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Original Article

Local injection of platelet-rich plasma is effective for non-healing hand wounds

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Abstract: Objective: To evaluate the clinical efficacy of local platelet-rich plasma (PRP) injections in treating non-healing hand wounds. Methods: Data of 80 patients with non-healing hand wounds were retrospectively selected for this study. Among them, 48 patients in the research group received local PRP injections, while 32 patients in the control group were treated with conventional dressing changes. The outcomes assessed included treatment efficacy, safety, frequency of dressing change, wound healing time, duration of hospitalization, treatment costs, wound healing rate, wound infection rate, Vancouver Scar Scale (VSS) scores, Bates-Jensen Wound Assessment Tool (BWAT) scores, Visual Analogue Scale (VAS) scores, serum wound growth factors, and patient satisfaction with wound appearance. Results: The research group demonstrated significantly superior outcomes compared to the control group, including higher overall treatment efficacy and wound healing rates. Furthermore, the research group exhibited a significantly lower incidence of adverse events, reduced frequency of dressing changes, shorter wound healing time, reduced hospitalization duration, lower treatment costs, and a lower infection rate. Post-treatment assessments revealed significantly lower VSS, BWAT, and VAS scores in the research group. Additionally, the upregulation of serum wound growth factors was more pronounced in the research group following treatment. Conclusions: Local PRP injection demonstrates clear efficacy in the management of non-healing hand wounds.

Keywords: Platelet-rich plasma, local injection, non-healing hand wounds, clinical efficacy

Introduction

Non-healing wounds have diverse etiologies, including pressure ulcers, diabetic ulcers, and venous ulcers. The pathogenesis is closely associated with the necrosis of cutaneous and subcutaneous tissues, driven by factors such as ischemia, infection, metabolic derangements, immunosuppression, or radiation exposure [1]. Chronic wounds, resulting from the interplay of these factors, fail to follow the normal healing trajectory, posing a significant threat to patients' well-being [2]. Wound healing is a highly dynamic and complex cellular process, involving the coordinated events of cellular migration, proliferation, extracellular matrix deposition and remodeling, as well as the regulation of inflammation and angiogenesis [3, 4]. The wound healing rate is partially influenced by its size. Minor wounds typically heal rapidly, often within a few days, while large wounds, which may result from trauma, acute medical conditions, or major surgical procedures, generally demand an extended period, often spanning several weeks. Moreover, these larger wounds frequently lead to fibrotic scaring of varying severity, which may impair tissue function [3]. Epidemiological data show that nearly 10 million individuals in the United States are affected by wounds, resulting in substantial economic costs estimated at approximately 30 billion dollars. Additionally, non-healing wounds not only elevate the risk of patient mortality but also significantly impact the overall quality of life [5, 6]. Despite the importance of this issue, research on therapeutic strategies for non-healing wounds, especially for non-healing hand wounds, remains limited. This study aims to address this gap by focusing on patients with non-healing hand wounds to optimize treatment protocols and improve treatment efficacy, wound-healing rates, and patients' quality of life.

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For non-healing hand wounds, thorough surgical debridement is typically required. Debridement involves the removal of vital tissues, coatings, microbial loads (including biofilms), and tissue debris, which accelerates wound cleansing and tissue repair [7, 8]. However, surgical debridement alone often fails to provide satisfactory therapeutic outcomes [9]. Platelet-rich plasma (PRP) is a concentrated biological preparation obtained through the centrifugation of venous blood. It can be sourced either autologously or allogenically and has become a cornerstone in regenerative medicine, particularly for tissue regeneration and repair [10]. The therapeutic effectiveness of PRP lies in its remarkable ability to promote tissue repair, primarily through the regenerative potential of platelets. Additionally, PRP has shown beneficial effects in hair regrowth [11]. In a rat experimental paradigm by Wang T et al. [12], sodium alginate hydrogel containing PRP demonstrated significant healing effects on burn-related wounds. Another investigation reported that PRP was effective in the treatment of photodamaged hand skin, mitigating signs of skin aging, such as wrinkle formation and elastotic tissue proliferation [13]. These findings strongly suggest that PRP may be a viable therapeutic option for non-healing hand wounds.

