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ORIGINAL ARTICLE
Hand

Usage of Dermal Regeneration Templates (Pelnac) for Coverage of Exposed Hand Tendons in Acute Setting

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Background: The loss of soft tissue coverage of tendons is a challenging reconstructive problem after acute hand trauma. Subsequent tendon adhesions and the loss of range of movement in addition to the poor aesthetic outcome and donor site scarring should be avoided when deciding the plan of management. Pelnac is one of the commonly used skin substitutes in reconstructive surgery that can be used for coverage of exposed tendons, but the postoperative functional outcome needs to be addressed in detail.

Methods: Twenty-six patients with acute isolated tendon injuries distal to the wrist joint were included. Two-stage reconstructive procedures were performed; the first one was the application of Pelnac. The second stage was carried out after the complete integration of Pelnac via the application of a split-thickness graft. The function outcome assesses the return of the normal range of motion to the affected hand and the QuickDASH score questionnaire. The aesthetic outcome was assessed using the Vancouver scar scale.

Results: The Pelnac was integrated in 100% of cases, with complete grafts taken in 22 of 26 patients. The mean QuickDASH score was 20.5 ± 15.7, and mean Vancouver scar scale was 3.53 ± 3.2. The full range of motion returned in 22 of 26 patients.

Conclusions: Using Pelnac to cover the exposed hand tendons in an acute setting is a convenient and efficient procedure with minimal morbidity. It can offer a good option for their coverage with preservation of hand function and acceptable aesthetic outcome. *(Plast Reconstr Surg Glob Open 2024; 12:e5673; doi: 10.1097/GOX.0000000000005673; Published online 4 March 2024.)*

INTRODUCTION

In the context of acute hand injuries, the loss of soft tissue coverage is a common issue that hand surgeons may face. Exposing important structures such as bones, joints, and tendons can have functional consequences during the recovery process. There are various options available for restoring soft tissue loss, ranging from local flaps such as the V-Y flap and cross-finger flap, to distant flaps for larger defects such as infraclavicular flaps, and even free flaps.[1,2] A study has reported the use of vacuum-assisted wound closure followed by split-thickness grafts.[3] A recent method for replacing soft tissue defects is the two-stage procedure, which involves using a dermal substitute in the first stage and then a skin graft in the second stage.[4] The idea behind dermal substitutes is to utilize the concept of sequential vascularization.[5] Histological examination of tissues after applying dermal substitutes has revealed that after 1 year, they integrate with the normal dermal-to-epidermal ratio and contain normally distributed blood vessels within the extracellular matrix.[6] When it comes to covering exposed defects, the ideal solution should not be bulky, should have minimal donor site morbidity, and should lead to an acceptable aesthetic outcome. The ultimate goal for managing patients with these injuries is to restore their normal daily activities. Dermal substitutes can meet all of these criteria, and several products have been used to cover the skin defects, including Integra,[7–9] Pelnac,[10,11] and acellular dermal matrix.[6] Previously published data

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have shown the effectiveness of these options in covering exposed tendons in hand or foot injuries,[12,13] and in post-surgical defects.[7] The Pelnac (Gunze Co., Ltd., Kyoto, Japan) is a bilayer dermal substitute. It consists of an underlying atelocollagen matrix layer that acts as a scaffold for dermal regeneration by accelerating fibroblast migration and an overlying semipermeable silicone layer that acts as a temporary epidermis. Since its introduction to the market in 1996, Pelnac has been utilized for the treatment of complex full-thickness skin defects caused by various factors and has shown promising results.[12,14]

Immediately after applying Pelnac, the sponge atelocollagen layer thins out due to hydration. This allows for visibility of the wound surface and enables detection of dermis-like tissue formation, which transforms the wound surface into a red granulation tissue-like appearance. The outer silicone layer can then be easily removed, and coverage with a thin split-thickness skin graft can be performed.[15]

In our study, we aimed to investigate the effectiveness of Pelnac in providing coverage for exposed bare-hand tendons in cases of acute posttraumatic injuries. Our goal was to restore hand function with acceptable aesthetic outcomes. Although this topic might seem to be addressed in various studies, we specifically focused on patients who solely had exposed tendons without any involvement of joints, bones, or neurovascular affection. This allowed us to assess the effect of this method of coverage in restoring a smooth gliding surface for tendons and minimizing postcoverage adhesions.

