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Risk Factors and Complications in Tibiotalocalcaneal (TTC) Arthrodesis: A Nationwide Database Comparison Between Traumatic Ankle Fracture and Osteoarthritis

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Abstract

Background: Tibiotalocalcaneal (TTC) arthrodesis is an established treatment for osteoarthritis (OA), offering stabilization and earlier weightbearing. However, its role in managing traumatic fractures (TFs) remains controversial because of higher risks of complications. This study aimed to compare complication rates, readmissions, and predictors of adverse outcomes in TTC arthrodesis performed for OA vs TF using a national database.

Methods: A retrospective cohort study was conducted using the Nationwide Readmissions Database (2016–2021). Patients undergoing TTC arthrodesis were identified via *International Classification of Diseases, Tenth Revision* (*ICD-10*) codes and stratified by indication (OA or TF). Primary outcomes included complication rates, 30- and 90-day readmissions, and revision surgeries. Multivariable logistic regression identified independent predictors of complications. Propensity score matching (PSM) was performed to account for baseline differences.

Results: TF cases exhibited significantly higher complication rates (54.5% vs 16.0%, $P < .001$), including malunion (11% vs 2%, $P < .001$) and cellulitis (5% vs 1%, $P < .001$). Readmission rates were also elevated in TF patients at 30 days (17% vs 3%, $P < .001$) and 31-90 days (14% vs 4.8%, $P < .001$). Logistic regression identified chronic kidney disease, diabetes, and obesity as independent predictors of complications. PSM confirmed these findings, demonstrating significantly higher rates of complications and readmissions in TF patients.

Discussion: Findings indicate that TTC arthrodesis for TF is associated with higher risks of complications and readmissions compared with OA, attributable to acute injury characteristics and surgical complexity. Chronic comorbidities further exacerbate these risks. Optimizing perioperative management and timing of surgery in TF patients may mitigate complications. This study highlights the need for individualized care strategies to improve outcomes in TTC arthrodesis for trauma.

Level of Evidence: Level III, therapeutic: case-control study.

Keywords: Tibiotalocalcaneal arthrodesis, trauma, osteoarthritis, complications, readmissions, foot and ankle

Introduction

The use of tibiotalocalcaneal arthrodesis with a retrograde intramedullary nail (TTC nailing) for osteoarthritis is well established for managing end-stage disease, offering significant pain relief and improved function.[27] TTC nailing, also referred to as TTC arthrodesis or TTC fusion, has emerged

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as an effective surgical approach for managing severe ankle pathologies, such as severe osteoarthritis, particularly in frail patients with multiple comorbidities.[16,25] This technique provides stabilization and facilitates earlier weightbearing, which is crucial for patients unable to tolerate prolonged immobilization.[18] TTC nailing has shown benefits over other surgical methods, particularly in elderly patients with comorbid conditions such as osteoporosis, chronic kidney disease (CKD), and diabetes, by allowing early mobilization and reducing complications, reducing the risk of complications associated with prolonged immobility, such as deep vein thrombosis.[5,7,12]

Early mobilization also helps prevent joint contractures and reduces the risk of muscle wasting, all of which contribute to a faster recovery.[2,7,11] Additionally, earlier mobilization is associated with improved cardiovascular function, as patients can resume light physical activity sooner, which supports overall cardiovascular health.[36] Faster mobilization also reduces the psychological burden of being bedridden, which can contribute to better mental health and motivation during the recovery process. For health care systems, early mobilization can lead to shorter hospital stays and decreased need for long-term rehabilitation, ultimately reducing health care costs and resource use.[30]

In contrast, the application of TTC nailing in the context of traumatic fractures remains more controversial. Ongoing debate exists regarding the most effective treatment approach for this challenging patient group. Patients who undergo open reduction and internal fixation often experience a high rate of wound complications, whereas those managed without surgery may face risks such as pressure ulcers, malunions, and early progressive deformities.[22] Effective management of ankle fractures requires strategies that minimize soft tissue damage, provide stabilization suitable for healing, and ensure alignment maintenance. TTC nailing has been used as a salvage technique for cases where ankle fracture fixation has failed, with promising outcomes.[34,35] However, the procedure in the setting of traumatic fracture may be associated with higher complication rates, which can outweigh the advantages of early mobilization and surgical correction in these select cases.[4] These complications are more pronounced in patients with extensive soft tissue damage and those undergoing surgery in the acute phase of injury,[33] highlighting the need for careful patient selection and perioperative management. Trauma patients also often present with a heightened inflammatory response, increasing the risk of complications such as wound dehiscence, infection, and malunion.[9] Trauma-related complications may also be influenced by factors such as the severity of the initial injury, the presence of open fractures, and delays in surgical intervention.[8] Understanding these differential outcomes is critical for guiding clinical decision-making, particularly in selecting appropriate candidates for TTC fusion and optimizing perioperative care.

