



ORIGINAL RESEARCH ARTICLE

LMWH prophylaxis after digital replantation and early vascular compromise

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ABSTRACT

Background: Early vascular compromise remains a major cause of failure after digital replantation, and the optimal low-molecular-weight heparin (LMWH) regimen remains unclear. This study compared intensified versus standard LMWH prophylaxis for preventing early vascular compromise after digital replantation.

Materials and methods: In this single-center retrospective cohort study, consecutive adult patients undergoing digital replantation (2023–2025) were included. All procedures were performed by one microsurgeon. Postoperative LMWH was administered subcutaneously for 7 days as either 5000 international units once daily (QD) or twice daily (BID), according to a preexisting department protocol. The primary endpoint was a composite of early vascular compromise, including vascular crisis, re-exploration, therapeutic bloodletting/leech therapy, or digit failure.

Results: Sixty-nine patients (85 digits) were included (QD: 39 patients; BID: 30 patients). The primary endpoint occurred in 12/39 patients in the QD group versus 1/30 in the BID group. All vascular crises were venous. Digit failure occurred in 5 QD patients, and none in the BID group. No bleeding or transfusion events were observed.

Conclusions: Twice-daily LMWH prophylaxis was associated with fewer early vascular compromise events after digital replantation compared with once-daily dosing. These findings are hypothesis-generating and require prospective validation.

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Introduction

Digital replantation can restore function and improve quality of life after traumatic digit amputation; however, early postoperative vascular compromise remains a major cause of replant failure and digit loss [1]. Early compromise most commonly occurs during the first postoperative days, when impaired inflow or, more often, inadequate venous outflow may rapidly threaten survival of the replanted digit [2–5].

Despite the clinical importance of this problem, postoperative systemic antithrombotic management remains highly variable across centers. Perioperative anticoagulation protocols differ substantially with respect to agent selection, timing, and intensity, reflecting persistent uncertainty about how best to balance potential benefits in reducing microvascular thrombosis against potential harms such as bleeding [6, 7]. Systematic reviews have highlighted marked heterogeneity in practice and the absence of high-quality evidence supporting a standard systemic anticoagulation regimen after digital replantation [6, 8, 9].

Low-molecular-weight heparin (LMWH) is commonly used in this setting because of its predictable pharmacokinetics, ease of administration, and favorable practical profile compared with unfractionated heparin [8–10]. However, evidence supporting LMWH specifically in digital replantation remains limited, and the optimal dosing strategy is unclear [8–10]. Prior literature has largely focused on whether systemic anticoagulation should be used at all, whereas direct comparative data on LMWH dosing intensity or frequency after

digital replantation are scarce. This lack of evidence is clinically relevant because venous congestion-related compromise remains common in the early postoperative period, and even modest differences in prophylactic intensity could influence salvage outcomes [2, 11–13].

Methods

Study design and setting

This retrospective cohort study was conducted at a single tertiary center and included consecutive digital replantation cases performed from January 1, 2023 to January 1, 2025. All replantation procedures during the study period were performed by the same microsurgeon.

Accordingly, the purpose of this study was to compare two postoperative LMWH regimens – 5000 international units (IU) once daily (QD) and 5000 IU twice daily (BID) – for the prevention of early vascular compromise after digital replantation. We hypothesized that intensified prophylactic LMWH dosing (5000 IU twice daily) would be associated with fewer early vascular compromise events without an increase in bleeding-related complications.

This study included all consecutive adult patients (≥ 18 years) who underwent digital replantation during the study period and received postoperative LMWH sodium. Patients were excluded if anticoagulation exposure could not be ascertained from the medical record or if alternative systemic anticoagulants were administered.