PATIENTS AND METHODS

Study Design

This prospective study was conducted from July 2022 to September 2023. We included patients with acute hand injuries presenting within the first 24 hours, specifically those with isolated intact tendon exposure. Patients with delayed presentation beyond 24 hours, associated bone or joint involvement, complete tendon injuries, or injuries proximal to the wrist joints are excluded from the study. Patients with any comorbidities that might impact wound healing are also excluded.

Patients and Materials

The study has received approval from the ethical committee of our institute, the Faculty of Medicine at Cairo University. All patients enrolled in the study have provided written consent. During the study period, a total of 30 patients were included and treated with the Pelnac dermal regeneration template (manufactured by Gunze Co., Ltd.). However, four patients were lost to follow-up due to loss of contact in two cases and refusal to continue participating in the study in the other two. Therefore, a final analysis of data is based on 26 patients. Of these, 24 are men and two are women, with a mean age of 21.7 ± 13.9 SD. The mode of trauma is injuries caused by sharp objects in 16 patients and degloving injuries in 10 patients. The exposed tendon is located on the volar aspect of the hand in 20 patients and the dorsal aspect in six patients. The dominant hand is affected in 12 patients, whereas the nondominant hand is affected in 14 patients. The surface area of the raw wound ranges from 1.5 to 54 cm^2, with the length of the exposed tendon ranging from 0.3 to 6 cm.

Takeaways

Question: In patients with acute posttraumatic exposure of hand tendons, does the dermal substitute provide a good covering option regarding the aesthetic outcome and restoration of hand function?

Findings: Pelnac is a cost-effective method to cover exposed tendons in acute hand trauma, as it can achieve good aesthetic outcomes with supple pliable coverage with avoidance of donor site morbidities. In addition to its ability to provide adequate coverage with good restoration of tendon gliding and minimal adhesions

Meaning: Pelnac is an effective reconstructive alternative to cover the exposed posttraumatic intact hand tendons.

Operative Technique

Two separate operative procedures are performed. The first procedure is performed within the first 24 hours postinjury. It involves debridement and proper hemostasis to remove any devitalized tissue and create a clean bed for the dermal substitute to be applied (Fig. 1A). The Pelnac is trimmed to the appropriate size to cover the defect. Then, it is secured to the edges of the defect and the overlying silicone layer is punctured to allow drainage of fluid (Fig. 1B). A secondary dressing is applied to the Pelnac, followed by an elastic bandage. The Pelnac is inspected every 3 days (days 3, 6, 9, 12, etc.) to assess the adherence of the silicone layer and the vascularization status (coloration of tissues beneath the transparent silicone layer), and to detect any complications such as infection or hematoma. The time taken for complete revascularization of the Pelnac is recorded.

The second stage is performed once complete revascularization of the Pelnac is achieved and the silicone layer is removed (Fig. 2A). An autologous split-thickness skin graft is then applied over the neo-dermis and tie-over fixation is performed (Fig. 2B). On the fifth postoperative day, the first graft check is conducted to evaluate graft survival. Subsequent graft checks take place on days 7 and 9. The percentage of grafts that have taken is calculated and documented on the 14th day postoperative. In terms of rehabilitation, patients are instructed to avoid any movement of the affected hand until the Pelnac has revascularized and the graft has adequately adhered. Afterward, they are encouraged to begin both passive and active ranges of motion. All patients are educated by a designated physiotherapist on performing home-based hand rehabilitation exercises.

Follow-up

After discharge, patients are followed up after 3 weeks for a quick assessment and monitoring of any