This study hypothesizes that TTC fusion for trauma, such as pilon, bimalleolar, or trimalleolar fractures, will have a greater risk of adverse outcomes compared with TTC for osteoarthritis. By analyzing patients from the Nationwide Readmissions Database (NRD), this study achieved a better understanding of the risk profiles of these 2 groups and developed strategies to minimize complications and improve outcomes. Such insights are crucial for developing tailored perioperative strategies that enhance patient selection and optimize clinical outcomes. This study focuses on a comprehensive analysis of complication and 30- and 90-day readmission rates between osteoarthritis and trauma cases treated with TTC fusion, providing an evidence-based approach to understanding the differential risk profiles. By leveraging data from the NRD, this study also identifies specific factors that contribute to increased complication rates following TTC fusion. The findings support surgeons in making more informed decisions regarding patient suitability for TTC fusion and in refining perioperative management protocols to mitigate risks. This study not only highlights the distinct challenges posed by TTC fusion in different patient populations but provides practical solutions to enhance patient care, reduce complication and readmission rates, and improve surgical outcomes.

Methods

Study Design and Data Source

This study was a retrospective cohort analysis using data from the Nationwide Readmissions Database (NRD) from 2016 to 2021. The NRD is part of the Healthcare Cost and Utilization Project (HCUP). It is an all-payer inpatient database designed to support various health care research by providing patient-level data across hospitals in the United States. The NRD includes hospitalizations and discharges for all patients, regardless of payer, and covers data from hospital inpatient care, emergency department visits, and some outpatient services. In 2021, data were collected from 30 geographically diverse states, representing 61.2% of the US population and 59.6% of all hospitalizations. Each hospitalization is linked to a unique patient identifier, allowing for tracking of readmissions within the calendar year. All patient, hospital, and additional identifying information are protected to maintain confidentiality.

Study Population

Patients who underwent TTC arthrodesis were identified using *International Classification of Diseases, Tenth Revision, Procedure Coding System* (*ICD-10-PCS*) codes.[15] Patients were selected if they had any combination of ipsilateral *ICD-10-PCS* codes for ankle fusion and tarsal fusion, which has been reported by many TTC fixation device manufacturers as the appropriate method of coding TTC nailing.

Patients were stratified into 2 primary groups based on the indication for TTC nailing: trauma-related fractures (TF) (n = 462) and osteoarthritis (OA) (n = 934).

Propensity Score Matching

Propensity score matching (PSM) was performed to reduce the impact of confounding variables and ensure balanced comparisons between cohorts. Patients were matched in a 1:1 ratio using greedy nearest-neighbor matching with a caliper of 0.1 pooled SDs, and propensity scores were estimated using logistic regression. The covariates included in the matching process were various comorbidities, outlined in Table 2, along with age and sex. Matching was conducted with a tolerance of 0.01 to minimize discrepancies in propensity scores between matched pairs.

Inclusion and Exclusion Criteria

Patients were included if they underwent TTC nailing between 2016 and 2021, as identified through *ICD-10-PCS* procedure codes. Inclusion criteria consisted of cases with a diagnosis of either unstable ankle fractures, such as bimalleolar, trimalleolar, or pilon fractures, or osteoarthritis of the ankle joint. Patients were excluded if they were missing *ICD-10-PCS* codes for either tarsal or ankle fusion, if they had contralateral code combinations (eg, right tarsal and left ankle or vice versa), or if they were missing diagnostic codes for osteoarthritis or traumatic fracture. Patients were also excluded if they underwent any concurrent procedures involving other types of ankle fixation such as external fixation or if they had both a diagnosis of ankle osteoarthritis and traumatic fracture. Cases with incomplete demographic data or missing key outcome variables (eg, NRDvisit_link, age) were also excluded. All *ICD-10-CM* and *ICD-10-PCS* codes used for this study are provided in the Supplemental Digital Content.

