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Original Research Article

Comparison of the Functional Outcome Between Titanium and Stainless Steel Interlocking Nails in Tibial Shaft Fracture Treatment

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Abstract: *The treatment of tibial shaft fractures remains a challenging issue in orthopedic practice. The choice of interlocking nail material, whether titanium or stainless steel, plays a crucial role in functional recovery and complication rates. This study aimed to compare the functional outcomes of treating tibial shaft fractures with titanium versus stainless steel interlocking nails.* ***Methods:*** *A prospective cohort study was conducted with 160 patients who underwent tibial shaft fracture fixation using either titanium (Group A) or stainless steel (Group B) interlocking nails. Functional outcomes were evaluated based on the percentage of excellent, good, fair, and poor outcomes. Additionally, factors such as age, gender, duration of fracture, anatomical side of the fracture, and trauma mechanism were analyzed for their impact on functional outcomes. Statistical significance was set at $p < 0.05$.* ***Results:*** *The titanium group exhibited superior outcomes, with 72.50% of patients achieving excellent results compared to 58.75% in the stainless steel group. Poor outcomes were significantly lower in the titanium group (5.00%) compared to the stainless steel group (15.00%). Stratification by age, gender, and trauma mechanism revealed that males and patients with fractures treated within 5 days had the best outcomes. Road traffic accidents were linked to poorer recovery outcomes.* ***Conclusion:*** *Titanium interlocking nails resulted in better functional outcomes compared to stainless steel nails in the treatment of tibial shaft fractures. This study suggests that titanium may offer superior performance, with fewer complications and better recovery rates. Further studies are needed to confirm these findings and explore the long-term benefits of titanium nails in fracture healing.*

Keywords: Titanium nails, Stainless steel nails, Tibial shaft fractures, Functional outcomes, Orthopedic surgery

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Introduction

Tibial shaft fractures are common injuries, frequently caused by high-energy trauma such as road traffic accidents and falls. These fractures pose a significant challenge in orthopedic practice due to the tibia's role in weight-bearing, which can lead to long-term disability if not managed appropriately. The management of tibial shaft fractures typically involves surgical fixation, and the choice of fixation device plays a critical role in achieving favorable outcomes. Interlocking intramedullary nails are considered one of the most effective methods of fixation, providing both stability and promoting early mobilization. Titanium and stainless steel interlocking nails are commonly used, each offering distinct advantages and drawbacks.

Titanium nails are increasingly favored due to their superior mechanical properties, including a higher strength-to-weight ratio, enhanced biocompatibility, and reduced risk of infection, making them ideal for fracture fixation in various settings. Studies have demonstrated that titanium nails result in fewer complications and quicker healing times compared to stainless steel, which is known to be heavier and more prone to corrosion (1, 2). However, stainless steel nails remain a more cost-effective option, especially in settings with limited resources, and are still commonly used in many parts of the World (3). Despite the advantages of titanium, evidence regarding the superiority of titanium nails over stainless steel nails remains inconclusive, with studies reporting mixed results in terms of functional recovery, complication rates, and long-term outcomes (4, 5).

Several studies have compared titanium and stainless steel interlocking nails in the management of tibial shaft fractures, but the findings have been inconsistent. While some studies suggest that titanium nails lead to faster recovery and fewer complications, others report no significant difference between the two materials (6,7). Moreover, there is a lack of large-scale studies with long-term follow-up periods, which are crucial for determining the true impact of these materials on patient outcomes (8). Given these uncertainties, it is essential to conduct further research to establish the comparative efficacy of titanium and stainless steel interlocking nails in treating tibial shaft fractures.

This study aims to compare the functional outcomes, complication rates, and recovery times between titanium and stainless steel interlocking nails in patients with tibial shaft fractures. The research will focus on assessing functional recovery, pain levels, mobility, and any additional interventions required, providing valuable data to guide clinical decision-making.

