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The Effect of Dynamization Versus Non-dynamization in the Union of Tibia Shaft Fracture-A Case-control Study

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Abstract: **Background:** Tibial shaft fractures are common long bone injuries, especially in children and adolescents, with an incidence of 15.7 to 16.9 per 100,000 individuals annually. High-energy tibial fractures are more prevalent in males. Closed fractures occur without skin disruption, while open fractures expose the bone, making them prone to complications like infection. Treatment typically involves intramedullary nailing (IMN), achieving 90-100% union rates. Complications such as delayed union can arise with treatments like dynamization or nailing exchange. The effectiveness of dynamization varies, with success rates influenced by factors like fracture type and healing conditions. **Aim of the study:** The study aims to evaluate and compare the impact of dynamization versus non-dynamization on the union of tibia shaft fractures in patients undergoing treatment, as determined through clinical outcomes and fracture healing rates. **Methods:** This retrospective case-control study was conducted at Department of Orthopedics Surgery, Bangabandhu Sheikh Mujib Medical University in Bangladesh, included 100 patients with closed and open grade 1 tibia shaft fractures treated with tibia intramedullary interlocking nailing. The patients were divided into two groups: 50 underwent dynamization at surgery onset (case group), and 50 did not (control group). Inclusion criteria focused on patients over 18 years with tibial diaphyseal fractures, while exclusion criteria eliminated cases with associated intra-articular or severe open fractures. Fracture healing was evaluated over 24 weeks, with statistical analysis performed using SPSS version 26.0, considering a p-value <0.05 as significant. **Results:** In this compared study, the highest age group in both groups was 30-39 years (case: 40%, control: 50%). Males dominated both groups (case: 70%, control: 72%). Road traffic accidents were the primary cause of injury (case: 66%, control: 60%). Closed fractures were predominant (case: 88%, control: 98%). Clinical outcomes were similar between the groups, with fair outcomes being the most common (case: 46%, control: 44%). There was no significant difference in outcomes, suggesting comparable treatment approaches. **Conclusion:** Dynamization showed a trend towards better clinical outcomes in tibia shaft fracture treatment, though not statistically significant. Radiographical follow-ups indicated improvement. Future research with larger samples is needed to clarify its role. Clinicians should tailor the use of dynamization based on individual patient characteristics and fracture specifics.

Keywords: Dynamization, Non-Dynamization, Tibia Shaft Fracture.

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INTRODUCTION

Tibial shaft fractures are one of the most frequent long bone fractures and constitute a substantial portion of orthopedic trauma cases. The Swedish Fracture Register estimates an incidence of approximately 15.7 fractures per 100,000 individuals annually, while a recent study in the United States reported a slightly higher incidence of 16.9 per 100,000 inhabitants [1,2]. These fractures are prevalent in children and adolescents, accounting for about 15% of all long bone fractures in this age group [3]. High-energy tibial fractures are approximately twice as prevalent in males compared to females among younger patients [4]. Closed tibia shaft fractures occur when the bone breaks without disrupting the skin. Open tibia shaft fractures involve a break in the skin, exposing the bone and surrounding tissues. Open fractures are more common in the tibia because one-third of the Tibial surface is subcutaneous throughout most of its length, and the blood supply to the tibia is more precarious than that of bones enclosed by heavy muscles [5]. Sports-related trauma and road traffic accidents (incidence 43%) accidents are the most common causes of injuries in older children and adolescents. In comparison, minor falls or twisting injuries are more common in younger children [6,7]. The extramedullary blood supply to the tibia, particularly in the midshaft and distal third regions, plays a crucial role in fracture healing. The anterior and posterior tibial arteries provide vascularization to the outer 10% to 33% of the tibial cortex, while the interosseous blood vessels supply the remaining inner third of the cortical region [8]. It poses substantial challenges in management due to the complexities associated with bone healing and potential complications like non-union, malunion, and infection [5]. Intramedullary nailing, or INN, has been the treatment of choice for most of them since it was introduced [6]. The union rates achieved with intramedullary nailing (IMN) range between 90% and 100% [9-11]. However, complications such as delayed union, which may result from factors including fracture morphology, soft tissue damage, and the surgical technique employed, can occur at rates of up to 40% [12-14]. Several treatment options are available to address these complications, including nailing exchange, fibular osteotomy, and dynamization, either as standalone procedures or in combination [15-18]. Dynamization, a technique that modifies the mechanical environment of the fracture site, has emerged as a potential solution for these complications. Dynamization consists of the removal of a statically locked screw to allow controlled transmission of axial loads to the fracture site. This process enhances bone contact and compression at the fracture site, thereby stimulating osteogenesis [19,20]. The reported union rates following nail dynamization range from 19% to 100% [21]. The current literature presents a dichotomy in the evaluation of dynamization's efficacy. While some studies advocate for its use, citing improved healing rates and functional outcomes [1,2,19], others suggest that exchange nailing may yield superior results in some instances, particularly in femoral non-unions [22]. The variability in success rates can be attributed to several factors, including the timing of dynamization, fracture morphology, and the presence of biological factors that influence healing [2, 23]. The study aims to evaluate and compare the impact of dynamization versus non-dynamization on the union of tibia shaft fractures in patients undergoing treatment, as determined through clinical outcomes and fracture healing rates.

