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ORIGINAL ARTICLE

Effect of cross-running polypropylene intradermal suture technique on keloid scar: a single-blind randomized controlled trial

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ABSTRACT

BACKGROUND
Keloids are abnormal scars that present a therapeutic challenge. Various treatment modalities have been developed, including surgical excision. While cross-running intradermal sutures were previously created using absorbable polyglycolic acid, this study introduces a modification using a non-absorbable material. Therefore, this study aimed to evaluate the effect of the cross-running polypropylene intradermal suture (CR-PIS) technique compared to the simple interrupted suture technique on keloid repair.

METHODS
This was a randomized controlled trial with a post-test-only design involving 30 male and female keloid patients aged 20-50 years. Participants were randomized into the treatment group (n=15) and the control group (n=15). Wound assessment using the Vancouver Scar Scale (VSS), Manchester Scar Scale (MSS), and Patient and Observer Scar Assessment Scale (POSAS) was performed at 3, 6, and 9 months after surgery. Differences in VSS, MSS, and POSAS scores between the CR-PIS group and the simple knot group were analyzed using the Mann-Whitney U test.

RESULTS
Statistical analysis revealed a significant difference between the simple knot and CR-PIS groups ($p<0.05$). The median scores for each assessment (VSS, MSS, and POSAS) decreased significantly at 3, 6, and 9 months, with the control group's values being higher than those in the CR-PIS group ($p<0.05$). These results indicate that the control group developed moderate scars, whereas the treatment group exhibited good scars.

CONCLUSIONS
The CR-PIS is more effective than the simple knot technique in improving keloid scars, as shown by changes in wound appearance, morphological function, topography, and patient and evaluator assessments.

Keywords: CR-PIS, intradermal suture, keloid, polypropylene

INTRODUCTION

The skin is the external part of the body that is vulnerable to injury.[1] The mechanism of cutaneous wound healing involves a series of dynamic processes, including the actions of various growth factors, the proliferation of fibroblasts, the formation of new blood vessels, and the production of an extracellular matrix, which collectively result in normothropic, flat, and thin scars.[2,3] However, in some conditions, the wound healing process becomes abnormal and produces a scar,[1] which is the final result of this process.[4]

Scar tissue can form as a result of burns, surgery, or other injuries. In the wound-healing process, there are two spectrums of scar formation: regeneration with normal scars and regeneration with pathological scars. Pathological scarring is divided into keloids and hypertrophic scars,[5] both of which contribute significantly to morbidity.[6] Hypertrophic scarring is a scar that forms after injury but is limited to the scar area and can cause contracture.[7] On the other hand, a keloid is excessive scarring that extends outside the area of the original injury. A keloid can cause pruritus and hyperesthesia, which may occur at any time after excision.[1,5] Keloids arise due to an imbalance in collagen synthesis and degradation.[8]

Keloid problems for some patients constitute a significant psychological burden,[5] because keloids are more frequently painful than hypertrophic scars.[9] Every individual has the potential for keloid formation, but it is greater in groups with more skin pigmentation.[10,11] These keloids commonly appear on the chest, upper arms, and scapular region,[12] as well as on the head, neck, shoulders, and ears.[11,13]

Keloid cases in Indonesia are categorized as highly prevalent. Based on a report by Andisi et al.,[14] the prevalence of keloid cases at the Dermato-Venereology Polyclinic of Prof. Dr. Kandou Hospital, Manado, was approximately 1.68%. On the other hand, Wardani et al.[15] reported a substantially higher prevalence of keloid cases, reaching 53.3%, at Dr. Soetomo Hospital, Surabaya, in the period of 2014–2017. Given their high incidence across several regions, it is evident that keloids remain a significant problem and require further attention in treatment.

Conventional treatments for keloids include massage,[16] corticosteroid injection,[17] radiotherapy,[18] and surgery.[7] In surgical treatment, the selection of suture material and technique is crucial for the successful outcome of keloid repair. The running suture technique is one of the most common wound-suturing techniques used in the outer skin, such as the eye folds, ears, and loose skin areas. However, it can also be used as an intradermal suture to repair surgical keloid approximation.[19] The development of the intradermal suture technique has been reported by Xiong et al.,[20] specifically the cross-running intradermal suture (CRIS), to enhance wound closure, reduce incision length, and minimize the potential for complications. Ario et al.[21] reported on surgical techniques to improve abnormal scars, including the intradermal suture technique with polypropylene.

Based on similar research, a prospective analytical study of patients who underwent dental implant surgery found that the use of resorbable polyglycolic acid (PGA) sutures in oral implantology procedures led to good healing and minimal biological complications, which resolved by 30 days post-surgery.[22] A prospective randomized trial involving 108 women aged 18–40 years with singleton pregnancies undergoing cesarean section, demonstrated that the use of either polyglycolic acid or polyglactin 910 sutures for subcutaneous closure had no significant impact on the incidence of abdominal wound disruption.[23]

Previous studies developing the CRIS technique have used absorbable suture materials, typically polyglycolic acid (PGA). Although the CRIS technique has been proven effective in minimizing wound tension and improving scar aesthetics, the use of absorbable sutures can still carry the risk of failure or long-term keloid recurrence.[7] This occurs because the suture's tensile strength decreases and the suture eventually disappears. This challenge underscores the need for a more durable and robust wound-closure method in patients prone to keloids. Therefore, this study focused on modifying the CRIS technique into the cross-running polypropylene intradermal suture (CR-PIS) using non-absorbable polypropylene sutures. Polypropylene sutures provide permanent tensile strength that, hypothetically, will give continuous mechanical support to the dermis. This support is crucial for minimizing long-term wound tension, which is a critical etiologic factor in the pathogenesis and prevention of keloid recurrence.