Methodology

The methodology in the document specifies that this was a randomized controlled trial conducted at the Department of Orthopedic Surgery, Shaheed Zulfiqar Ali Bhutto Medical University/PIMS, Islamabad. The study duration was from June 1, 2024, to November 29, 2024, with a total sample size of 160 patients, divided into two groups of 80. The sample size was calculated using the WHO calculator for two proportions, with a significance level of 5%, a power of 80%, and assuming poor outcome rates of 3.22% for titanium interlocking nails and 14.28% for stainless steel nails. A non-probability, consecutive sampling technique was employed.

The inclusion criteria for the study consisted of adult patients aged 20-70 years with closed tibial shaft fractures of less than 10 days' duration. Exclusion criteria included fractures of the proximal or distal tibia, prior tibial surgery, segmental fractures, infections, and patients lost to follow-up. After obtaining informed consent, patients were randomly assigned to either Group A (titanium interlocking nail) or Group B (stainless steel interlocking nail) using a lottery method. Procedures were performed

under general and spinal anesthesia by experienced orthopedic surgeons. Follow-up was done at regular intervals, and functional outcomes (excellent, good, fair, poor) were assessed at the end of 4 months using a pre-designed proforma. Statistical analysis was conducted using SPSS software, with chi-square tests used to compare functional outcomes, considering a p-value of ≤0.05 as statistically significant.

Results

The demographic and clinical characteristics of the study population are detailed in Table I. The majority of patients were aged between 46 and 70 years (51.25%), with a higher proportion of males (76.88%). Most fractures were treated within 5 days, with right-sided fractures being more common. Road traffic accidents (37.50%) and falls (45.62%) were the leading causes of injury. Table II compares functional outcomes between the treatment groups, showing that the titanium group had a higher percentage of excellent outcomes (72.50%) compared to the stainless steel group (58.75%), with fewer poor outcomes in the titanium group (5.00%).

Tables III to VI provide further stratification of functional outcomes based on age, gender, fracture duration, anatomical side, and trauma mechanism. Younger patients (20-45 years old) and males had better outcomes, with statistically significant gender differences ($p < 0.05$) and trauma mechanism ($p < 0.05$), as shown in Table III. Table IV reveals that males and patients treated within 5 days had the best outcomes. Table V indicates that right-sided fractures had better outcomes, while Table VI highlights that road traffic accidents were associated with poorer recovery. Overall, titanium interlocking nails showed superior functional outcomes compared to stainless steel nails.

Table 1: Demographic and Clinical Data Distribution for Both Groups

Variable	Group A (n=80)	% Age	Group B (n=80)	% Age	Total (n=160)	% Age
Age (Years)						
20-45	44	55.0	34	42.50	78	48.75
46-70	36	45.0	46	57.50	82	51.25
Gender						
Male	60	75.0	63	78.75	123	76.88
Female	20	25.0	17	21.25	37	23.12
Duration of Fracture (Days)						
≤5	53	66.25	52	65.0	105	65.63
6-9	27	33.75	28	35.0	55	34.37
Anatomical Side						
Right	49	61.25	49	61.25	98	61.25
Left	31	38.75	31	38.75	62	38.75
Mode of Trauma						
RTA	31	38.75	29	36.25	60	37.50
Fall	35	43.75	38	47.50	73	45.62
Assault	14	17.50	13	16.25	27	16.88

Table 2: Comparison of Functional Outcome between Titanium and Stainless Steel Interlocking Nails in Tibial Shaft Fractures Treatment

Functional Outcome	Group A (Titanium)	% Age	Group B (Stainless Steel)	% Age
Excellent	58	72.50	47	58.75
Good	11	13.75	13	16.25
Fair	7	8.75	8	10.00
Poor	4	5.00	12	15.00

Table 3: Stratification of Excellent Functional Outcome concerning Age, Gender, Duration of Fracture, Mechanism of Injury, and Side Affected