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Microvascular reconstruction

Microvascular reconstruction aimed to maximize both arterial inflow and venous outflow whenever technically feasible. The number of repaired vessels was not fixed and varied according to the level of amputation, vessel quality, and whether the case involved single- or multi-digit replantation. In the operative dataset, 57 patients underwent single-digit replantation and 12 underwent multi-digit replantation. At the case level, the number of repaired arteries ranged from 1 to 5, most commonly two arteries (47/69 cases), whereas the number of repaired veins ranged from 0 to 8, most commonly 2–3 veins (53/69 cases). Interposition vein grafts were used selectively when required by intraoperative vessel condition or defect length and were uncommon overall. Nail plate removal was used as an adjunctive method of venous drainage when indicated, particularly in distal replantations; this was performed in 33/36 Tamai I–II cases. External bleeding measures (e.g. controlled bleeding/puncture or medicinal leech therapy) were not used routinely after replantation but were reserved as salvage interventions for clinically evident postoperative venous congestion. Because some patients underwent multi-digit replantation, vessel counts represent case-level totals rather than per-digit counts.

Anticoagulation exposure

Postoperative anticoagulation was initiated only after completion of the entire replantation procedure, including completion of the arterial and venous anastomoses, any indicated skeletal, tendon, or nerve repair, and skin closure, after the patient had returned to the ward. LMWH was not administered intraoperatively or after each individual anastomosis.

All patients received subcutaneous LMWH sodium (Jipailin®) anti-factor Xa IU for 7 days. The once-daily (QD) regimen was 5000 IU every 24 hours, and the twice-daily (BID) regimen was 5000 IU every 12 hours. Regimen assignment (QD vs BID) followed a preexisting department-level routine practice rule based on the parity of the registry patient ID (odd vs even), which was part of routine clinical workflow rather than investigator-directed treatment allocation. The present study was retrospective and did not introduce, alter, or conceal treatment assignment for research purposes. No intentional screening or preferential assignment was performed according to patient characteristics, injury severity, intraoperative findings, or anticipated prognosis. This retrospective study was approved by the institutional review board. A written informed consent was obtained from all patients in accordance with institutional requirements. All patients were treated according to routine clinical practice, and the present study involved retrospective analysis of existing clinical data.

Postoperative management and monitoring

All patients remained hospitalized for at least 7 postoperative days during the anticoagulation period. During this interval, vascular monitoring and clinical assessment were performed by the replantation team according to routine postoperative clinical criteria, including skin color, turgor, capillary refill, pinprick bleeding, temperature, and Doppler signal. Escalation of care was triggered by clinically evident vascular compromise. Venous congestion was suspected in the setting of cyanosis/duskiness, increased turgor, brisk dark pinprick bleeding, or deterioration in venous outflow, whereas arterial insufficiency was suspected in the setting of pallor, coolness, delayed or absent capillary refill, poor pinprick bleeding, or loss of Doppler signal. Depending on the clinical pattern and severity, escalation could include intensified monitoring, salvage

bloodletting or medicinal leech therapy for venous congestion, or return to the operating room for re-exploration. Because the exact charted frequency of vascular checks and the precise bedside-versus-operative escalation threshold were not uniformly retrievable from the retrospective record, these details could not be analyzed as formal protocolized variables.

Outcomes

The primary outcome was a patient-level composite endpoint of any of the following within 7 postoperative days: documented vascular crisis (arterial insufficiency or venous congestion), unplanned return to the operating room for re-exploration, salvage bloodletting therapy (e.g. controlled bleeding/puncture or medicinal leeches), or any digit failure. Vascular crisis was defined as acute clinical evidence of compromised perfusion prompting escalation of monitoring and/or salvage intervention, assessed using standard postoperative criteria including skin color, turgor, capillary refill, pinprick bleeding, temperature, and Doppler signal (e.g. cyanosis/duskiness with brisk dark bleeding for venous congestion; pallor/coolness with delayed or absent capillary refill for arterial insufficiency) [14, 15]. Re-exploration or salvage external bleeding measures were initiated when these findings were judged by the replantation team to represent clinically meaningful vascular compromise requiring escalation beyond routine bedside monitoring. Secondary outcomes included the individual components of the composite, venous versus arterial crisis, and any digit failure. Digit failure was defined as complete necrosis requiring debridement or revision amputation, or partial failure in multi-digit replantations when any replanted digit became nonviable. Additional descriptive postoperative-course and follow-up outcomes included postoperative bed rest duration and 6-month static two-point discrimination. Bed rest duration was recorded in days during the index hospitalization. Static two-point discrimination was assessed at approximately 6 months in patients with surviving replanted digits and available follow-up and is presented as a descriptive functional outcome. These additional outcomes were not components of the primary endpoint and were not included in the prespecified adjusted regression models.