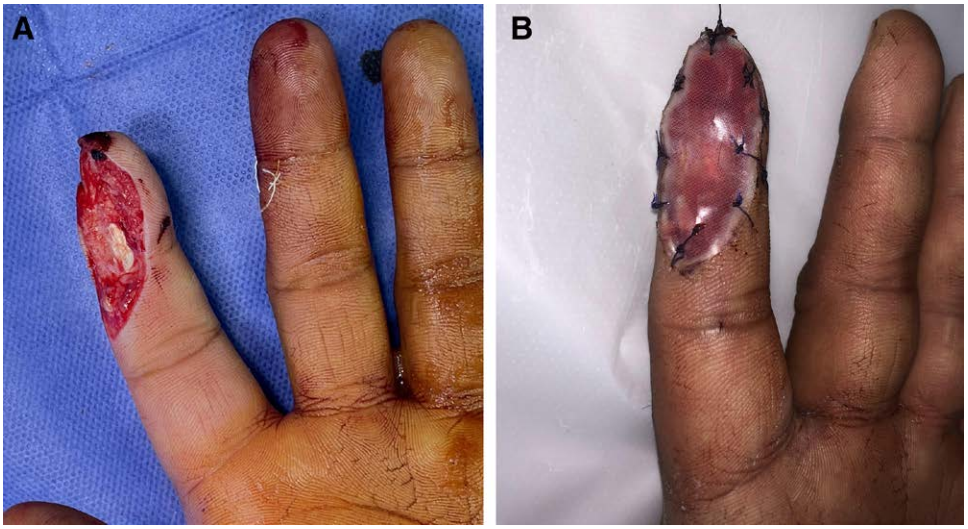

Fig. 1. Male patient with an acute sharp injury to the index finger. A, Exposed flexor digitorum profundus tendon at zone I. B, Close-up view of Pelnac after application.

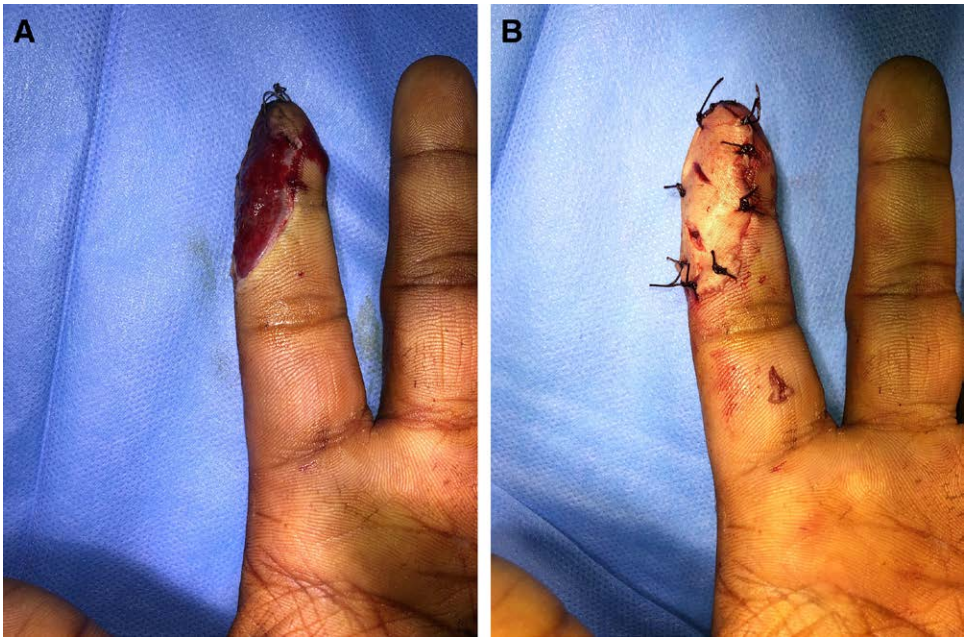

Fig. 2. Second stage of tendon coverage. A, Adequate revascularization and formation of the dermis-like layer. B, After split-thickness graft application.

complications such as infection or loss of the skin graft. Subsequent follow-up appointments are scheduled at 3 and 6 months, during which the quality of the scar is assessed using the Vancouver Scar Scale (VSS). This scale evaluates the aesthetic result of the graft based on four aspects: vascularity, pigmentation, pliability, and height. Higher scores indicate more severe scarring. (**See figure, Supplemental Digital Content 1**, which displays the VSS, **http://links.lww.com/PRSGO/D105**.)

Functional recovery of the hand is subjectively assessed using the QuickDASH questionnaire (disabilities of arm, shoulder, and hand). This questionnaire consists of 11 self-reported items, with a total score ranging from 0 points (no disability) to 100 points (maximum disability). The objective assessment of functional recovery involves measuring the range of motion of the affected joints and comparing it to the normal range of motion of the nonaffected contralateral joint.

Statistical analysis

Data were analyzed using Statistical Program for Social Science version 24. Qualitative data were expressed as frequency and percentage. Quantitative data were expressed as mean ± SD for normally distributed data or

median (interquartile range) for not normally distributed data.