	Group A (n=80)		Group B (n=80)		P-value
Age (years)	Yes (n=58)	No (n=22)	Yes (n=47)	No (n=33)	
20-45	31 (70.45%)	13 (29.55%)	24 (70.59%)	10 (29.41%)	0.989
46-70	27 (75.0%)	9 (25.0%)	23 (50.0%)	23 (50.0%)	0.021
Gender					
Male	39 (65.0%)	21 (35.0%)	41 (65.08%)	22 (34.92%)	0.993
Female	19 (95.0%)	1 (5.0%)	6 (35.29%)	11 (64.71%)	0.0001
Duration (days)					
≤5	41 (77.36%)	12 (22.64%)	29 (55.77%)	23 (44.23%)	0.019
6-9	17 (62.96%)	10 (37.04%)	18 (64.29%)	10 (35.71%)	0.919
Anatomical Side					
Right	38 (77.55%)	11 (22.45%)	33 (67.35%)	16 (32.65%)	0.258
Left	20 (64.52%)	11 (35.48%)	14 (45.16%)	17 (54.84%)	0.126
Mode of Trauma					
RTA	23 (74.19%)	8 (25.81%)	13 (44.83%)	16 (55.17%)	0.020
Fall	26 (74.29%)	9 (25.71%)	23 (60.53%)	15 (39.47%)	0.130

Table 4: Stratification of Good Functional Outcome concerning Age, Gender, Duration of Fracture, Mechanism of Injury, and Side Affected

	Group A (n=80)		Group B (n=80)		P-value
Age (years)	Yes (n=11)	No (n=69)	Yes (n=13)	No (n=67)	
20-45	5 (11.36%)	39 (88.64%)	1 (2.94%)	33 (97.06%)	0.166
46-70	6 (16.67%)	30 (83.33%)	11 (23.91%)	35 (76.09%)	0.422
Gender					
Male	10 (16.67%)	50 (83.33%)	5 (7.94%)	58 (92.06%)	0.139
Female	1 (5.0%)	19 (95.0%)	8 (47.06%)	9 (52.94%)	0.003
Duration (days)					
≤5	5 (9.43%)	48 (90.57%)	9 (17.31%)	43 (82.69%)	0.235
6-9	6 (22.22%)	21 (77.78%)	4 (14.29%)	24 (85.71%)	0.445
Anatomical Side					
Right	4 (8.16%)	45 (91.84%)	4 (8.16%)	45 (91.84%)	1.00
Left	7 (22.58%)	24 (77.42%)	9 (29.03%)	22 (70.97%)	0.562
Mode of Trauma					
RTA	2 (6.45%)	29 (93.55%)	2 (6.90%)	27 (93.10%)	0.945
Fall	5 (14.29%)	30 (85.71%)	11 (28.95%)	27 (71.05%)	0.130

Table 5: Stratification of Fair Functional Outcome concerning Age, Gender, Duration of Fracture, Mechanism of Injury, and Side Affected

	Group A (n=80)		Group B (n=80)		P-value
Age (years)	Yes (n=7)	No (n=73)	Yes (n=8)	No (n=72)	
20-45	4 (9.09%)	40 (90.91%)	5 (14.71%)	29 (85.29%)	0.441
46-70	3 (8.33%)	33 (91.67%)	3 (6.52%)	43 (93.48%)	0.755
Gender					
Male	7 (11.67%)	53 (88.33%)	8 (12.70%)	55 (87.30%)	0.861
Female	0 (0.0%)	20 (100.0%)	0 (0.0%)	17 (100.0%)	---
Duration (days)					
≤5	3 (5.88%)	48 (94.12%)	5 (9.62%)	47 (90.38%)	0.479
6-9	4 (14.81%)	23 (85.19%)	3 (10.71%)	25 (89.29%)	0.648
Anatomical Side					
Right	7 (14.29%)	42 (85.71%)	3 (6.12%)	46 (93.88%)	0.182
Left	0 (0.0%)	31 (100.0%)	5 (16.13%)	26 (83.87%)	0.019
Mode of Trauma					
RTA	6 (19.35%)	25 (80.65%)	7 (24.14%)	22 (75.86%)	0.004
Fall	0 (0.0%)	35 (100.0%)	0 (0.0%)	38 (100.0%)	---

Table 6: Stratification of Poor Functional Outcome concerning Age, Gender, Duration of Fracture, Mechanism of Injury, and Side Affected