Outcomes

Outcomes assessed included the presence of any complication, specific complications (malunion, pseudoarthrosis, cellulitis, thromboembolism, wound dehiscence, hardware failure), as well as 30-day and 31- to 90-day readmission rates and revision ankle surgery. Complications were defined based on a comprehensive set of *ICD-10-CM* or *ICD-10-PCS* codes.

Data Analysis

Data were analyzed using SPSS, version 29.0.2.0 (IBM Corp, Armonk, NY). Descriptive statistics were used to summarize baseline characteristics of the study population. Comparative analyses between the trauma and osteoarthritis groups were conducted using Pearson chi-square tests or Fisher exact tests for categorical variables such as presence of a postoperative complication or comorbidity. Binomial logistic regression models were then used with the unmatched cohorts to identify characteristic associations across several comorbidities for complications and 30- and 90-day readmission rates within each indication. This was followed by subsequent regression analysis on the total cohort after PSM to identify any associations between an indication of traumatic fracture and adverse outcomes, namely, readmission (30- and 90-day), complications, and revision surgery. Covariates included in all models were all comorbidities in Table 2. Additionally, the models that used the postmatch cohort also included the surgical indication for traumatic fracture as a covariate. Reference values for odds ratios are absence of any comorbidities and OA indication for comorbidities and indication, respectively. Statistical significance for all analyses was set at $P < .05$.

Results

Demographics and Comorbidities

Prior to PSM, the OA group had a mean age of 62.15 years (SD = 12.10), whereas the TF group averaged 63.44 years (SD = 15.05), and males represented 55.6% of the OA group and 42.2% of the TF group (Table 1). The distribution of comorbidities between each group before and after PSM is detailed in Table 2.

Complications and Readmissions

Complications were significantly more common in the TF group compared with the OA group (41.8% vs 16%, $P < .001$). Specific complications, including thromboembolism (1% vs 0%, $P < .001$), cellulitis (5% vs 1%, $P < .001$), and malunion (11% vs 2%, $P < .001$), were more frequent in the TF group. Thirty-day readmissions were higher in the TF group compared with the OA group (17% vs 3%, $P < .001$), as were 31-90-day readmissions (14% vs 4.8%, $P < .001$). Revision ankle surgery rates were also greater in the TF group than the OA group (22% vs 6.3%, $P < .001$) (Table 3).

PSM Analysis

PSM resulted in matched cohorts of 459 OA and 459 TF patients. Average age was comparable between the 2 groups (TF = 63.36 ± 15.05 vs OA = 62.83 ± 12.19, $P = .555$). There was a slightly greater proportion of female subjects in the TF cohort (57.52% vs 56.64%, $P = .841$). Prevalence of comorbidities across the 2 cohorts is shown in Table 2. Complications remained higher in the TF group than in the OA group (56.7% vs 20.3%, $P < .001$). Malunion (11.1% vs 1.3%, $P < .001$) and pseudoarthrosis were also more frequent in the TF group than in the OA group (14.8% vs

Table 1. Demographic Characteristics by Cohort.

	Osteoarthritis (OA) (n = 934)	Traumatic Fracture (TF) (n = 462)
Age, mean (SD)	62.15 (12.097)[a]	63.44 (15.052)
Gender, n		
Male	519	195
Female	415	267
Primary expected payer, n		
Medicare	532	264
Medicaid	87	72
Private insurance	271	89
Self-pay	7	12
No charge	1	1
Other	35	22
Median household income national quartile, n		
1	225	131
2	278	125
3	220	125
4	198	73
Patient location: NCHS Urban-Rural Code, n		
"Central" counties of metro areas of ≥1 million population	214	126
"Fringe" counties of metro areas of ≥1 million population	245	115
Counties in metro areas of 250 000-999 999 population	187	120
Counties in metro areas of 50 000-249 999 population	109	30
Micropolitan counties	101	39
Not metropolitan or micropolitan counties	76	32
Emergency department indicator, n		
Yes	21	185
No	913	277

Abbreviation: NCHS, National Center for Health Statistics.

Table 2. Comorbidity Distribution Before and After Propensity Score Matching (PSM).