This study aims to compare local PRP injection therapy with conventional dressing change treatment in patients with non-healing hand wounds following thorough surgical debridement. The objective is to evaluate the clinical utility of local PRP injections in managing non-healing hand wounds.

Materials and methods

Case selection

This retrospective analysis included 80 patients with non-healing hand wounds, who were admitted to Tiantai County People's Hospital between May 2021 and May 2024. All participants underwent thorough surgical debridement. Specifically, 48 patients were allocated to the research group and received local PRP injections, while 32 patients were assigned to the control group and received conventional dressing change management. This study was approved by the Tiantai County People's Hospital Ethics Committee.

Inclusion criteria: 1. Confirmed diagnosis of non-healing hand wounds, as per established clinical criteria [14]. 2. Presence of two or more residual wounds. 3. Age between 18 and 80 years. 4. No known allergies to study medication. 5. No coagulation disorders. 6. Failure of wound healing one month after injury. 7. Availability of complete medical documentation for comprehensive evaluation. 8. Normal cognitive and communicative abilities, enabling effective participation in the study.

Exclusion criteria: 1. Wound ulcers attributable to malignant neoplasms. 2. History of severe cardiopulmonary diseases, including but not limited to cor pulmonale and acute myocardial infarction. 3. Substance abuse disorders, such as drug addiction or alcoholism. 4. Mental health disorders or psychological impairments that could confound the study results. 5. Severe underlying systemic diseases. 6. Impaired liver or kidney function. 7. Hematopoietic system disorders. 8. Recent use of immunosuppressive or anticoagulant therapies. 9. Subjects who have taken medications that may affect the results of this study in the past three months. 10. Women lactating or pregnant.

Intervention methods

The research group received local PRP injections, a procedure meticulously executed under stringent aseptic conditions. Based on the patient's wound volume, an appropriate amount (20-50 mL) of venous blood was aseptically drawn and transferred into sterile centrifuge tubes (Zhejiang Youlai Biotechnology Co., Ltd., CT-0150-C). These tubes were promptly placed in a horizontal-swing-type centrifuge (Beckman Coulter International Trading (Shanghai) Co., Ltd., Optima XPN) and centrifuged at 400 r/min for 10 minutes. After centrifugation, the tubes were left undisturbed for 3 to 5 minutes to allow natural stratification into three distinct layers: the plasma layer, the platelet-rich layer, and the erythrocyte layer. The platelet-rich layer was then carefully aspirated and homogenized by gentle agitation to obtain the PRP preparation. Autologous PRP was then administered via local injection to the patient. After the injection, the wound was bandaged under pressure. The interval between the first and the second injection was 3-5 days, and subsequent injections were scheduled at intervals of 2 to 3 days.

The control group was treated with conventional dressing changes. First, the patients were anesthetized, followed by thorough debridement to remove unhealthy granulation and necrotic tissues. Subsequently, routine wound dressing changes were carried out in accordance with standard clinical procedures.

Data collection and outcome measurements

(1) Therapeutic efficacy: Treatment efficacy was assessed using the following criteria: Complete epithelialization of the wound, accompanied by the absence of exudation, erythema, and swelling in the perilesional tissues after treatment, was defined as cured. A significant reduction in wound size, along with minimal exudate volume, was considered marked effective. A wound that was substantially clean with minimal exudate was classified as effective. Conversely, if the wound failed to heal, showed an increase in size, or demonstrated a significant depth, it was regarded as ineffective.

(2) Safety: Adverse events, including urticaria, neutrophilia, increased exudation, and local pain, were vigilantly monitored and documented in both groups. The incidence rate of these adverse events was subsequently calculated.

(3) Perioperative indicators: The frequency of dressing changes, time to wound healing, duration of hospitalization, and treatment costs were systematically recorded for both groups.

(4) Wound-related indicators: The wound healing rate and wound infection rate were determined for each group.