We extracted variables anticipated to influence outcomes, including age, sex, current smoking, injury mechanism (sharp vs crush/avulsion), level of amputation (Tamai distal I–III vs proximal IV–V), and operative technical variables including case-level numbers of repaired arteries and veins, interposition vein graft use, nail plate removal, and ischemia time. Given the limited number of outcome events, adjusted analyses were prespecified to include a small set of clinically relevant covariates.

Statistical analysis

Categorical variables were compared using Fisher's exact test when expected cell counts were <5 and chi-square tests otherwise. Continuous variables were compared using Welch's *t* test for approximately normally distributed data and the Mann–Whitney *U* test otherwise. The primary effect measure was the odds ratio (OR) for the patient-level primary composite endpoint comparing BID versus QD dosing; we additionally reported absolute risk differences with 95% confidence intervals.

Adjusted analyses were prespecified to include a limited set of clinically relevant covariates to mitigate overfitting, given the small number of outcome events. Because outcome events were rare in the BID group, the primary adjusted model used Firth penalized logistic regression to reduce small-sample bias and

address potential separation. The model included age (continuous), current smoking (yes/no), injury mechanism (sharp vs crush/avulsion), and Tamai group (proximal IV–V vs distal I–III). For comparison, we also fit a conventional maximum-likelihood logistic regression model with the same covariates.

Sensitivity analyses were performed to assess the robustness of the findings and to explore potential residual confounding. To account for potential temporal changes over the study period, we repeated the Firth model with an additional indicator for earlier versus later cases, defined according to chronological case order. We also repeated the main comparison using a more objective composite endpoint consisting of re-exploration, salvage external bleeding therapy (controlled bleeding/puncture or medicinal leeches), or any digit failure, excluding documented vascular crisis without downstream intervention.

Missing data were handled with complete-case analysis. Two-sided *p*-values < 0.05 were considered statistically significant. Analyses were performed in Python (SciPy and statsmodels); Firth penalized logistic regression was implemented using a custom script based on standard penalized-likelihood methodology.

Ethics

This study was approved by the institutional review board. A written-informed consent was obtained from all patients. This study was conducted in accordance with the Declaration of Helsinki.

Reporting

This observational study is reported in accordance with the STROBE statement [16].

Results

Study population

The cohort included 69 patients undergoing digital replantation, comprising 85 replanted digits (QD: 39 patients, 47 digits; BID: 30 patients, 38 digits). Baseline and operative characteristics were broadly comparable between groups (Table 1). In addition to similar demographic and injury profiles, operative technical variables were also balanced between groups, including case-level numbers of repaired arteries and veins, interposition vein graft use, nail plate removal, and ischemia time. Local anesthesia was used in most cases, and injury mechanism did not differ materially between groups after subdivision into sharp, crush, and avulsion categories. All patients completed inpatient monitoring during the 7-day postoperative observation window. When stratified by the dichotomized Tamai grouping used in this study, proximal IV–V cases underwent more venous repairs and were less likely to undergo nail plate removal than distal I–III cases (Supplementary Table S3).

