective factor for infection, and may be in part due to the effect of testosterone on the immune system
- Our study results are in line with the literature, finding the rate of ORIF procedures, the rate of hardware removal and infection-related hardware removal to have decreased during the study period.

Conclusion

- Hardware removal rates due to infection increased in all fractures except radial/ulnar fractures.
- Diabetes, liver disease, and rheumatoid arthritis were important predictors of infection-related hardware removal.
- Our study identified some risk factors for hardware related infection following ORIF, such as diabetes, liver disease, and rheumatoid arthritis, that should be studied further in an attempt to implement strategies to reduce rate of infection following ORIF.

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