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Original Article

Clinical Outcomes of Shoelace-Assisted Wound Closure in Large Traumatic and Fasciotomy Defects: A Prospective Observational Cohort Study at a Tertiary Orthopedic Trauma Institute

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ABSTRACT

Background: Progressive dermatotraction through the shoelace technique represents an economical and simple strategy for managing extensive traumatic and fasciotomy-related wounds. This investigation assessed its clinical performance and safety profile. **Objectives:** To evaluate clinical outcomes using the shoelace suturing method in patients presenting with large traumatic or fasciotomy wounds exceeding 50 cm² post-debridement. **Methods & Materials:** A prospective cohort investigation was performed at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh, spanning June 2021 to June 2026. Thirty consecutive patients with substantial post-debridement wounds underwent treatment with progressive shoelace fixation at 24–72-hour intervals. Primary outcome was successful wound approximation and definitive closure without flap reconstruction. Secondary measures included time to healing, number of tightening cycles, need for skin autografting, adverse events, and duration of hospitalization. **Results:** Participant cohort included 19 males and 11 females (mean age 38.6 ± 14.2 years). Eighteen wounds resulted from blunt or penetrating injury, while 12 arose from compartment syndrome fasciotomy. Mean wound surface area was 95.2 ± 38.6 cm². Successful definitive closure without flap reconstruction occurred in 28 patients (93.3%). Four cases required autografting (13.3%), and two necessitated flap reconstruction (6.7%). Average interval to complete closure measured 8.8 ± 4.1 days. Adverse events included wound infection (n=3, 10.0%), marginal necrosis (n=1, 3.3%), and partial separation (n=1, 3.3%). Mean hospitalization duration was 13.0 ± 5.2 days. **Conclusions:** In appropriately selected patients, the shoelace-assisted closure technique demonstrates substantial efficacy for wound-margin approximation with high rates of primary closure without flap reconstruction in large traumatic and fasciotomy wounds.

Keywords: *Shoelace technique; progressive dermatotraction; fasciotomy wounds; traumatic wounds; wound closure*

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INTRODUCTION

Extensive tissue loss stemming from mechanical trauma, crushing mechanisms, or surgical fasciotomy remains among the most challenging reconstructive problems encountered in orthopedic surgery[1]. Management approaches encompass postponed primary approximation, application of negative-pressure wound therapy (NPWT), partial-thickness autografting, and utilization of autologous tissue flaps (local, regional, or free transfers). Selection of the optimal strategy depends upon multiple factors: wound dimensions, degree of contamination, quantity of remaining soft tissue, vascular perfusion adequacy, presence of structural support, surgeon expertise, and available institutional resources[2].

Progressive suture-based traction of wound margins, commonly designated the shoelace technique, employs placement of standard suture material or vessel loops in an interlocking configuration with methodical sequential tightening to progressively narrow the wound[3]. This approach has proven beneficial for extensive fasciotomy closures and burn-related tissue deficits[4]. Compared with negative-pressure systems, this technique utilizes conventional operative supplies and permits administration in inpatient general wards or ambulatory clinic environments requiring minimal technological infrastructure[5].

Contemporary international publications demonstrate encouraging findings with this approach, including favorable comparisons with vacuum-assisted systems [6,7]. Recent systematic evaluation by Obuh and colleagues emphasized the advantageous cost profile and acceptable morbidity trajectory associated with dermatotraction methodologies in economically constrained regions[8]. Nevertheless, comprehensive data from the South Asian context remain sparse. Considering the substantial incidence of traumatic morbidity and fasciotomy requirements within our geographic region, evaluation of this technique warrants investigation[9].

This investigation aimed to prospectively appraise the clinical effectiveness, safety considerations, and utility of shoelace-assisted closure in patients with substantial traumatic and fasciotomy wounds managed at a tertiary referral center for orthopedic trauma in Bangladesh.

OBJECTIVES

Primary Objective: To assess the rate of successful wound closure without requirement for flap reconstruction utilizing the shoelace suturing approach in large traumatic and fasciotomy wounds. Secondary Objectives: To document (1)

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duration from injury to technique initiation; (2) number of progressive tightening procedures; (3) mean intervals separating tightening sessions; (4) total time to complete wound approximation; (5) proportion requiring autograft reconstruction; (6) proportion requiring flap-based coverage; (7) frequency and nature of wound-related complications; (8) length of institutional stay; and (9) wound quality and aesthetic parameters at designated follow-up intervals.