(5) Recovery assessment: The Vancouver Scar Scale (VSS) and the Bates-Jensen Wound Assessment Tool (BWAT) [15] were employed to comprehensively evaluate the wound condition. The VSS ranges from 0 to 15 points, while the BWAT ranges from 13 to 65 points. In both scales, lower scores correspond to a more favorable wound condition. Additionally, the Visual Analogue Scale (VAS) [16] was utilized to assess patients' pain intensity. With a scoring range of 0-10 points, the VAS score is directly proportional to the degree of pain experienced by the patients.

(6) Wound-associated growth factor concentrations: Before and after treatment, 5 mL of fasting venous blood was collected from each patient. These samples were then centrifuged, and the resulting supernatants were stored at -80°C for subsequent analysis. The levels of epidermal growth factor (EGF), insulin-like growth factor (IGF), and platelet-derived growth factor (PDGF) were quantified using the enzyme-linked immunosorbent assay (ELISA; Amyjet Scientific Inc., NDC-KBB-TQ1K4G-96, NDC-KBB-GG6GMS-96, NDC-KBB-7X8KQB-96) technique.

(7) Appearance satisfaction: Patients' satisfaction with the wound appearance was categorized into three levels: dissatisfaction, relative satisfaction, and high satisfaction. The overall satisfaction rate was calculated as the proportion of patients reporting either relative or high satisfaction out of the total number of subjects.

The primary outcome measures included therapeutic efficacy, safety profile, perioperative parameters, wound-related indicators, and patient satisfaction with wound appearance. Secondary outcome measures encompassed VSS, BWAT, VAS scores, and serum levels of key growth factors, including EGF, IGF, and PDGF.

Statistical analysis

For quantitative data, descriptive statistics were presented as the mean ± standard error of the mean (SEM). To assess differences in the quantitative data between the two groups, an independent sample t-test was performed. A paired t-test was utilized to evaluate changes in quantitative data within each group before and after treatment. Categorical data were expressed as frequencies (%), and group-wise comparisons of categorical data were performed using the chi-square (χ^2) test. All statistical analyses were performed using SPSS 21.0 software. Statistical significance was set at a *P*-value of less than 0.05.

Results

Comparison of baseline characteristics between the two groups

The mean age of patients was (44.25 ± 8.75) years in the research group and (44.69 ± 7.48) years in the control group. The male-to-female

Table 1. Baseline characteristics of the two groups

Indicators	Research group (n=48)	Control group (n=32)	χ^2/t	P
Age (years)	44.25 ± 8.75	44.69 ± 7.48	0.233	0.816
Sex (male/female)	29/19	18/14	0.138	0.711
Disease course (months)	3.10 ± 1.21	3.31 ± 1.20	0.763	0.448
BMI (kg/m^2)	23.00 ± 2.55	23.53 ± 2.55	0.911	0.365
Married (no/yes)	18/30	7/25	2.182	0.140
Place of residence (rural/urban)	16/32	9/23	0.242	0.623

Note: BMI, body mass index.

Table 2. Clinical efficacy in the two groups

Indicators	Research group (n=48)	Control group (n=32)	χ^2	P
Cure	10 (20.83)	4 (12.50)		
Marked efficacy	19 (39.58)	9 (28.13)		
Effectiveness	15 (31.25)	10 (31.25)		
Ineffectiveness	4 (8.33)	9 (28.13)		
Overall effective rate	44 (91.67)	23 (71.88)	5.526	0.019

Table 3. Clinical safety in the two groups

Indicators	Research group (n=48)	Control group (n=32)	χ^2	P
Urticaria	0 (0.00)	1 (3.13)		
Neutrophilia	0 (0.00)	1 (3.13)		
Increased exudation	2 (4.17)	2 (6.25)		
Local pain	1 (2.08)	3 (9.38)		
Total	3 (6.25)	7 (21.88)	4.286	0.038

ratio in the research group was 29:19, while in the control group, it was 18:14. After comprehensive comparison, apart from age and gender, no significant inter-group differences were observed in other baseline characteristics such as disease course, body mass index (BMI), marital status, and place of residence (P > 0.05, **Table 1**).

Comparison of clinical efficacy between the two groups

In the control group, the numbers of patients achieving cured, markedly effective, effective, and ineffective were 4, 9, 10, and 9, respectively. In contrast, those numbers in the research group were 10, 19, 15, and 4, respectively. The overall treatment efficacy rate of the research group reached 91.67%, which was significantly higher than the 71.88% observed in the control group (P < 0.05, **Table 2**).