The following tests were done:

- Mann-Whitney U test when comparing between two groups (for abnormally distributed data).
- Pearson correlation coefficient (r) test was used for correlating data.
- Chi-square test (χ^2) test was used when comparing nonparametric data.
- Spearman correlation coefficient (s) test was used for correlating data.
- Probability (P value) P less than 0.05 was considered significant; P less than 0.001 was considered highly significant; and P greater than 0.05 was considered insignificant.

RESULTS

The mean follow-up period was 272 ± 7 days (range 258–286 days). The total surface area of the raw area ranged from 1.5 to 54 cm^2. In all cases, the dermal regeneration template was applied within the first 24 hours after the injury. The duration of Pelnac application ranged from 13 to 24 days, with an average duration of 16.7 ± 3.05 days and a 100% success rate in terms of take and complete revascularization. No patients required a reoperation of the second stage of the procedure. During long-term follow-up, the integrated Pelnac and the overlying graft exhibited reasonable adherence to the bed and stable coverage.

At the final assessment of both functional and aesthetic outcomes of the procedure, 84.6% of patients achieved full recovery in the range of movement of the affected digits, compared with their normal contralateral digits (Table 1).

Patient satisfaction with the functional outcome was assessed using the Arabic version of the QuickDASH score. The minimum score was 4.5, the maximum score was 54.5, and the mean score was 20.5 ± 15.7 SD. The aesthetic outcome of the graft was assessed by the operator using the VSS. The mean VSS score was 3.6 ± 2.4, with a minimum score of 2 and a maximum score of 9. Table 2 summarizes the clinical and functional outcomes.

Table 1. Description of Active Normal ROM in All Studied Patients

Regaining Active Normal Range of Motion	Studied Patients (N = 26)	
Yes	22	84.6%
No	4	15.4%

Table 2. Description of QuickDASH Score and VSS in All Studied Patients

		Studied Patients (N = 26)
QuickDASH score	Mean ± SD	20.5 ± 15.7
	Minimum–maximum	4.5–54.5
VSS	Mean ± SD	3.6 ± 2.4
	Minimum–maximum	2–9

Table 3. Correlation between Clinical Outcome and Other Studied Data in All Studied Patients

	QuickDASH		VSS	
	r	P	r	P
Pelnac application time	0.37	0.06 NS	0.38	0.049 S
Percentage of graft take	−0.25	0.213 NS	−0.54	0.004 S

NS, P value >0.05 is considered nonsignificant; r, Pearson correlation coefficient; S, P value <0.05 is considered significant.

Complications occurred in eight (30.8%) patients out of the total number of patients studied. Four patients (15.4%) experienced tendon adhesions, which subsequently led to a decreased range of movement in the affected joint. Additionally, four (15.4%) patients developed wound infections, resulting in partial graft loss. However, all of these cases healed after repeated dressing, and none of them required graft reoperative procedures.

The analysis of the functional outcome using the QuickDASH score revealed a positive correlation between the score and the duration of the Pelnac application, but it was not statistically significant (P = 0.06). Moreover, a negative correlation was observed between the QuickDASH score and the percentage of successful grafts, but again, the correlation was not statistically significant (P = 0.213). These findings are summarized in Table 3.

Regarding the aesthetic outcome evaluated using the VSS, a statistically significant positive correlation was found between the VSS and the duration of Pelnac application (P = 0.049). Additionally, there was a statistically significant negative correlation between the VSS, and the percentage of grafts taken (P = 0.004). Table 4 provides a summary of these results. (Figs. 3 and 4).

When assessing the impact of the mode of trauma on the outcomes, it was observed that patients who presented with sharp injuries had significantly better outcomes in terms of the QuickDASH score (P < 0.001). Moreover, the VSS showed lower scores in patients who were injured with sharp objects compared with those who presented with degloving injuries, although this difference was not statistically significant (P = 0.097). These findings are illustrated in Table 4 and Figures 5–7.