Primary endpoint

The primary composite endpoint occurred in 12/39 (30.8%) patients in the QD group and 1/30 (3.3%) patients in the BID group (OR 0.08, 95% CI 0.01–0.64; *p* = 0.004; Table 2). In a descriptive analysis stratified by injury mechanism, fewer primary-endpoint events were observed with BID dosing in both sharp and crush injuries; however, subgroup numbers were small, particularly for avulsion injuries (Supplementary Table S2). The absolute risk

Table 1. Baseline and operative characteristics by the postoperative LMWH regimen.

Characteristic	QD (5000 IU once daily) (n = 39)	BID (5000 IU twice daily) (n = 30)	<i>p</i>
Patients, <i>n</i>	39	30	–
Replanted digits, <i>n</i>	47	38	–
Age, y	47.2 ± 9.2	46.7 ± 10.5	0.846
Male sex, <i>n</i> (%)	31 (79.5)	29 (96.7)	0.067
Current smoking, <i>n</i> (%)	15 (38.5)	17 (56.7)	0.152
Single-digit replantation, <i>n</i> (%)	33 (84.6)	24 (80.0)	0.751
Injury mechanism, <i>n</i> (%)			0.740
Sharp	21 (53.8)	14 (46.7)	
Crush	16 (41.0)	15 (50.0)	
Avulsion	2 (5.1)	1 (3.3)	
Tamai level, <i>n</i> (%)			1.000
Distal I–III	29 (74.4)	22 (73.3)	
Proximal IV–V	10 (25.6)	8 (26.7)	
Repaired arteries per case, median (IQR)	2 (1.5–2.0)	2 (1.0–2.0)	0.923
Repaired veins per case, median (IQR)	3 (2.0–3.0)	3 (2.0–3.0)	0.928
Interposition vein graft use, <i>n</i> (%)	2 (5.1)	1 (3.3)	1.000
Nail plate removal, <i>n</i> (%)	25 (64.1)	23 (76.7)	0.301
Ischemia time, h, median (IQR)	9 (8–11)	9 (8–11)	0.898
Anesthesia, <i>n</i> (%)			0.187
Local	35 (89.7)	25 (83.3)	
Brachial plexus	3 (7.7)	1 (3.3)	
General	1 (2.6)	4 (13.3)	

Note: Continuous variables are presented as mean ± SD or median (IQR), as appropriate. Categorical variables are presented as *n* (%). *P* values were calculated with Welch's *t* test, Fisher's exact test, chi-square test, or Mann–Whitney U test, as appropriate. Repaired artery and vein counts are case-level totals; 57 patients underwent single-digit replantation and 12 underwent multi-digit replantation. Interposition vein graft use was recorded at the case level. LMWH: low-molecular-weight heparin; IQR: interquartile range; IU: international units; SD: standard deviation.

reduction was 27.4% (95% CI, 9.4–43.3%), corresponding to an approximate number needed to treat of 4, acknowledging the observational design and small sample. Because the total number of primary-endpoint events was limited, the prespecified adjusted model was restricted to a small number of clinically relevant covariates to reduce overfitting; operative technical variables were therefore examined descriptively rather than entered simultaneously into the primary multivariable model.

Table 2. Outcomes by the postoperative LMWH regimen (patient-level).

Outcome	QD (5000 IU once daily) (n = 39)	BID (5000 IU twice daily) (n = 30)	<i>p</i>
Clinically significant vascular crisis (documented)	7/39 (17.9)	1/30 (3.3)	0.125
Re-exploration for vascular compromise	7/39 (17.9)	1/30 (3.3)	0.125
Therapeutic bloodletting/external bleeding	4/39 (10.3)	0/30 (0.0)	0.127
Any digit failure (patient-level)	5/39 (12.8)	0/30 (0.0)	0.064
Primary composite endpoint	12/39 (30.8)	1/30 (3.3)	0.004
Bleeding/transfusion/hematoma	0/39 (0.0)	0/30 (0.0)	1.000
Partial skin necrosis	1/39 (2.6)	1/30 (3.3)	1.000
Surgical site infection	0/39 (0.0)	0/30 (0.0)	1.000
Bed rest duration, d	7.21 ± 1.36 (n = 39)	7.30 ± 0.92 (n = 30)	0.731
6-Month static two-point discrimination, mm	6.79 ± 2.87 (n = 38)	7.58 ± 1.09 (n = 26)	0.131