Comparison of clinical safety between the two groups

The total incidence of adverse events, including urticaria, neutrophilia, increased exudation, and local pain, was 6.25% in the research group, significantly lower than the 21.88% in the control group (P < 0.05, **Table 3**).

Comparison of treatment-associated metrics between the two groups

The frequency of dressing changes, time to wound healing, duration of hospitalization, and treatment costs in the research group were all significantly lower compared to those in the control group (all P < 0.05, **Table 4**).

Comparison of wound healing-related parameters between the two groups

The research group exhibited a significantly higher wound healing rate and a significantly lower wound infection rate compared to the control group (P < 0.05, **Table 5**).

Comparison of recovery condition between the two groups

Prior to treatment initiation, no significant differences were observed in the VSS, BWAT, and VAS scores between the two groups (all P > 0.05). After treatment, a significant decline was observed in all these metrics for both groups (P < 0.05). Notably, the post-treatment VSS, BWAT, and VAS scores were significantly lower

Table 4. Treatment-associated metrics in the two groups

Indicators	Research group (n=48)	Control group (n=32)	t	P
Frequency of dressing change (times)	4.94 ± 1.41	17.69 ± 5.93	14.342	< 0.001
Wound healing time (d)	28.40 ± 6.95	35.03 ± 12.00	3.127	0.003
Duration of hospitalization (d)	8.73 ± 2.13	13.88 ± 2.98	9.017	< 0.001
Treatment costs (yuan)	4626.38 ± 887.43	5148.00 ± 1247.20	2.186	0.032

Table 5. Wound healing-related parameters in the two groups

Indicators	Research group (n=48)	Control group (n=32)	χ^2	P
Wound healing	42 (87.50)	20 (62.50)	6.882	0.009
Wound infection	4 (8.33)	8 (25.00)	4.183	0.041

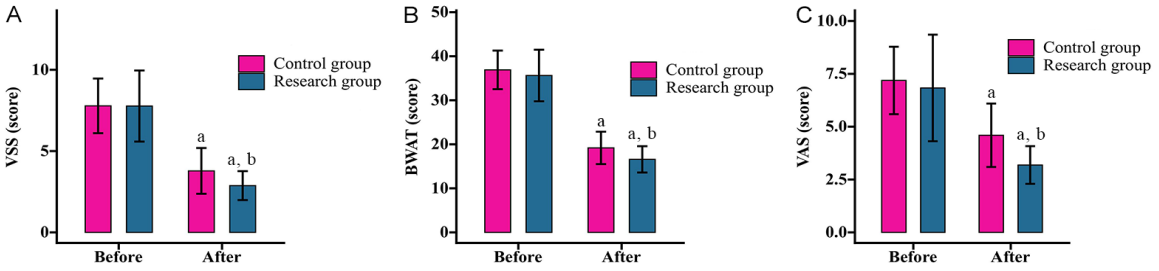

Figure 1. Recovery status of the two patient groups. A. Pre- and post-interventional VSS scores in two groups. B. Pre- and post-interventional BWAT scores in two groups. C. Pre- and post-interventional VAS scores in two groups. Note: [a]P < 0.05 vs. before intervention; [b]P < 0.05 vs. Control; VSS, Vancouver Scar Scale; BWAT, Bates-Jensen Wound Assessment Tool; VAS, Visual Analogue Scale.