METHODS & MATERIALS

Study Design, Setting, and Duration

A prospective observational cohort design was implemented at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh, between June 2021 and June 2026. NITOR functions as a 1000-bed tertiary referral facility specializing in orthopedic trauma and rehabilitative centre. Institutional review board approval was granted by the NITOR Ethics Committee. All participants or authorized legal representatives furnished signed informed consent prior to study enrollment. The investigation adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting standards for observational research and complied with the Declaration of Helsinki principles. Participants explicitly consented to utilization of clinical photographs for academic dissemination.

Participant Selection Criteria

Inclusion Criteria:

- Age ≥10 years
- Large traumatic or fasciotomy-related defects measuring ≥50 cm² following adequate debridement
- Presence of sufficient soft-tissue margins facilitating stepwise approximation
- Wound stability appropriate for technique application following initial debridement and hemodynamic stabilization
- Ability to furnish informed permission and maintain compliance with structured follow-up assessments

Exclusion Criteria:

- Defects suitable for immediate primary approximation
- Predetermined requirement for early flap reconstruction
- Severe arterial or venous injury mandating emergent flap coverage
- Critical anatomic structures exposed (arterial/venous, neural tissue, skeletal, or tendinous elements) with inadequate intervening tissue
- Unwillingness or inability to comply with serial follow-up
- Loss to clinical follow-up prior to complete closure

Operative Procedure

All participants underwent comprehensive wound evaluation and iterative debridement procedures to eliminate necrotic elements, foreign material, and bacterial contamination. Upon achievement of hemodynamic stability and development of a clean wound base with viable granulation tissue, the shoelace technique was implemented. The wound margin was irrigated with isotonic saline and carefully dried. Suture material (typically 1-0 or 2-0 polypropylene non-absorbable or polydioxanone absorbable suture, selected according to surgeon preference) was positioned perpendicular to the wound margin, approximately 1.0–1.5 cm distant from the edge, in a crossover pattern with spacing intervals of 1.5–2.0 cm. Sutures were initially left untightened. Methodical advancement was undertaken at 24–72-hour intervals to progressively narrow wound margins whilst minimizing the risk of ischemic injury. Tightening sessions transpired under aseptic technique in the general ward or ambulatory clinic setting. Following each intervention, comprehensive wound inspection was performed evaluating tissue viability, presence of infection, and ischemic changes. Tightening was discontinued upon achievement of satisfactory approximation or when further narrowing became infeasible.

Postoperative Care and Wound Administration

Daily wound management incorporated sterile dressing replacement utilizing isotonic saline cleansing and low-adherence dressing materials. Antibiotic administration (both preventive and therapeutic) was determined by clinical assessment, wound characteristics, and bacterial culture results when obtainable. Discomfort management followed institutional pain control protocols. Continuous observation was maintained for indicators of wound infection, partial separation, and tissue ischemia. Upon satisfactory wound-margin approximation, definitive closure was accomplished through one of three methodologies: (1) Primary approximation with interrupted or continuous absorbable suture material; (2) Partial-thickness autograft reconstruction; (3) Autologous flap-based reconstruction (local or regional transfer). Selection of final closure approach was determined by the responsible surgeon based on wound status, accessible soft-tissue options, and clinical decision-making.

Data Acquisition and Outcome Measures

Baseline demographics, wound specifications, procedural parameters, and clinical outcomes were documented systematically utilizing a standardized data capture instrument. Photographic documentation was obtained at essential intervention stages. Primary Outcome: Achievement of definitive closure via direct approximation or autografting without necessity for flap reconstruction. Secondary Outcomes: (1) Time interval from injury through technique initiation; (2) quantity of sequential tightening procedures; (3) mean duration between procedures; (4) complete time to wound closure; (5) frequency of autograft requirement; (6) frequency of flap reconstruction; (7) adverse event incidence and classification; (8) total hospitalization duration; (9) healing characteristics and cosmetic quality at 6 weeks, 3 months, and 6 months post-discharge.

