Failure Rates of the Induced Membrane Technique in Tibial Shaft Fractures in the Setting of Ballistic Injury as Compared to Blunt Injury: A Level I Trauma Center's Experience

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INTRODUCTION: The induced membrane technique (IMT) is often used in cases of significant bone loss. Though well-studied in military settings, there remains a paucity of literature comparing the failure rates of the IMT in civilian patients with tibial shaft fractures due to blunt versus ballistic injuries. This study seeks to analyze the failure rates of the IMT in such patients. Secondary objectives include evaluating patient demographics and injury characteristics to identify possible predictors of poor outcomes after the IMT.

METHODS: A retrospective cohort study of 18 subjects undergoing the IMT for a tibial shaft fracture between January 1, 2018, and March 31, 2024, was conducted. Subjects were excluded if they underwent bone transport as the initial management for their bone loss. Failure was defined radiographically as a score less than 10 on the Radiographic Union Scale for Tibial Fractures six months after phase two of the procedure, or if an additional procedure was required to address the fracture. Subjects were then stratified by mechanism of injury – ballistic versus blunt trauma. Failure rates between the two groups were then compared using Fisher's Exact test. Odds ratios were calculated to evaluate the relationship between patient age, smoking status, comorbidities, type of fixation, type of bone grafting used in phase two, number of surgeries on the operative leg, number of days between phase one and two, vascular injury, need for plastic surgery intervention, bone defect size (mm), and failure of the IMT procedure.

RESULTS: The overall failure rate was 77.8%, however there was no significant difference in failure rates between the two groups. Nine subjects sustained their injury due to blunt trauma and nine subjects sustained their injury due to ballistic trauma. The number of surgeries on the affected limb was an independent risk factor for failure (OR 4.52). Increased number of days between phase one and two significantly decreased risk of failure (OR 0.64). Increased age, current smoking status, need for plastic surgery intervention, and larger bone defect size, are correlated with higher risk of failure, however these were not statistically significant (Table 1).

DISCUSSION AND CONCLUSION: This study population has a high overall failure rate of the IMT, though there was no significant difference between ballistic and blunt injuries. It is apparent that the rate of failure in the data presented here is inconsistent with those presented in the existing literature. One potential explanation for this discrepancy is the widespread variation in definitions of both success versus failure, and union versus nonunion across studies. Future investigations should include a large, multicentered prospective study focusing on patients with significant bone loss resulting from ballistic and blunt trauma to best improve patients' post-operative outcomes.

Table 1: Odds Ratio Calculations

Variable	Odds Ratio (95% CI)	*p*
Age (years) • Increment: 10 years	1.35 (0.40, 4.61)	0.63
Smoking Status • Current vs. Former & Never Smoker	4.00 (0.33, 48.65)	0.28
Comorbidities • Presence of ≥ 1 comorbidity vs. None	1.20 (0.09, 15.26)	0.89
Plastic Surgery Intervention • ≥ 1 Plastic Surgery Procedure vs. None	1.33 (0.14, 12.37)	0.80
Elapsed Time between Phases 1 and 2 (days) • Increment: 20 days	0.64 (0.39, 1.07)	0.088
Size of Bone Defect (mm) • Increment: 20mm	1.10 (0.41, 2.99)	0.85
Size of Bone Defect • Bone Defect ≥ 60 mm vs. > 60 mm	4.00 (0.33, 48.65)	0.28
Total Surgeries Performed on Injured Limb • Increment: 2 surgeries	4.52 (1.04, 19.57)	0.044
Type of Fixation at Phase 1 • External Fixator vs. Intramedullary Nail	4.44 (0.19, 102.34)	0.96
Type of Bone Grafting at Phase 2 • Iliac Crest Autograft vs. RIA	1.33 (0.10, 17.10)	0.83
Vascular Injury • Patients who sustained a vascular injury vs. those who did not	0.25 (0.02, 3.04)	0.28

Abbreviations: CI = Confidence Interval, vs = versus, mm = millimeter, RIA = Reamer-Irrigator-Aspirator