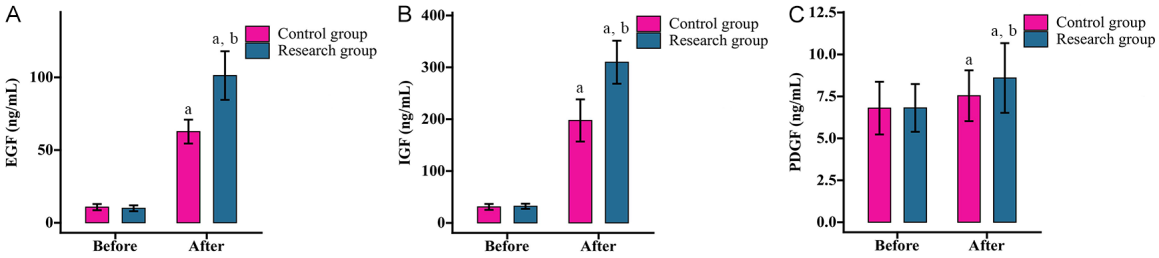

Figure 2. Wound-associated growth factor levels in the two patient groups. A. Pre- and post-interventional EGF levels in two groups. B. Pre- and post-interventional IGF levels in two groups. C. Pre- and post-interventional PDGF levels in two groups. Note: [a]P < 0.05 vs. before intervention; [b]P < 0.05 vs. Control; EGF, epidermal growth factor; IGF, insulin-like growth factor; PDGF, platelet-derived growth factor.

in the research group compared to the control group (all P < 0.05, **Figure 1**).

Comparison of wound-associated growth factor levels between the two patient groups

At baseline, the levels of EGF, IGF, and PDGF were comparable between the two groups (P > 0.05). After treatment, significant increases in these factors were observed in both groups (P < 0.05). Moreover, the post-treatment levels of EGF, IGF, and PDGF in the research group were markedly higher than those of the control group (all P < 0.05, **Figure 2**).

Comparison of patient satisfaction between the two groups

The appearance satisfaction rate in the research group after treatment was 89.58%, sig-

Table 6. Patient satisfaction with appearance of the two groups

Indicators	Research group (n=48)	Control group (n=32)	χ^2	P
High satisfaction	19 (39.58)	10 (31.25)		
Relative satisfaction	24 (50.00)	12 (37.50)		
Dissatisfaction	5 (10.42)	10 (31.25)		
Total satisfaction	43 (89.58)	22 (68.75)	5.470	0.019

nificantly higher than 68.75% in the control group ($P < 0.05$, **Table 6**).

Discussion

Non-healing hand wounds pose a significant challenge in the treatment of traumatic hand injuries. The hand, with its remarkable dexterity and heightened sensitivity, consists of a complex interplay of anatomical structures uniquely adapted to fulfill diverse functional requirements [17]. Conventional surgical approaches to non-healing hand wounds often yield suboptimal outcomes. These methods typically encounter difficulties in effectively restoring the compromised soft tissue components of hand injuries and may increase the risk of complications such as infection and joint stiffness [18]. Considering these limitations, this study aims to introduce an innovative intervention strategy: local PRP injection following comprehensive surgical debridement in patients with non-healing hand wounds. This approach seeks to explore new therapeutic possibilities and potentially revolutionize the treatment paradigm for this complex clinical condition.

In this study, the research group exhibited a significantly higher overall effective rate compared to the control group (91.67% versus 71.88%). This finding underscores the pronounced effectiveness of local PRP injections in managing non-healing hand wounds. The therapeutic potential of PRP can be attributed to its ability to convey concentrated platelets and growth factors to the wound site. These components activate the body's endogenous healing mechanisms, thereby stimulating cellular proliferation and extracellular matrix synthesis [19, 20]. Moreover, emerging evidence suggests that PRP plays a regulatory role in wound healing by modulating inflammation, angiogenesis, and re-epithelialization [21]. These findings substantiate the efficacy of PRP in the treatment of non-healing hand wounds and offer partial insights into its underlying therapeutic mechanisms.

Regarding safety, the total incidence of adverse events in patients treated with local PRP injections was markedly lower (6.25% versus 21.88%), highlighting the high safety profile of this treatment modality. Deng Z et al. [22] demonstrated that PRP's clinical safety stems from its capacity to enhance wound healing, mitigate periwound inflammation, and improve granulation tissue and angiogenesis. These findings firmly establish the clinical safety of local PRP injections for non-healing hand wounds.