Statistical Methods

Numerical variables are presented as mean ± standard deviation (SD) with ranges or 95% confidence intervals where appropriate. Categorical parameters are summarized as frequencies and proportions. Descriptive statistical analysis was performed for all measured outcomes. Given the single-arm observational design without comparative reference group, inferential statistical testing was not performed. Data examination was conducted utilizing SPSS software (release 26.0, IBM Corporation, Armonk, New York, United States).

Ethical Approvals and Considerations

Approval for this investigation was obtained from the Institutional Review Board at NITOR (NITOR-IRB/2021/006). All procedures adhered to the tenets of the Declaration of Helsinki. Written informed consent was procured from all participants or authorized legal guardians. When clinical photographs containing identifying characteristics were incorporated, explicit written permission was obtained prior to manuscript preparation.

RESULTS

Participant and Wound Characteristics

Thirty participants were enrolled. The mean age was 38.6 ± 14.2 years (range 10–68), and 19 participants were male. Wounds followed traumatic injury in 18 participants and fasciotomy for compartment syndrome in 12; most defects involved the lower extremity. Open fractures were present in 14 participants. Associated injuries included vascular compromise in 8 participants, neurological injury in 6, and significant soft-tissue deficiency requiring a reconstruction strategy in 7. A mean of 2.4 ± 0.9 debridement procedures (range 1–4) was performed before shoelace application. Detailed baseline demographics and wound characteristics are presented in *Table I*.

Table I
Baseline Participant Demographics and Wound Specifications (*n*=30).

Characteristic	Value (n=30)
Age (years), mean ± SD (range)	38.6 ± 14.2 (10–68)
Male, n (%)	19 (63.3%)
Female, n (%)	11 (36.7%)
Traumatic wounds, n (%)	18 (60.0%)
Fasciotomy wounds, n (%)	12 (40.0%)
Lower limb location, n (%)	26 (86.7%)
Upper limb location, n (%)	4 (13.3%)
Wound length (cm), mean ± SD	14.8 ± 5.2
Wound width (cm), mean ± SD	6.4 ± 2.1
Wound area (cm²), mean ± SD (range)	95.2 ± 38.6 (50–180)
Open fractures present, n (%)	14 (46.7%)
Associated vascular injury, n (%)	8 (26.7%)
Associated neurological injury, n (%)	6 (20.0%)
Significant soft-tissue loss, n (%)	7 (23.3%)
Mean debridement procedures ± SD (range)	2.4 ± 0.9 (1–4)

Shoelace Application and Treatment Outcomes

The shoelace technique was initiated a mean of 3.6 ± 1.8 days after injury or fasciotomy. Definitive closure without flap reconstruction was achieved in most participants; two required flap coverage, and no free tissue transfer was needed. Wound-related complications were managed with antimicrobial therapy, conservative care, or delayed re-approximation, as appropriate; no serious complications such as recurrent compartmentalization, vascular insufficiency, or systemic infection were documented. Mean hospitalization was 13.0 ± 5.2 days (range 7–28). Detailed treatment outcomes are summarized in *Table II*, and the progressive shoelace application is illustrated in *Figure 1*.

Table II
Shoelace Application and Primary Treatment Outcomes (*n*=30).

Outcome Parameter	Value (n=30)
Time to technique initiation (days), mean ± SD (range)	3.6 ± 1.8 (1–8)
Number of tightening procedures, mean ± SD (range)	3.2 ± 1.1 (2–5)
Interval between procedures (days), mean ± SD	2.3 ± 0.7
Time to definitive closure (days), mean ± SD (range)	8.8 ± 4.1 (4–18)
Closure without flap coverage, n (%)	28 (93.3%)
Primary closure via suturing, n (%)	24 (80.0%)
Partial-thickness autograft required, n (%)	4 (13.3%)
Flap coverage required, n (%)	2 (6.7%)
Wound-related complications, n (%)	5 (16.7%)
Wound infection, n (%)	3 (10.0%)
Marginal tissue necrosis, n (%)	1 (3.3%)
Partial wound separation, n (%)	1 (3.3%)
Mean hospitalization (days), mean ± SD (range)	13.0 ± 5.2 (7–28)

Structured follow-up evaluation transpired at 6-week, 3-month, and 6-month post-discharge timepoints. Mean observation interval was 6.4 ± 2.1 months. Terminal assessment encompassed evaluation of complete epithelialization, scar tissue maturation, articulation mobility in adjacent joints, functional capacity, and recurrent wound complications. Majority of cases demonstrated satisfactory to excellent healing trajectory with minimal scar formation. Zero participants required revision surgical intervention or supplementary reconstruction throughout observation period.