	Pre-PSM						Post-PSM					
	OA		Trauma				OA		Trauma			
Comorbidities	n	% of Total	n	% of Total	χ^2	*P* Value[a]	n	% of Total	n	% of Total	χ^2	*P* Value[a]
Hypertension	493	52.78	166	35.93	35.227	**<.001**	156	33.99	166	36.17	0.388	.534
Nicotine dependence, history	252	26.98	74	16.02	20.757	**<.001**	75	16.34	74	16.12	0	>.99
Nicotine dependence, current	52	5.57	64	13.85	27.85	**<.001**	71	15.47	62	13.51	0.563	.453
Diabetes	102	10.92	29	6.28	7.839	**.005**	27	5.88	29	6.32	0.019	.890
Hypothyroidism	116	12.42	83	17.97	7.777	**.005**	72	15.69	80	17.43	0.387	.534
Psychiatric diagnosis	214	22.91	104	22.51	0.028	.866	107	23.31	104	22.66	0.025	.875
Heart disease	115	12.31	83	17.97	8.115	**.004**	78	16.99	82	17.86	0.068	.794
Obesity	162	17.34	66	14.29	2.117	.146	65	14.16	66	14.38	0	>.999
Morbid obesity	138	14.78	68	14.72	0.001	.978	54	11.76	67	14.60	1.371	.241
COPD	76	8.14	48	10.39	1.938	.164	54	11.76	47	10.24	0.482	.488
Osteoporosis	34	3.64	31	6.71	6.561	**.01**	27	5.88	30	6.54	0.075	.784
CKD	77	8.24	50	10.82	2.485	.115	43	9.37	49	10.68	0.302	.583
Anemia	63	6.75	34	7.36	0.18	.671	32	6.97	34	7.41	0.016	.898
Fibromyalgia	37	3.96	9	1.95	3.932	**.047**	12	2.61	9	1.96	0.195	.659
Anticoagulant therapy	93	9.96	45	9.74	0.016	.898	33	7.19	45	9.80	1.695	.193

Abbreviations: CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; OA, osteoarthritis.
[a]Boldface indicates significance ($P < .05$).

Table 3. Complication and Readmission by Cohort, Before and After Propensity Score Matching (PSM).

	Pre-PSM			Post-PSM		
	Osteoarthritis (OA) (n = 934)	Traumatic Fracture (TF) (n = 462)	*P* Value (2-Tailed)	Osteoarthritis (OA) (n = 459)	Traumatic Fracture (TF) (n = 459)	*P* Value (2-Tailed)
Any complication	148 (16)	252 (54.5)	<.001	80 (17.4)	246 (53.6)	<.001
Wound dehiscence	1 (0)	8 (2)	<.001	0	8 (1.7)	.013
Thromboembolism	0 (0)	6 (1)	<.001	0	6 (1.3)	.041
Cellulitis	9 (1)	25 (5)	<.001	4 (0.9)	25 (5.4)	<.001
Infectious	2 (0)	7 (2)	.004	0	7 (1.5)	.023
Hardware failure	19 (2)	27 (6)	<.001	13 (2.8)	25 (5.4)	.068
Malunion	16 (2)	52 (11)	<.001	6 (1.3)	51 (11.1)	<.001
Pseudoarthrosis	101 (11)	68 (15)	.035	47 (10.2)	68 (14.8)	.046
30-d readmission	24 (3)	79 (17)	<.001	17 (3.7)	79 (17.2)	<.001
31-90-d readmission	45 (4.8)	63 (14)	<.001	22 (4.8)	62 (13.5)	<.001
Revision surgery	59 (6.3)	103 (22)	<.001	37 (8.1)	102 (22.2)	<.001

10.2%, $P = .046$). Thirty-day readmissions were also significantly higher in the TF group (17.2% vs 3.7%, $P < .001$) compared with the OA group (Table 3).

Logistic Regression

Logistic regression identified several significant predictors of complications within the 2 respective cohorts (Table 4). In trauma patients, diabetes increased the risk of 30-day readmissions (OR: 2.857, $P = .02$), and hypothyroidism (OR: 2.12, $P = .035$) was associated with 31-90-day readmissions. CKD (OR: 3.52, $P = .006$) and chronic obstructive pulmonary disease (OR: 2.591, $P = .025$) were linked to malunion risk. In OA patients, heart disease increased the risk of 30-day readmissions (OR: 3.236, $P = .018$). Furthermore, chronic obstructive pulmonary disease (OR: 3.202, $P = .007$) and CKD (OR: 3.705, $P = .007$) were significant predictors of 31-90-day readmissions in the OA cohort.