METHODOLOGY & MATERIALS

The retrospective case-control study was conducted at the Department of Orthopaedic Surgery Bangabandhu Sheikh Mujib Medical University, Bangladesh from July 2023 to August 2024. Total 100 patients suffering from closed and open grade 1 tibia shaft fractures operated for tibia intramedullary interlocking nailing (static/dynamic). The study cases were divided into two groups, each group containing (N=50) patients.

Case group (N=50): Patients who have undergone tibia nail dynamization at the onset of surgery.
Control Group (N=50): Patients who have not undergone any dynamization.

Inclusion criteria

- Patients aged more than 18 years and both groups.
- Patients with tibial diaphyseal fractures (fracture at any level of diaphysis), closed tibia fractures, and open Gustilo-Anderson type 1 fracture, tibial diaphyseal fracture confirmed with appropriate radiographs.
- Patients who are medically fit for surgery.
- Patients willing to provide voluntary written informed consent for participation in the study.

Exclusion criteria

- Patients with associated intra-articular fractures of proximal/distal tibia, open tibia fractures (Gustilo Anderson type 2 and type 3), tibial diaphyseal fracture with associated tibial plateau fracture.
- Patients who were not willing to surgical intervention.

These patients were evaluated for their fracture healing and clinical condition during a scheduled hospital visit. They were evaluated using variables: whether the union is present or absent and the union rate by comparing time to the union between the two groups. Follow-up clinical evaluation will be made at six weeks,12 weeks, and 24 weeks, which will be noted, and data at the end of 24 weeks will be analyzed for the study.

Statistical analysis

The collected data was coded and entered into a Microsoft Excel spreadsheet, then analyzed using SPSS (Statistical Package for the Social Sciences) version 26.0. The results were presented in tabular and graphical formats, with each table and graph accompanied by a descriptive explanation to ensure clarity. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were reported as frequencies and percentages. The Chi-Square test was used to compare categorical variables. A p-value of less than 0.05 was considered statistically significant, indicating the results' significance.

RESULT

A total of 100 patients with tibia shaft fractures were included in the study, equally divided into two groups: dynamization (n=50) and non-dynamization (n=50). Both groups had an equal number of participants, ensuring a balanced comparison. The age distribution among the case and control groups varied across different age ranges (Table 1). In the case group, the highest proportion of patients was aged 30-39 (40%), followed by those aged 20-29 (36%). The control group also had the highest proportion of patients in the 30-39 age range (50%), with a smaller proportion in the 20-29 years range (22%). The youngest age group (10-19 years) constituted a minor percentage in both groups (2% in the case group and 4% in the control group). The case and control groups exhibited a male predominance (Table 2). In the case group, 70% of the patients were male, while 30% were female. Similarly, the control group had 72% male and 28% female participants. The group distribution was consistent, indicating no significant gender-based differences in the study population. The nature of the injury varied among the participants (Table 3). Road traffic accidents (RTA) were the most common cause of injury, accounting for 66% in the case group and 60% in the control group. Other causes included assault (10% in the case group and 8% in the control group), falls (4% in the case group and 10% in the control group), and farming injuries (8% in both groups). The distribution of injury types was similar between the two groups. Most fractures in both groups were closed fractures (Table 4). In the case group, 88% had closed fractures, while 12% had open type 1 fractures. In the control group, 98% had closed fractures, and only 2% had open type 1 fractures. This distribution highlights the predominance of closed fractures in both groups, with a slightly higher proportion of open fractures in the case group. The two groups assessed and compared the clinical outcomes (Table 5). In the case group, 46% of patients had a fair outcome, 30% had a good outcome, 18% had an excellent outcome, and 6% had a poor outcome. In the control group, 44% of patients had a fair outcome, 34% had a good outcome, 10% had an excellent outcome, and 12% had a poor outcome. The P-value indicated no significant difference in clinical outcomes between the two groups, suggesting that dynamization and non-dynamization approaches yield comparable results in the union of tibia shaft fractures.