DISCUSSION

In the acute setting of hand trauma, loss of skin coverage of important hand structures is a common problem

Table 4. Correlation Study between Clinical Outcome and Mode of Trauma in All Studied Patients

		MOT			
		Sharp (N = 16)	Degloving (N = 10)	Stat. Test	P
Active range of motion	No	0 (0%)	4 (40%)	χ^2 = 7.5	0.006 S
	Yes	16 (100%)	6 (60%)		
QuickDASH	Median	9.05	38.6	MW = 4	<0.001 HS
	IQR	6.8–15.05	23.3–47.75		
VSS	Median	2	4	MW = 48	0.097 NS
	IQR	2–3	2–8.25		

HS, P value <0.001 is considered highly significant; IQR, interquartile range; MW, Mann-Whitney U test; NS, P value >0.05 is considered nonsignificant; S, P value <0.05 is considered significant.

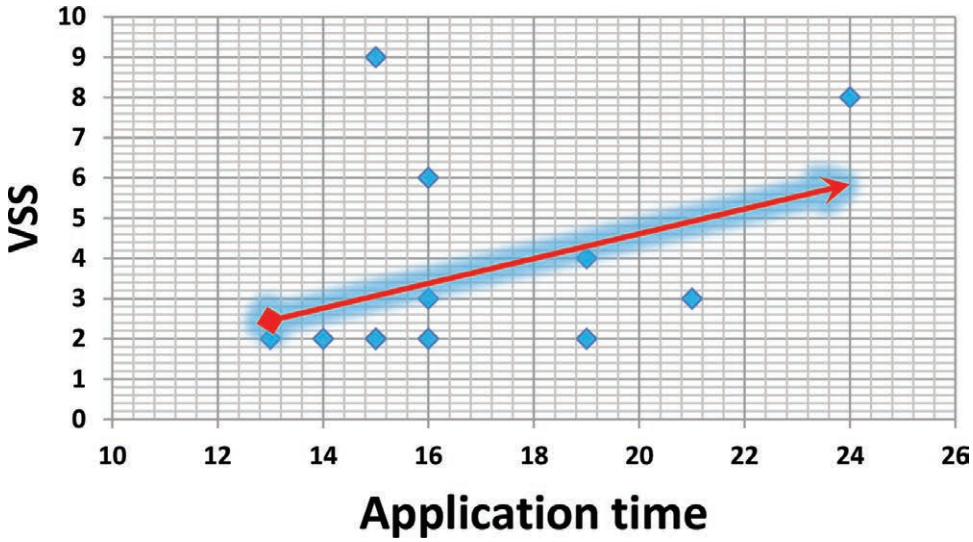

Fig. 3. Positive correlation ($r = 0.38$) between VSS and Pelnac application time in studied patients. Statistically significant ($P = 0.049$) correlation.

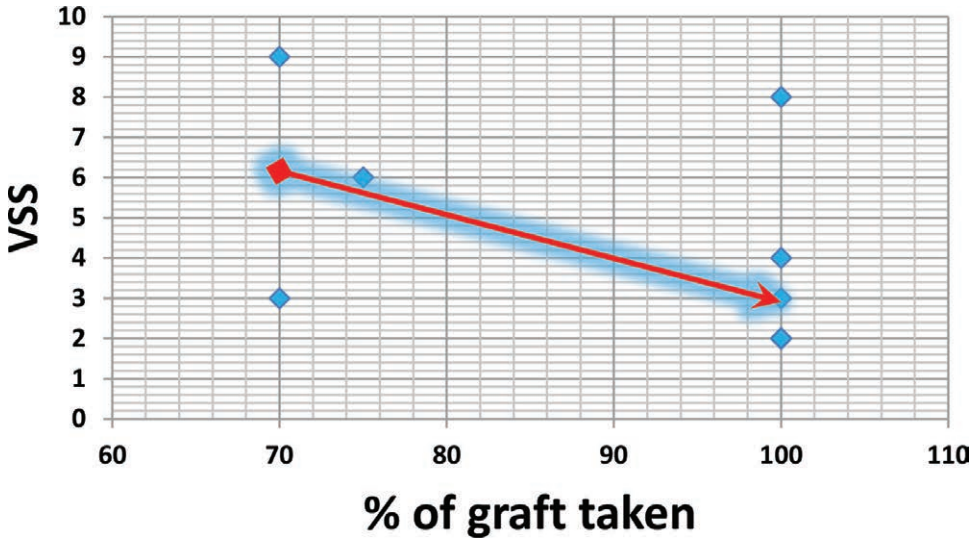

Fig. 4. Negative correlation ($r = -0.54$) between VSS and % of grafts taken in studied patients. Statistically significant ($P = 0.004$) correlation.