Note: Values are presented as *n*/*N* (%) or mean ± SD, as appropriate. *P* values were calculated with Fisher's exact test, chi-square test, Welch's *t* test, or Mann–Whitney U test, as appropriate. All outcomes are patient-level. LMWH: low-molecular-weight heparin; IU: international units; SD: standard deviation; QD: once daily; BID: twice daily.

Vascular compromise characteristics

Documented postoperative vascular crises were exclusively venous in nature (8/8). Re-exploration for vascular compromise occurred in eight patients, with a median time to re-exploration of 1 day (IQR 1–2). Therapeutic bloodletting or external bleeding measures were performed in 4 patients, all in the QD group.

Digit survival and safety

Any digit failure (complete or partial) occurred in 5/39 (12.8%) QD patients and 0/30 (0%) BID patients ($p = 0.064$). No documented bleeding, transfusion, or hematoma events were identified in the medical record in either group. Partial skin necrosis was uncommon (QD: 1/39, BID: 1/30), and no surgical site infections were recorded.

Additional descriptive postoperative-course and follow-up outcomes

Bed rest duration did not differ between groups (QD: 7.21 ± 1.36 days vs BID: 7.30 ± 0.92 days; $p = 0.731$). Six-month static two-point discrimination, available in patients with surviving replanted digits and follow-up data, was 6.79 ± 2.87 mm in the QD group ($n = 38$) and 7.58 ± 1.09 mm in the BID group ($n = 26$; $p = 0.131$).

Adjusted and sensitivity analyses

In the unadjusted analysis, BID dosing was associated with lower odds of the composite endpoint (OR 0.08, 95% CI 0.01–0.64; $p = 0.004$). In the prespecified Firth penalized multivariable model, BID dosing remained associated with the composite endpoint (adjusted OR 0.09, 95% CI 0.02–0.55; $p = 0.009$; Table 3). Sensitivity analysis additionally adjusting for chronological case order yielded consistent results (adjusted OR 0.10, 95% CI 0.02–0.57; $p = 0.010$; Supplementary Table S1).

Discussion

In this retrospective cohort of 69 patients (85 replanted digits), an intensified postoperative LMWH regimen (5000 IU twice daily for 7 days) was associated with fewer early vascular compromise events after digital replantation than once-daily dosing. This association remained consistent after adjustment for key clinical covariates in the prespecified Firth penalized model. No documented bleeding, transfusion, or hematoma events were identified in the medical record in either group; however, given the modest sample size, these findings should not be interpreted as excluding uncommon bleeding-related complications. The predominance of local anesthesia in this cohort reflects our institutional practice in selected cooperative adult

patients, whereas brachial plexus block or general anesthesia was used selectively according to patient tolerance, operative extent, and injury complexity.

Because the primary endpoint was a composite, its individual components did not each reach statistical significance on their own. Accordingly, the observed between-group difference should be interpreted as reflecting the overall burden of clinically meaningful vascular compromise during the first postoperative week rather than a single dominant event type. This interpretation is consistent with the clinical rationale for using a composite endpoint in a small observational cohort, where individual adverse events are infrequent but collectively represent the early failure pathway most relevant to replant survival.

Our findings are directionally consistent with the broader literature, emphasizing that the early postoperative period after digital replantation is often dominated by venous outflow problems and microvascular thrombosis. Prior work has suggested that venous complications account for a substantial proportion of early failures, and that the number of repaired veins may influence short-term survival. In our cohort, all documented vascular crises were venous, and the close overlap between venous crisis and re-exploration further underscores the clinical importance of vigilant venous monitoring and timely salvage intervention in the first postoperative days [3–5, 13].