Table-1: Group wise age distribution of the study population

Age range (in years)	Case group (N=50)		Control group (N=50)	
	n	%	n	%
10-19	1	2.00	2	4.00
20-29	18	36.00	11	22.00
30-39	20	40.00	25	50.00
40-49	8	16.00	8	16.00
>50	3	6.00	4	8.00
Total	50	100.00	50	100.00

Table-2: Group wise sex distribution of the study population

Gender	Case group (N=50)		Control group (N=50)	
	n	%	n	%
Male	35	70	36	72
Female	15	30	14	28
Total	50	100	50	100

Table-3: Distribution of the type of injury based on case and control group

Type of injury	Case group (N=50)		Control group (N=50)	
	n	%	n	%
Assault	5	10	4	8
Fall	2	4	5	10
Fall of an object	1	2	3	6
Farming injury	4	8	4	8
Industrial injury	3	6	2	4
RTA	33	66	30	60
Sports injury	2	4	2	4

Total	50	100	50	100

Table-4: Distribution of the type of fracture based on case and control group

Type of fracture	Case group (N=50)		Control group (N=50)	
	n	%	n	%
Close	44	88	49	98
Open type 1	6	12	1	2
Total	50	100	50	100

Table-5: Comparison of Clinical Outcomes Between Case and Control Groups.

Outcome	Case group (N=50)		Control group (N=50)		P-value
	n	%	n	%	
Fair	23	46	22	44	NS
Good	15	30	17	34	
Excellent	9	18	5	10	
Poor	3	6	6	12	
Total	50	100	50	100	