that may face many plastic surgeons. Exposed tendons, bone, and neurovascular bundles can be covered by many alternatives. Local hand flaps include V-Y flaps, thenar flaps, and or cross-finger flaps.[2] Others recommend the application of VAC till the formation of healthy granulation tissue and then graft.[3] These flaps are successful in achieving stable coverage to these structures, but they cannot suit all situations of hand injuries. Limitations of donor sites, and donor site morbidities, can limit its use in some cases. Searching for other alternatives and their applicability in the replacement of soft tissue defects has been addressed. The dermal regeneration templates have been used in many studies. Acellular dermal matrix, Integra, and Pelnac are the commonly used dermal substitutes.

When choosing between the available alternatives for use as a template before grafting, Kashimura et al[8] compared the difference between Integra and Pelnac in 26 patients after soft tissue defects either due to postburn or postsurgical etiology. Kashimura et al[8] concluded that Pelnac has a significantly shorter mean waiting time to be integrated in comparison to Integra. There was no correlation between the wound size and the waiting time. The mean time was 17.5 ± 4.2 and 22 ± 4.2 days in Pelnac and Integra, respectively.[8]

In this study, we addressed the usage of Pelnac as a dermal regeneration template in coverage of acute hand injuries presented with exposed intact hand tendons distal to the wrist joint. Pelnac is used to cover the exposed tendons in the first 24 hours after initial debridement of

Fig. 5. A 60-year-old man with exposed flexor digitorum profundus tendon of the ring finger. A, Before application of Pelnac. B, Twenty-first day follow-up. C, Range of motion after 6 months.

the wound. The outcome of the results was assessed in the early postoperative period by the duration of the Pelnac application and the percentage of graft intake. Late outcome was assessed both functionally by the return of normal range of motion and patient satisfaction using the Arabic version of the QuickDASH score and aesthetically by the VSS. The outcomes were correlated with the mode of trauma, the duration of Pelnac application, and the percentage of grafts taken.

Although the application of Pelnac in coverage of posttraumatic defects was studied before, in our study, we investigate its applicability in a larger patient cohort. Zhenmu et al[12] addressed the efficacy of Pelnac in coverage of soft tissue defects in 13 patients; only four cases presented with exposed tendons of the hand. Widjaja and Maitz[11] addressed five patients with postburn hand injuries, Scuderi et al[16] published their article with a single case report patient, and Lou et al[10] in eight patients in both hand and scalp defects. Also, we addressed the coverage of exposed intact hand tendons, and we excluded any patients with concomitant bone or joint injury to minimize variables that may affect the return of normal range of motion. Therefore, the postoperative outcome will address whether the Pelnac and overlying skin graft successfully offered pliable supple coverage for the tendon gliding or not. The mean duration of the Pelnac application in our study was 16.7 ± 3.05 (13–24) days. When compared with the previous studies which used Pelnac, the mean interval was 21.2 ± 4.2 (range 14–31) days when applied to cover exposed bones or tendons in the hand and forearm.[12] However, Kashimura et al[8] observed that the time needed for the Pelnac was 17.5 ± 4.2 days.

The percentage of the Pelnac integration into the defect was 100% in all patients; no infection, hematomas, or seromas were recorded in any patient. Our results are superior when compared with the previously published studies by Kashimura et al,[8] Lv et al,[12] and Lisa et al[17] as the percentage of Pelnac intake was 100% in 91%–92% of patients.

Assessment of functional recovery of our patients revealed that the normal range of motion regained in 84.6% of our patients within 6 months. The second functional assessment method was the QuickDASH questionnaire: the mean score was 20.5 ± 15.7 (range 4.5–54.5), and the highest score (54.5) was recorded in a 17-year-old male patient who presented with a degloving injury of the palm affecting the tendons of the four fingers. The Pelnac was applied for 24 days; on follow-up visits, the patient complained of difficulties in regaining daily activities. Our results are consistent with Lv et al,[12] where the average DASH score was 27.2 ± 18.5 (range 0–62).