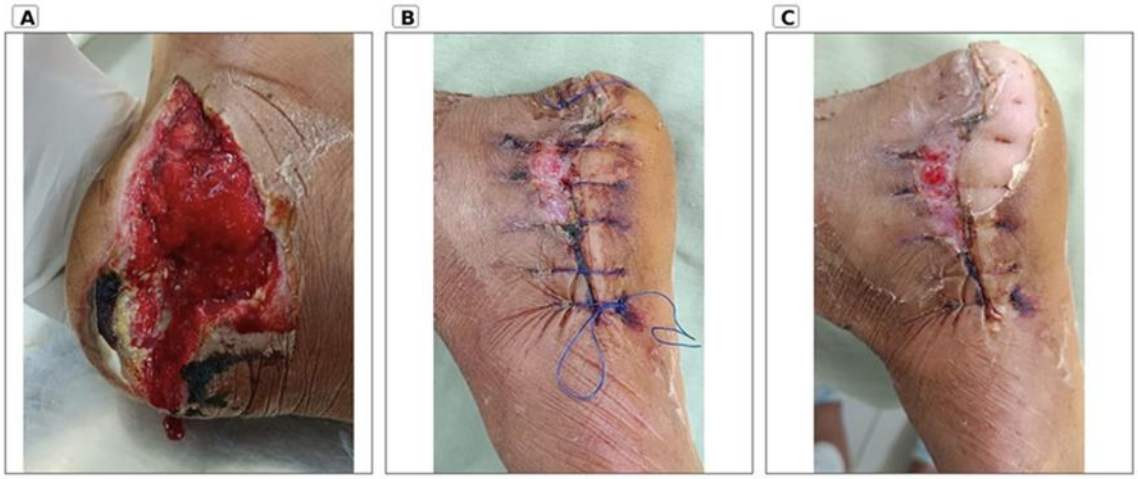


Figure 1 Sequential intraoperative and early postoperative photographic documentation illustrating progressive shoelace suturing methodology in a substantial traumatic wound. Panel A demonstrates expansive open defect antecedent to suture implementation. Panel B illustrates placement of progressive sutures demonstrating initial wound-margin approximation. Panel C exhibits continued margin narrowing with evidence of healthy granulation tissue following iterative tightening maneuvers.

DISCUSSION

This prospective investigation of 30 participants documented that implementation of shoelace-assisted wound closure achieved satisfactory margin approximation and definitive healing without flap reconstruction in 93.3% of substantial traumatic and fasciotomy-related wounds. The technique successfully addressed defects averaging 95.2 cm² within approximately 9 days subsequent to suture placement, requiring approximately three sequential tightening interventions spaced at roughly 24–72 hour intervals. These outcomes substantiate the efficacy of shoelace-assisted closure as a valuable reconstructive strategy for wound management.

Current findings demonstrate concordance with and extension of established international literature. Zorrilla and colleagues documented management of 18 fasciotomy defects utilizing progressive suture traction, achieving closure in 17 instances (94.4%) with mean healing duration of 8.8 days[10]. Kakagia et al. executed prospective randomization comparing shoelace suturing with vacuum-assisted systems for fasciotomy wounds, documenting superior direct closure proportions and expedited healing intervals with progressive suturing[11]. Johnson et al. prospectively contrasted progressive suture technique with negative-pressure reconstruction following extremity fasciotomy, determining that 88% of defects managed with progressive traction achieved direct closure as opposed to 68% in the negative-pressure cohort[12]. Within a retrospective series of 25 participants with electrical-burn fasciotomy wounds, Arumugam and collaborators documented successful closure in 24 cases (96%) with median healing interval of 7 days employing progressive suturing[13]. Recently, Onoe et al. communicated experience managing 62 participants with extremity fasciotomy wounds, establishing that progressive suturing technique accomplished direct closure in 49 subjects (79%), with 13 necessitating autografting[14]. Our documented closure proportion of 93.3% and autograft frequency of 13.3% demonstrate favorable alignment with published evidence.