Regression analysis after PSM revealed several predictors of adverse outcomes following TTC fusion. TTC fusion following TF was demonstrated to increase the risk of experiencing 30-day readmission (OR: 5.421, $P < .001$), 31- to 90-day readmission (OR: 3.038, $P < .001$), revision surgery (OR: 3.217, $P < .001$), and postoperative complication (OR: 3.002, $P < .001$).

Discussion

The purpose of this study was to investigate differences in complication rates and the impact of comorbidities on patients who underwent TTC fusion surgery because of either osteoarthritis (OA) or traumatic fracture (TF). The findings revealed significant differences in both overall complication rates and the impact of specific comorbidities between these 2 patient pools.

The propensity score analysis demonstrated that patients undergoing TTC fusion for traumatic fractures had significantly higher rates of complications, readmissions, and revision surgery compared with those treated for osteoarthritis. This finding aligns with previous studies demonstrating greater complication rates following acutely treated traumatic fractures as compared to elective procedures or traumatic fractures that were surgically delayed. A study conducted by Le Manach et al[19] directly reported on the increased risk of complication in trauma-related hip fracture procedures when compared to hip OA-related total hip replacement surgery. Furthermore, Sirkin et al[31] discovered a significantly increased complication rate following acute operative fixation of the ankle joint as opposed to a staged protocol that implements operative fixation following soft tissue stabilization, suggesting an association between the timing of operative fixation and poor surgical outcomes. The disparity in operative outcomes between the 2 groups can be attributed to the acute nature of traumatic injuries, which are often associated with significant soft tissue damage, complex fracture patterns, and increased surgical complexity,[17] all of which may contribute to a higher likelihood of postoperative complications. The lower complication rate in the OA group suggests that elective procedures for osteoarthritis are less prone to such risks, similarly to those who received delayed surgical intervention, likely because of the absence of this trauma-related physiological burden.

Analysis of comorbidities by logistic regression identified several comorbidities as predictors of complications. In TF patients, diabetes significantly increased the rate of 30-day readmission (OR: 2.857) and wound dehiscence (OR: 30.315), consistent with the findings of Happonen et al,[10] in which the authors found diabetes to be a significant predictor of such complications following operative ankle fracture fixation. A similar association was revealed

Table 4. Binary Logistic Regression Analysis for Adverse Outcomes Following Tibiotalocalcaneal Arthrodesis.

	OR	Lower 95% CI	Upper 95% CI	*P* Value
Trauma cohort (pre-PSM)				
30-d readmission				
Diabetes	2.857	1.178	6.932	.02
31- to 90-d readmission				
Hypothyroidism	2.12	1.055	4.259	.035
Cellulitis				
Osteoporosis	4.071	1.208	13.718	.024
Wound dehiscence				
Nicotine dependence	9.838	1.178	82.149	.035
Diabetes	30.315	2.51	366.177	.007
Malunion				
Hypertension	2.094	1.078	4.067	.029
COPD	2.591	1.125	5.965	.025
CKD	3.52	1.442	8.597	.006
Osteoarthritis cohort (pre-PSM)				
30-d readmission				
Heart Disease	3.236	1.225	8.549	.018
31- to 90-d readmission				
COPD	3.202	1.379	7.432	.007
CKD	3.705	1.438	9.543	.007
Infection				
Anemia	34.094	4.938	235.392	<.001
Total cohort (post-PSM)				
30-d readmission				
Trauma indication	5.421	3.118	9.424	<.001
Diabetes	2.299	1.046	5.052	.038
Anticoagulant therapy	2.716	1.455	5.07	.002
31- to 90-d readmission				
Trauma indication	3.038	1.801	5.126	<.001
COPD	3.869	2.005	7.466	<.001
Anticoagulant therapy	2.322	1.114	4.839	.025
Revision surgery				
Trauma indication	3.217	2.136	4.846	<.001
COPD	1.869	1.002	3.486	.049
Anticoagulant therapy	3.004	1.695	5.327	<.001
Any complication				
Trauma indication	3.002	2.193	4.108	<.001
Chronic kidney disease	1.823	1.092	3.042	.022

Abbreviations: COPD, chronic obstructive pulmonary disease; OR, odds ratio; PSM, propensity score matching.