The skin grafts taken were 100% in 84.6% of the patients, which is comparable to Lv et al,[18] where it was 100% in 81% of cases published in their article, and also comparable to Lv et al,[19] where it was 85%–100% in all patients, and Lembo et al,[20] where it was 100% in 93% of their cases.

When we investigated the correlations between the study outcomes and mode of trauma, we found that in patients with degloved injuries, it takes a long time for Pelnac to integrate, resulting in partial graft loss and subsequently worse functional and aesthetic outcomes. Therefore, we recommend delaying the application of Pelnac after 48 hours in these patients. We suggest starting with an initial debridement session followed by the application of conventional dressing. Then, after 24–48 hours of the initial debridement, a second assessment is preferred to ensure good vascularity at the wound edges.

The VSS ranged from 2 to 9, with a mean value of 3.6 ± 2.4 in our study. Our results were slightly higher compared with Lv et al,[19] who reported a VSS of 2.1 (SD 1.8, range 1.0–5.5) after 12 months. They were also higher than De Francesco et al,[21] who reported a mean VSS of 2.3 ± 1.81. However, our results are consistent with Lembo et al,[20] who recorded a VSS of 4 (range 3–8) at 6 months. Our findings show similarities to previously published data in some aspects and advanced in other aspects. However, our study has some limitations. The short follow-up time limited our ability to accurately assess the aesthetic outcome, as the final assessment should be conducted after the completion of the remodeling phase of healing.