Evidence supporting systemic antithrombotic therapy after digital replantation remains inconsistent, and the literature is better characterized by heterogeneous institutional protocols than by a single standard regimen. In the systematic review by Reissis et al., only 7 comparative studies met eligibility criteria, yet 14 distinct perioperative thromboprophylaxis protocols were identified [6]. The updated Cochrane review also concluded that the evidence is insufficient to determine whether LMWH improves digital salvage [8]. Individual reports further illustrate this variability. Continuous systemic heparinization has been associated with improved survival compared with intermittent bolus heparinization in artery-only distal digital replantation [17], whereas a randomized trial of intravenous unfractionated heparin found no overall indication for routine heparin after replantation, despite a possible age-specific signal and biochemical adverse effects in the high-dose group [18]. Other approaches include continuous local intra-arterial infusion of antithrombotic agents [19], provincial or center-specific intravenous heparin protocols [20], therapeutic postoperative intravenous heparin evaluated in a large propensity-matched cohort [21], combined dextran/heparin/fluid regimens [13], and standardized artery-only fingertip protocols using dextran-40, heparin, and leech therapy to maintain low-resistance outflow until venous drainage is reestablished [22].

These protocols should not be treated as interchangeable. Artery-only fingertip replants managed by external bleeding or leech therapy, distal replants with limited venous repair, proximal replants with repaired veins, crush or avulsion injuries, and multi-digit replants differ substantially in venous outflow physiology, endothelial injury, and baseline risk of thrombosis. Likewise, activated partial thromboplastin time (aPTT)-titrated intravenous unfractionated heparin, weight-based pump infusion, local intra-arterial infusion, dextran-based regimens, and fixed-dose subcutaneous LMWH differ in route, monitoring burden, pharmacodynamics, and bleeding profile. For that reason, the present study should not be read as evidence that increasing systemic anticoagulation is uniformly beneficial after digital replantation. It addresses a narrower clinical question within LMWH-based postoperative care: whether, in a single-surgeon cohort treated under the same institutional pathway, twice-daily fixed-dose LMWH was associated with fewer early vascular compromise events than once-daily LMWH.

Table 3. Multivariable firth penalized logistic regression for the primary composite endpoint.

Predictor	Adjusted OR	95% CI	<i>p</i>
LMWH regimen (BID vs QD)	0.09	0.02–0.55	0.009
Age (per year)	1.03	0.95–1.11	0.460
Current smoker (yes vs no)	2.98	0.77–11.52	0.114
Mechanism (sharp vs crush/avulsion)	1.07	0.28–4.18	0.918
Tamai level (proximal IV–V vs distal I–III)	2.98	0.73–12.21	0.128

Note: The Firth penalized logistic regression model was adjusted for age, current smoking, injury mechanism (sharp vs crush/avulsion), and Tamai level (proximal IV–V vs distal I–III). OR: odds ratio; CI: confidence interval; LMWH: low-molecular-weight heparin; QD: once daily; BID: twice daily.

The biologic rationale for this association is plausible but should be interpreted with caution. Early vascular compromise after replantation is not a purely pharmacologic event; it reflects the interaction of endothelial injury, low-flow microcirculation, edema, venous outflow limitation, injury mechanism, vessel quality, and the number and configuration of repaired vessels. In our cohort, all documented vascular crises were venous, which supports the clinical relevance of venous outflow failure as an early pathway to re-exploration or digit loss. A twice-daily LMWH regimen may have provided more consistent anti-Xa exposure during the first postoperative week and thereby reduced microthrombus propagation in a vulnerable low-flow venous system. However, anti-Xa levels were not measured, treatment allocation was retrospective, and no direct comparison was made with pump-administered, weight-adjusted, or aPTT-guided heparin protocols. This explanation therefore remains a mechanistic interpretation rather than proof of a pharmacodynamic dose-response effect.