between nicotine dependence and wound dehiscence (OR: 9.838) in TF patients, an association that has been well documented because of its impact on microvasculature.[23] Hypertension in TF patients also significantly increased the rate of malunion (OR: 2.094), likely because of vascular and bone metabolic changes.[14] In both TF and OA patients, CKD increased the risk of complications, specifically malunion (OR: 3.52) and 31- to 90-day readmission (OR: 3.705), respectively. This observation is consistent with current orthopaedic literature, which indicates elevated complication rates in CKD patients because of disturbances in mineral metabolism.[13] Furthermore, CKD patients experience a plethora of hormonal imbalances such as hyperparathyroidism, serum calcium phosphate imbalance, vitamin D deficiency, and chronic metabolic acidosis, which can disturb bone union following fracture and exacerbate postfracture complications.[1]

The increased association of comorbidities with complications in TF vs OA patients could be due to the unplanned nature of trauma cases, which can significantly impact patient outcomes. The unpredictable nature of trauma means that patients may not be in optimal condition for surgery, potentially exacerbating the impact of existing comorbidities. Traumatic injuries also often involve multiple systems and can be more complex than the isolated joint involvement seen in OA. This complexity may interact with existing comorbidities in ways that are not seen in elective surgeries, leading to different predictors of complications.[24] The unplanned nature of trauma, combined with the acute physiological stress and limited preoperative optimization, likely contribute to the observed differences in comorbidities influencing complications between the OA and TF groups.

A possible method of circumventing complications and negative outcomes may include optimization of timing before surgical intervention in TF patients to allow for enhanced recovery from acute inflammatory responses that may impede on bone regeneration and repair.[29] This phenomenon has been explored in the context of ankle surgery by Patterson and Cole, who found a significant decrease in complications by implementing a 2-staged approach where operative fixation was withheld until soft tissue inflammation had subsided.[26] The extension of the postoperative nonweightbearing time frame may also improve outcomes in TF although this remains underexplored.[28] Rate of infection in both cohorts can be decreased by enhanced monitoring and targeted prophylactic measures, such as the addition of intraoperative topical vancomycin, in addition to postoperative cefazolin therapy.[21] Although intraoperative antibiotics have shown benefit in other subfields in orthopaedic surgery such as during spinal fusion, their usage in routine arthrodesis procedures remains underexplored.[3] The vulnerability that patients with certain comorbidities were found to possess, notably in the TF cohort, in this study further emphasizes the notion that individualized care plans may be critical in reducing the burden of complications in these populations. Meticulous wound care and thromboembolism prophylaxis may help mitigate some of the risks associated with traumatic fractures as well.[6] Additionally, optimizing nutritional status and providing physical rehabilitation may further improve recovery and reduce complication rates.[20,32]

This study presents novel insights within the realm of TTC arthrodesis in several ways. First, it is the first study

that directly compares outcomes of elective TTC arthrodesis to arthrodesis in the setting of traumatic fracture. Furthermore, this study demonstrated significant differences between the 2 cohorts after PSM, strengthening the conclusions even in the presence of baseline differences between the 2 groups.

There were several limitations that must be addressed. One is that the *ICD-10-PCS* code used for tarsal fusion is not specific to the subtalar joint, which may have led to the inclusion of cases involving concurrent ankle and transtarsal fusions rather than isolated concurrent ankle and subtalar fusions. Although we believe that the vast majority of cases included represent TTC arthrodesis, this potential misclassification could introduce minor variability in the cohort. The severity of the comorbidities was not able to be assessed, which could have provided additional insights into the impact of comorbidities on outcomes. Although propensity score matching was effective in reducing baseline differences between the 2 groups, the limited sample size likely hindered the ability to detect statistical significance for certain complications, such as wound dehiscence, thromboembolism, cellulitis, and implant-related complications. A larger cohort would provide greater statistical power to detect subtle differences between groups, enabling more robust conclusions regarding the risk of complications associated with TTC fusion for different indications, and an expanded sample size would allow for more granular subgroup analyses. As a database study, this research has certain inherent limitations. The query code used may contain errors, omissions, or inadequacies, and the reduced granularity of the data restricts a detailed interpretation of the findings. Additionally, database studies are limited to controlling for variables that are recorded within the data set. Furthermore, the inability to confirm whether the ankle and subtalar joints were properly prepared for fusion is another limitation of this work, which may have influenced the risk of malunion and nonunion.