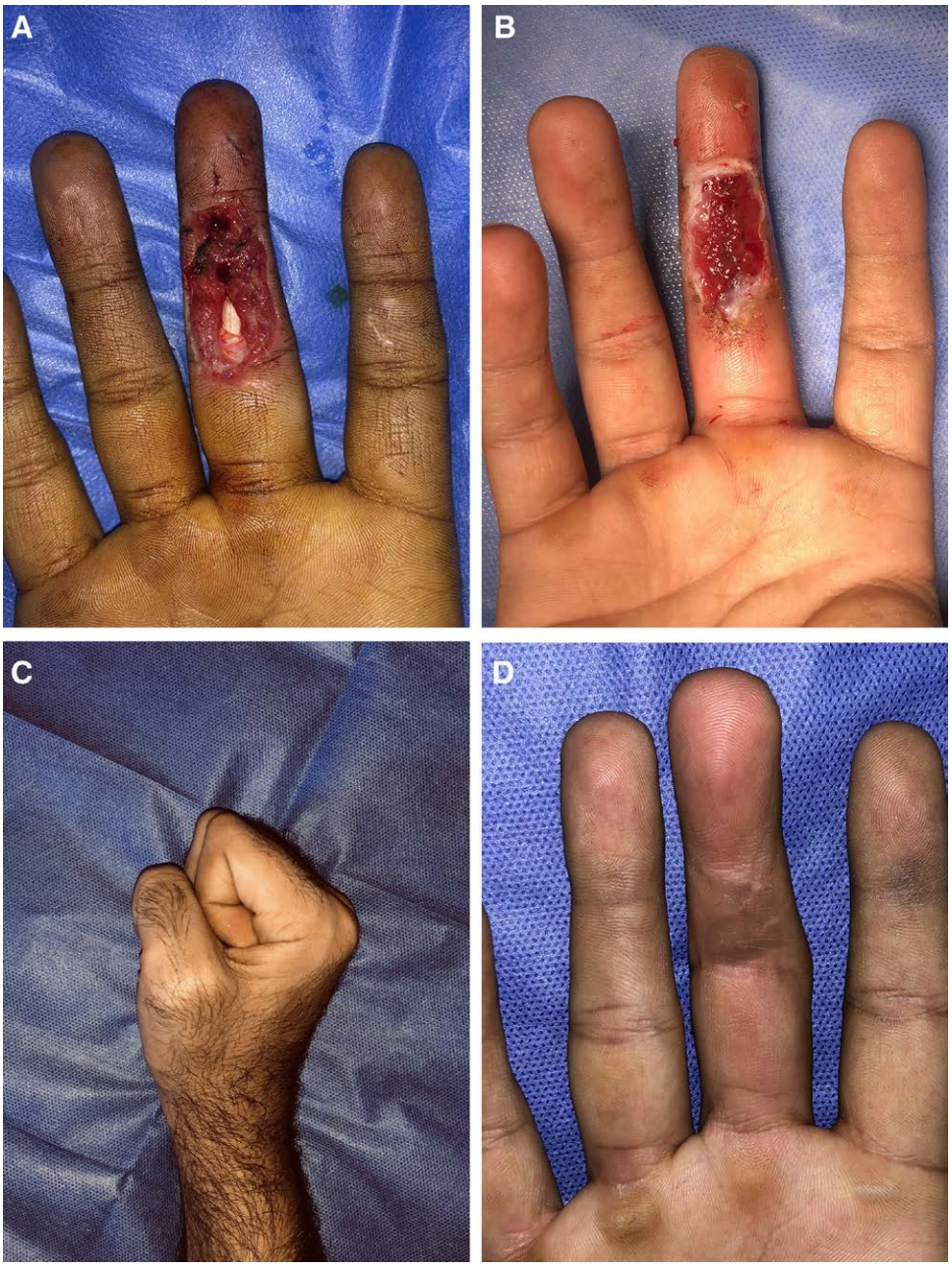

Fig. 6. Exposed flexor digitorum profundus of the middle finger. A, Before Pelnac application. B, After complete Pelnac integration. C-D, Nine months of follow-up with the restoration of hand function.

Additionally, it hindered the assessment of the functional outcome after physiotherapy.

CONCLUSIONS

Pelnac is a cost-effective method for covering exposed tendons in acute hand trauma, which can achieve good aesthetic outcomes with supple and pliable coverage while avoiding donor site morbidities. Furthermore, Pelnac can provide adequate coverage, restoring tendon gliding, and minimizing adhesions. However, it should be taken into consideration that in cases of degloved injuries, it is preferred to apply Pelnac after a second assessment of the wound and to begin strict postoperative rehabilitation and physiotherapy programs to enhance functional recovery.

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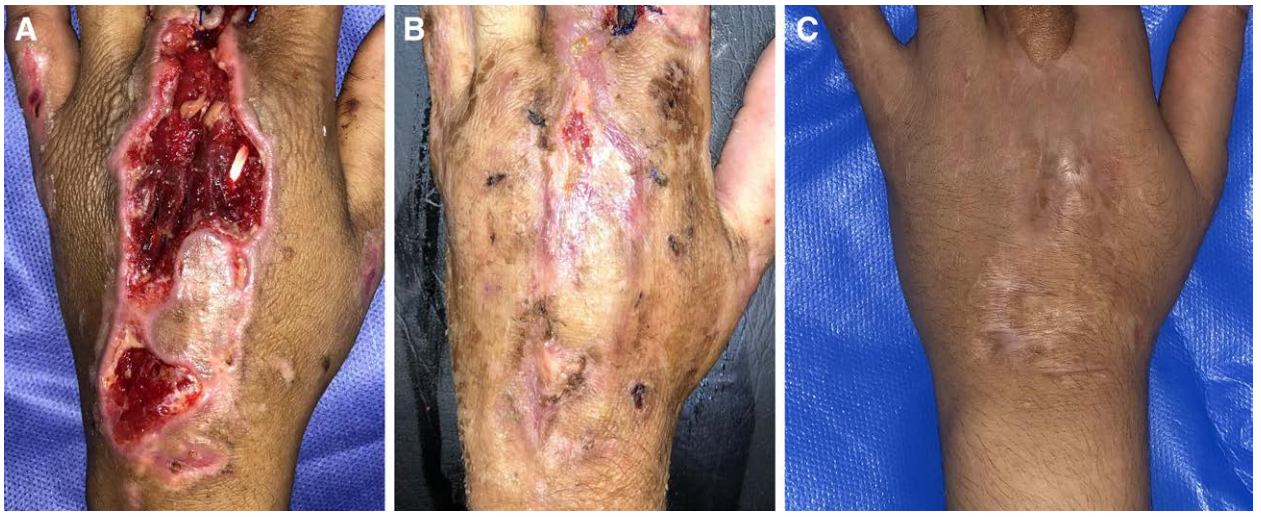

Fig. 7. Female patient with degloving injury to the dorsum of the hand (A) exposed extensor digitorum communis of the index. B, Results at 21st day follow-up after split-thickness skin graft. C, Seventh month follow-up.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

ETHICAL APPROVAL

The ethical committee of our institute, the Faculty of Medicine at Cairo University, approved this study under number MS-51-2023.

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