In the treatment of non-healing hand wounds, local PRP injection resulted in fewer dressing changes, shorter wound healing times, reduced hospital stays, and lower treatment costs compared to conventional dressing change treatment. Additionally, it led to a higher wound healing rate and a lower wound infection rate. These results indicate that local PRP injections not only accelerate wound healing but also expedite hospital discharge with fewer dressing changes, while also being more cost-effective. A study by Zhang W et al. [23] pointed out that PRP can release antibacterial substances and reduce local inflammation, which helps prevent wound infections. Therefore, local PRP injections offer significant clinical benefits in managing non-healing hand wounds, including reduced dressing change frequency, lower treatment expenses, decreased wound infection rates, accelerated wound healing, and shorter hospital stays, ultimately improving overall healing outcomes.

Moreover, patients with non-healing hand wounds who underwent local PRP injections demonstrated notably reduced scarring, superior wound recovery, and diminished pain perception. A study by Moretti L et al. [24] reported that PRP application in supraspinatus tendinopathy significantly alleviated pain and improved both quality of life and functional scores, findings that align with the results of our study. These findings suggest that the therapeutic advantages of local PRP injections for non-healing hand wounds extend to minimizing scar formation, facilitating wound recovery, and effectively reducing associated pain.

Additionally, our study revealed that local PRP injections in patients with non-healing hand wounds resulted in a more pronounced elevation in the levels of EGF, IGF, and PDGF. This outcome is consistent with the findings of Eppley BL et al. [25]. EGF plays a pivotal role in enhancing wound healing through stimulating human keratinocyte proliferation. IGF, a hormone endowed with potent anabolic properties, can effectively rectify impaired wound development and actively modulate the wound healing process. Furthermore, following finger replantation, an upregulation of PDGF expression has been shown to facilitate microcirculation following anastomosis of the severed finger [26-28]. These results suggest that a notable clinical benefit of local PRP injections is their ability to modulate the levels of key growth factors, such as EGF, IGF, and PDGF, thereby promoting wound healing in non-healing hand wounds.

Finally, we observed that patients with non-healing hand wounds who received local PRP injections demonstrated a significantly higher level of appearance satisfaction (89.58% versus 68.75%). In the research of Du X et al. [29], PRP was found to promote the healing of open hand injuries and skin defects. This approach not only significantly shortens the operative duration, alleviates pain, and reduces costs but also aids in preserving a greater extent of nail-bed integrity and joint mobility, corroborating the findings of our investigation. These results affirm the clinical advantages of local PRP injections in enhancing appearance satisfaction for patients with non-healing hand wounds.

Over the years, many researchers have dedicated substantial efforts to exploring treatment options for non-healing wounds. For instance, Holubová A et al. [30] indicated that medical-grade honey could serve as an alternative to antibiotic treatment for non-healing wounds, effectively reducing local infections while exerting antibacterial, anti-inflammatory, and antioxidant effects. Additionally, Wei Q et al. [31] reported that small extracellular vesicles derived from mesenchymal stem cells hold promise as a potential therapeutic strategy for chronic non-healing wounds. These vesicles primarily promote wound healing by regulating cellular behavior and participating in processes such as inflammation, angiogenesis, re-epithelialization, and scar-less healing. These findings highlight the potential of alternative therapeutic modalities currently utilized in the management of non-healing wounds.

This study has several limitations that warrant consideration. First, the absence of mechanism research represents a significant gap. Future supplementary experiments could help elucidate the underlying mechanisms of local PRP injections in the treatment of non-healing hand wounds. Second, the absence of long-term follow-up data limits our ability to assess the sustained therapeutic effects and potential long-term outcomes for patients. Incorporating such data in future studies would provide a more comprehensive understanding of the treatment's impact. Third, the psychological and emotional well-being of patients was not evaluated. Addressing this aspect could reveal whether local PRP injection is associated with any adverse emotional responses, thereby offering a more holistic view of their effects. These limitations highlight key areas for future research, which we plan to explore progressively in subsequent studies.

In summary, local PRP injections can significantly enhance treatment efficacy for patients with non-healing hand wounds, while minimizing the overall risk of adverse events. Furthermore, this treatment approach accelerates wound healing and postoperative rehabilitation, reduces scarring, and alleviates pain. Additionally, it can remarkably elevate the levels of EGF, IGF, and PDGF and contribute to a higher level of patient satisfaction with the appearance of the healed wounds.

Disclosure of conflict of interest

None.

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