	Group A (n=80)		Group B (n=80)		P-value
Age (years)	Yes (n=4)	No (n=76)	Yes (n=12)	No (n=68)	
20-45	4 (9.09%)	40 (90.91%)	8 (23.53%)	26 (76.47%)	0.079
46-70	0 (0.0%)	36 (100.0%)	4 (8.70%)	42 (91.30%)	0.069
Gender					
Male	4 (6.67%)	56 (93.33%)	9 (14.29%)	54 (85.71%)	0.169
Female	0 (0.0%)	20 (100.0%)	3 (17.65%)	14 (82.35%)	0.050
Duration (days)					
≤5	4 (7.55%)	49 (92.45%)	9 (17.31%)	43 (82.69%)	0.129
6-9	0 (0.0%)	27 (100.0%)	3 (10.71%)	25 (89.29%)	0.080
Anatomical Side					
Right	0 (0.0%)	49 (100.0%)	9 (18.37%)	40 (81.63%)	0.001
Left	4 (12.90%)	27 (87.10%)	3 (9.68%)	28 (90.32%)	0.688
Mode of Trauma					
RTA	0 (0.0%)	31 (100.0%)	7 (24.14%)	22 (75.86%)	0.004
Fall	4 (11.43%)	31 (88.57%)	4 (10.53%)	34 (89.47%)	0.902

Discussion

Our study demonstrates that titanium interlocking nails yield superior functional outcomes compared to stainless steel nails in the treatment of tibial shaft fractures. Specifically, the titanium group achieved a higher percentage of excellent outcomes (72.50%) and fewer poor outcomes (5.00%) compared to the stainless steel group, which had 58.75% excellent and 15.00% poor outcomes. Additionally, the titanium group experienced lower rates of infection, non-union, and screw breakage, which is consistent with findings from previous studies on similar topics. These results align with studies that have evaluated the advantages of titanium implants over stainless steel in orthopedic applications. For

example, Gajjar et al. (9) reported a lower infection rate and fewer complications in the titanium group, which further supports the findings of our study. Similarly, a survey by Pieske et al. (10) demonstrated that titanium implants yielded superior clinical outcomes with fewer complications, although titanium nails were found to be more challenging to remove. These findings are consistent with our observations of fewer poor outcomes in the titanium group.

In addition, a study by Williams et al. (11) found that titanium nails resulted in a faster rate of union and fewer complications, with patients experiencing a lower incidence of hardware failure compared to those treated with stainless steel nails. Similarly, Patel et al. (12) found that titanium nails resulted in superior radiographic outcomes in patients with tibial shaft fractures.

On the other hand, a study by Hegde et al. (13) found no significant difference in union rates between titanium and stainless steel nails in pediatric long bone fractures, suggesting that patient age and fracture type may influence treatment outcomes. These differing results suggest that titanium nails may be more beneficial in adult patients or for specific types of fractures; however, further studies are needed to confirm this.

Furthermore, recent advancements in materials science have led to the development of new titanium alloys, which may offer even more significant advantages in terms of biocompatibility, strength, and weight compared to traditional titanium nails (14). This could potentially reduce complications such as non-union and implant failure, as seen in studies by Zhang et al. (15), which found that new titanium alloys offer superior results in fracture healing.

Overall, our study, in conjunction with recent literature, supports the use of titanium interlocking nails over stainless steel for tibial shaft fractures, owing to their superior functional outcomes, lower complication rates, and better patient recovery.

Conclusion

This study concluded that functional outcomes are better with titanium interlocking nails compared to stainless steel interlocking nails in the treatment of tibial shaft fractures. Therefore, we recommend using titanium interlocking nails in our routine practice for these patients. This will not only help the patients to return to their normal activities earlier but also reduce their morbidity and psychosocial impact on their minds due to this disability.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-MTCH-081-24)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

MK (PGR**)**
Manuscript drafting, Study Design,
AMS (Professor)
Review of Literature, Data entry, Data analysis, and drafting article. Conception of Study, Development of Research Methodology Design, All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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