Injury mechanism remains an important determinant of replantation outcome and may influence both baseline risk and the apparent effect size of postoperative anticoagulation. In the descriptive mechanism-stratified analysis, fewer primary-endpoint events were observed with BID dosing in both sharp and crush injuries; however, subgroup counts were small, particularly for avulsion injuries and for events in the BID group overall. These findings should therefore be regarded as descriptive only and should not be interpreted as evidence that intensified LMWH has uniform benefit across all injury mechanisms. For the adjusted analysis, we retained the prespecified binary mechanism variable (sharp vs crush/avulsion) in order to reduce overfitting in the context of a limited number of outcome events.

This study has several limitations. First, the retrospective single-center design limits causal inference and external validity. In addition, all procedures were performed by a single microsurgeon. Although this reduces inter-surgeon variability, it may also limit generalizability to other centers and operative practices. Second, although LMWH regimen assignment followed a preexisting department-level routine practice rule based on registry patient ID parity rather than deliberate clinical selection, this was not a prospectively implemented randomized trial with allocation concealment. Residual confounding by unmeasured factors therefore remains possible, including granular per-digit arterial and venous repair configuration, vessel quality, intraoperative findings, adherence, and other operative details not uniformly captured in the retrospective dataset. To address small-sample bias and potential separation, we used Firth penalized logistic regression and prespecified a sensitivity analysis additionally adjusting for chronological case order; however, these measures cannot eliminate residual confounding. Third, although all patients were managed as inpatients during the 7-day postoperative observation period and monitored by the replantation team using routine postoperative clinical criteria, the exact charted frequency of vascular checks and the precise threshold for escalation to salvage bloodletting or operative re-exploration were not uniformly retrievable from the medical record. These features of postoperative care therefore could not be formally analyzed as protocolized variables. Fourth, vascular crisis was determined from contemporaneous clinical documentation and may therefore be susceptible to some degree of misclassification. Nonetheless, the composite endpoint also incorporated more objective downstream clinical actions, including re-exploration and salvage external bleeding therapy. Fifth, anti-factor Xa activity was not routinely measured, and dosing was not weight-adjusted, precluding pharmacodynamic comparisons between regimens. Finally, the total number of outcome events – particularly in the BID group – was small, leading to limited precision

for some secondary and subgroup analyses. In addition, the present data do not provide a direct comparison with weight-based pump infusion, aPTT-guided intravenous heparin, local intra-arterial infusion, or dextran-based protocols used in other centers.

Future prospective multicenter studies should incorporate standardized postoperative monitoring, explicit adjudication of vascular compromise, and more granular operative data, including per-digit arterial and venous repair characteristics and vessel quality. Where feasible, pharmacodynamic assessment such as anti-factor Xa activity may also help clarify whether the observed association reflects a true dose-response effect and may assist in defining the optimal balance between thrombotic protection and bleeding risk.

Conclusion

In this single-center retrospective cohort, postoperative LMWH 5000 IU twice daily for 7 days was associated with fewer early vascular compromise events after digital replantation than once-daily dosing. Given the observational design, limited event count, and potential for residual confounding, these findings should be viewed as hypothesis-generating and require prospective validation before broad clinical implementation.

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None.

Author contributions

All authors made substantial contributions to study conception/design, data acquisition, analysis/interpretation, drafting, and critical revision of the manuscript and approved the final version.

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Conflict of interest

The authors declare no conflicts of interest.

Ethics approval

Institutional review board approval was obtained (approval No. Jinghangyi-Lunshen-2026-(001)). A written-informed consent was obtained from all patients for treatment and the use of clinical data in research, in accordance with institutional requirements.

Data availability

De-identified data may be made available upon reasonable request and subject to institutional approvals.

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