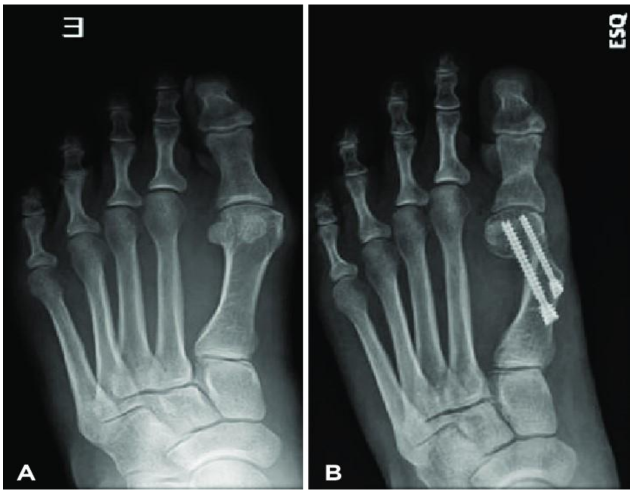

Figure-1: Preoperative radiographic image

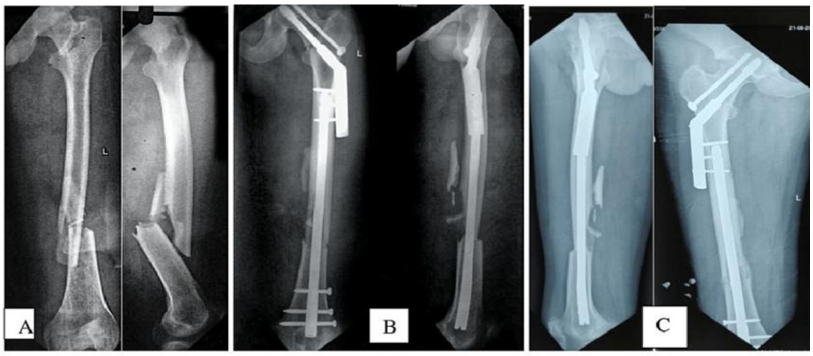

Figure-2: Immediate post-operative radiograph image

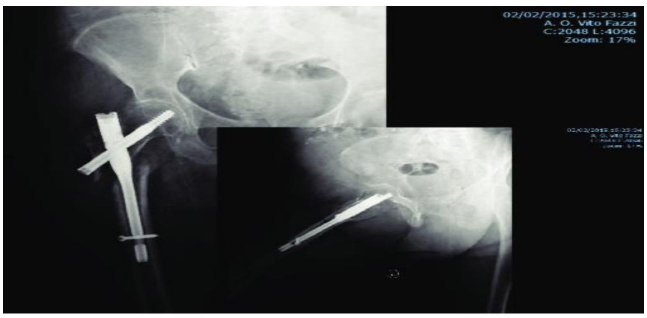

Figure-3: 6 months follow-up X-ray with fracture union

DISCUSSION

The anterior surface of the tibia is predominantly subcutaneous along its length, which increases the susceptibility of the tibia to open fractures. Additionally, the tibia's blood supply is more tenuous than bones surrounded by substantial muscle mass, leading to a higher incidence of delayed union and non-union than other long bones. In tibial injuries, the bone is subjected not only to bending forces but also to rotational forces. Since the knee and ankle joints are hinge joints and do not permit rotational adjustments, it is crucial to ensure that rotational alignment is corrected as closely as possible to the standard anatomical position during treatment [2]. The current study aimed to evaluate the effect of dynamization versus non-dynamization on the union of tibia shaft fractures. The findings provide insight into the clinical outcomes of each approach, highlighting potential implications for treatment decisions in orthopedic surgery. The study included 100 patients, equally divided into two groups: those who underwent dynamization and those who did not. The equal distribution ensured a balanced comparison between the two techniques. Including an equal number of patients in both groups strengthens the reliability of the study, as it minimizes selection bias, which is a crucial aspect of case-control studies. The age distribution between the two groups showed that most patients were in the 20-39 age range, with a higher proportion of patients in the control group aged 30-39 years (50%) compared to the case group (40%). This age distribution aligns with the demographic profile of individuals most likely to sustain tibial shaft fractures due to high-energy trauma, particularly in younger, more active populations. Similar age distribution patterns have been reported in a study conducted by Gunay S *et al*., indicating a common demographic trend among patients with tibia shaft fractures [24]. Gender distribution was similar, with males predominating (70% in the case group and 72% in the control group). This predominance of male involvement can be attributed to males' more significant participation in outdoor activities and engagement in more physically demanding labor than females in the Asian context. A study conducted by Hernandez-Vaquero *et al*. showed a similar level of male involvement [25]. Road traffic accidents (RTA) were the most common cause of injury in both groups, accounting for 66% of cases and 60% of controls. This finding aligns with other studies, which have also identified RTAs as the most common mechanism of injury in tibia fractures. The high incidence of RTAs in our study population underscores the need for improved road safety measures and awareness campaigns to prevent such injuries [2,24]. Other causes of tibia shaft fractures included falls, assaults, and industrial injuries, reflecting the diverse range of mechanisms that can lead to these injuries. The distribution of injury mechanisms is comparable to findings in other research, where similar patterns have been observed [2]. In our study, the types of fractures were predominantly closed, with a small percentage of open fractures. This is consistent with existing literature, where closed fractures are more prevalent due to the nature of tibia shaft injuries, which often occur without the involvement of open wounds [26]. The comparison of clinical outcomes between the two groups revealed some key differences. The case group (dynamization) had a higher proportion of excellent outcomes (18%) compared to the control group (10%). Conversely, the control group had more poor outcomes (12% vs. 6% in the case group). These results suggest dynamization may contribute to better clinical outcomes regarding fracture healing and functional recovery. Our findings align with those of other studies that have explored the effects of dynamization on fracture healing. For instance, a meta-analysis by Hernandez *et al*. highlighted that dynamization significantly improves the time to union compared to static fixation methods [2,27]. Similar results of better union with dynamization have also been observed in various studies, which have been effectively summarized in the systematic review and meta-analysis by Loh *et al*. [28]. Furthermore, a systematic review by Bleeker *et al*. indicated that while dynamization may reduce complication rates, the outcomes are highly dependent on the fracture type and the characteristics of the patient population [29]. This variability underscores the need for further research to delineate the specific dynamization indications and identify patient subsets that may benefit the most from this intervention.

Limitations of the study: Several limitations should be considered when interpreting these results. The study's sample size was relatively small, which may affect the generalizability of the findings. Additionally, the retrospective nature of the study introduces potential biases in patient selection and treatment assignment. A larger, prospective study with randomization could provide more robust evidence regarding the effectiveness of dynamization versus non-dynamization.

CONCLUSION AND RECOMMENDATIONS

In conclusion, while dynamization showed a trend towards better clinical outcomes compared to non-dynamization. However, the difference was not statistically significant in this study. The post operative follow-up radiographical and X-ray shows the improvement and progression. Future research with larger sample sizes and more controlled designs is needed to better understand the role of dynamization in tibia shaft fracture treatment. Clinicians should consider individual patient characteristics and fracture specifics when deciding on the use of dynamization in fracture management.

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