Practical Advantages:

The progressive suturing approach demonstrates substantial practical merits. First, the methodology utilizes readily obtainable materials (conventional suture materials or vascular loops) necessitating neither specialized instrumentation nor substantial financial expenditure. Second, sequential tightening can be executed within ambulatory or ward environments without requirement for negative-pressure apparatus or dedicated operative facilities. Third, the technique demonstrates straightforward implementation, necessitating only fundamental surgical proficiency. Fourth, avoidance of negative-pressure dressing system expenses and operational complexity renders this approach particularly suitable in economically constrained resource environments[15].

Within our series, complication incidence remained within acceptable parameters. Wound infection occurred in 3 participants (10.0%) and was successfully managed via antimicrobial intervention and intensified dressing protocols. One participant demonstrated marginal tissue necrosis (3.3%) and one experienced partial separation (3.3%), both resolving through conservative administration. These complication proportions demonstrate equivalence to or improvement upon frequencies documented with negative-pressure wound therapy[15]. Critical complications including fulminant infection, advancing tissue necrosis, or systemic inflammation were not encountered.

Technical Limitations:

The progressive suturing methodology encompasses significant constraints and is not universally applicable. The technique necessitates adequate soft-tissue reserves on both defect margins to facilitate progressive approximation. Implementation is contraindicated when critical vascular, neurological, osseous, or tendinous structures remain exposed without intervening tissue buffer, as underlying anatomy faces compromise during tightening maneuvers. Within our series, 8 participants displayed associated vascular injury; nevertheless, these compromised structures underwent vascular reconstruction prior to technique implementation. Similarly, progressive closure is inappropriate for defects demonstrating severe vascular insufficiency or compromised microvascular perfusion incapable of supporting gradual margin narrowing. Within such scenarios, emergent flap-based reconstruction remains the optimal methodology[16].

The progressive suturing methodology demands participant cooperation and psychological tolerance throughout sequential tightening procedures. Throughout our series, all enrolled participants completed therapeutic protocols, suggesting favorable tolerability. Nevertheless, in participants experiencing severe discomfort, psychological distress, or logistical barriers to repeated procedures, implementation feasibility may be compromised[17].

Study Limitations:

This investigation encompasses several methodological constraints. First, the single-institution observational design without comparative reference populations does not establish methodological superiority over negative-pressure systems, deferred closure, autografting, or flap reconstruction methodologies through randomized methodology. Second, the participant cohort of 30 individuals, while comparable to numerous published series, remains modest for robust statistical examination. Third, observation duration restricted to mean 6.4 months; protracted assessment regarding scar quality, functional capacity, and chronic complications would enhance understanding[18]. Fourth, the extended timeframe from 2021 to 2026 potentially encompassed modifications in operative techniques and wound-administration protocols. Fifth, systematic quality-of-life evaluation and participant satisfaction assessment were not formally performed, though observational data indicated satisfactory acceptance.

Progressive suturing methodology demonstrates particular applicability in economically constrained environments where negative-pressure systems remain inaccessible or fiscally prohibitive. Optimal implementation requires integration within comprehensive wound-administration protocols encompassing satisfactory initial debridement, antimicrobial management, nutritional optimization, and judicious deployment of autografting or flap reconstruction when indicated. The technique optimally addresses substantial traumatic and fasciotomy defects demonstrating adequate soft-tissue margins and absence of critical structural exposure, managed within dedicated trauma facilities providing suitable infrastructure and appropriately trained personnel.

Prospective investigations should incorporate randomized controlled designs directly contrasting progressive suturing against negative-pressure systems and supplementary modalities, implementation of standardized outcome quantification (encompassing validated scar appraisal instrumentation), and protracted observation intervals for functional and aesthetic evaluation. Cost-utility investigation and quality-of-life analysis would demonstrate particular relevance within economically restricted contexts.

CONCLUSION

Implementation of shoelace-assisted suture closure accomplished satisfactory healing proportion devoid of flap reconstruction (93.3%) in carefully selected substantial traumatic and fasciotomy wounds at a tertiary orthopedic trauma institute. Characteristics including operative simplicity, expedited healing intervals, minimal fiscal requirements, and modest infrastructure prerequisites establish this methodology as a pragmatic reconstructive strategy in economically constrained resource environments. Comparative investigation remains warranted to delineate optimal positioning within the reconstructive armamentarium and refined participant selection parameters.

CONFLICT INTERESTS

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