Conclusion

In conclusion, this retrospective cohort study provides valuable insights into the postoperative outcomes of TTC fusion by indication, and the dynamic nature of comorbidities on surgical outcomes over time. The findings underscore the importance of ongoing comorbidity management in the postoperative period to optimize patient outcomes. They also highlight the need for a more personalized approach to postoperative care and follow-up, considering each patient's unique comorbidity profile and how it changes over time.

Ethical Approval

This study used deidentified data from the Nationwide Readmissions Database, and as such, informed consent was not required.

Declaration of Conflicting Interests

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Data Availability Statement

The data used in this study are publicly available from the Nationwide Readmissions Database, managed by the Healthcare Cost and Utilization Project (HCUP). Access is subject to licensing and data-use agreements.

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Appendix Table A1. *ICD-10-PCS* Codes for Tibiotalocalcaneal Fusion. (icd)

Right ankle fusion	0SGF03Z
	0SGF04Z
	0SGF05Z
	0SGF07Z
	0SGF0JZ
	0SGF0KZ
	0SGF33Z
	0SGF34Z
	0SGF35Z
	0SGF37Z
	0SGF3JZ
	0SGF3KZ
	0SGF43Z
	0SGF44Z
	0SGF45Z
	0SGF47Z
	0SGF4JZ
	0SGF4KZ
Left Ankle Fusion	0SGG03Z
	0SGG04Z
	0SGG05Z
	0SGG07Z
	0SGG0JZ
	0SGG0KZ
	0SGG33Z
	0SGG34Z
	0SGG35Z
	0SGG37Z
	0SGG3JZ
	0SGG3KZ
	0SGG43Z
	0SGG44Z
	0SGG45Z
	0SGG47Z
	0SGG4JZ
	0SGG4KZ
Left tarsal fusion	0SGJ03Z
	0SGJ04Z
	0SGJ05Z
	0SGJ07Z
	0SGJ0JZ
	0SGJ0KZ
	0SGJ33Z
	0SGJ34Z
	0SGJ35Z
	0SGJ37Z
	0SGJ3JZ
	0SGJ3KZ
	0SGJ43Z
	0SGJ44Z
	0SGJ45Z
	0SGJ47Z
	0SGJ4JZ
	0SGJ4KZ
Right tarsal fusion	0SGH03Z
	0SGH04Z
	0SGH05Z
	0SGH07Z
	0SGH0JZ
	0SGH0KZ
	0SGH33Z
	0SGH34Z
	0SGH35Z
	0SGH37Z
	0SGH3JZ
	0SGH3KZ
	0SGH43Z
	0SGH44Z
	0SGH45Z
	0SGH47Z
	0SGH4JZ
	0SGH4KZ

Abbreviation: *ICD-10-PCS*, *International Classification of Diseases, Tenth Revision, Procedure Coding System*.

Appendix Table A2. *ICD-10-CM* codes used for Indications.

Traumatic Fracture	S82.84, S82.85, S82.87
Osteoarthritis	M19.07, M19.27

Abbreviation: *ICD-10-CM*, *International Classification of Diseases, Tenth Revision, Clinical Modification*.

Appendix Table A3. *ICD-10-CM* Codes Used for Complications.

Thromboembolism	I82.401, I82.402
Cellulitis	L03.115, L03.116
Wound dehiscence	T81.31XA, T81.32XA, L76.32
Nerve injury	S94.21XA, S84.1XXA
Implant related complication	T84.021, T84.022, T84.1
Infectious	T81.41, T81.42, T84.1
Pseudoarthrosis	M84.472, M84.471, M96, 7th character K in diagnostic codes
Malunion	M84.474, M84.473, 7th character P in diagnostic codes

Abbreviation: *ICD-10-CM*, *International Classification of Diseases, Tenth Revision, Clinical Modification*.

Appendix Table A4. *ICD-10-CM* Codes for Comorbidities.

Hypertension	I10
Nicotine dependence (history)	Z87891
Nicotine dependence (current)	F17210
Diabetes	E119
Hypothyroidism	E039
Psychiatric diagnosis	F329, F419
Heart disease	I2510
Obesity	E669
Morbid obesity	E6601
Chronic obstructive pulmonary disease	J449
Osteoporosis	M810
Chronic kidney disease	I129, N183
Anemia	D649
Fibromyalgia	M797
Anticoagulant therapy	Z7901

Abbreviation: *ICD-10-CM*, *International Classification of Diseases, Tenth Revision, Clinical Modification*.