The objective of this study was to determine the effect of modifying the CRIS technique to CR-PIS using non-absorbable polypropylene thread on keloid scar repair.

METHODS

Research design

A single-blind, randomized controlled trial with a post-test-only design was conducted from June 2021 to June 2022 at Saiful Anwar General Hospital, Malang.

Research subjects

A saturated sample of 30 subjects was selected from all patients who visited the Plastic Surgery Clinic at Saiful Anwar Hospital, Malang, and met the inclusion criteria. The inclusion criteria were: age 20-50 years; diagnosed with keloids less than 2 cm wide and eligible for primary suturing with a simple advancement flap; and no previous treatment. The exclusion criteria for this study were: subjects with diseases or conditions related to wound-healing disorders, such as diabetes mellitus, malnutrition, or hemophilia; subjects who were receiving therapy before becoming a patient at Saiful Anwar Hospital, Malang.

Randomization and blinding

The participants were randomized using a computer-generated randomization sequence with block sizes of 6. A sequentially numbered, opaque, sealed envelope technique was used to randomize participants. A total of 30 eligible subjects were randomized to either the treatment (n=15) or the control (n=15) group. The control group underwent intradermal suture treatment with simple knots, while the treatment group received treatment with the CR-PIS method. The subjects were unaware of the allocation status in this study. This strict randomization protocol was implemented to ensure that potential confounding variables were distributed equally between the two groups.

Interventions

All keloid excisions were performed using total excision, followed by a standardized two-layer wound closure technique (deep dermal layer closure and superficial intradermal layer closure) to minimize incision tension. The deep dermal layer closure for both the control and treatment groups was done identically using a continuous running suture. This utilized an absorbable, braided polyglycolic acid (4.0) thread, with complete absorption within 60 to 90 days. The superficial intradermal layer in both groups was closed with a non-absorbable polypropylene suture (4.0). The two groups differed only in the suture technique applied to this layer; this suture was completed within 7-15 days. In the control group, the non-absorbable polypropylene suture was applied using the simple interrupted suture technique, whereas in the treatment group, the non-absorbable polypropylene suture was applied using the modified CR-PIS technique. The CR-PIS combines running and crossing patterns to improve wound eversion and ensure even tension distribution across the incision line.

Post-operative keloid assessment was conducted every trimester, namely at 3, 6, and 9 months. Quarterly follow-up progress was according to Ogawa's method[12], in which patients undergoing treatment for keloid and hypertrophic scars must be checked regularly, at least once every three months or 18 to 24 months for early detection, without receiving further treatment if recurrence occurs as a result of the procedure, especially for high-tension surgical sites (chest, abdomen). Follow-up can be discontinued when the wound appears flat and smooth. In addition to visual observation, the data obtained is also subjected to statistical analysis.

Study outcomes

A reconstructive and aesthetic plastic surgeon performed scar quality assessment at 3, 6, and 9 months after surgery, using the Vancouver scar scale (VSS) to evaluate pliability, height, vascularity, and pigmentation.[24] The VSS score range is typically 0 to 13. The Manchester scar scale (MSS) is used to assess scar characteristics, including color, finish (matte or shiny), contour, distortion, texture, and overall appearance using a visual analog scale.[25] The MSS score ranges from a minimum of 5 to a maximum of 18. The patient and observer scar assessment scale (POSAS) uses two numerical assessment scales, namely: 1. scar assessment by patients; 2. scar assessment by observers. For observers, the aspects assessed include vascularization, pigmentation, softness, and thickness. For patients, the assessed aspects include pain, itching, differences in wound color, and changes in scar stiffness.[26] The POSAS score uses individual item scores from 1 (normal skin) to 10 (worst imaginable scar), with total scores ranging from 6 to 60.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics 23. In this study, non-parametric tests were used because the data were not normally distributed. The Mann-Whitney U test was used to compare the two groups (control and treatment) in each trimester. A p-value < 0.05 was considered statistically significant. Descriptive data were presented as medians and range.

Ethical approval

Ethical approval for this research was obtained from the ethics committee of Saiful Anwar General Hospital, Malang, with ethical clearance number 400/021/CR/102.7/2025.

RESULTS

We assessed 32 patients between June 2021 and June 2022, with 2 patients declined to participate. Thus, 30 subjects were randomized into two intervention groups: 15 to the control group and 15 to the treatment group. All subjects completed the 9-month follow-up (Figure 1). At base-line the demographic characteristics regarding age, gender, and scar site were comparable between the two groups (p>0.05), as shown in Table 1.

Based on median score analysis, the CR-PIS group experienced a significant decline in each trimester across the VSS, MSS, and POSAS assessments. Similarly, the control group also experienced a significant decrease, but the median scores were still lower in the CR-PIS group (Figure 2). A comparison of the clinical picture in the control group is presented in Figure 3 for preoperative and in Figure 4 for postoperative views. Meanwhile, the clinical picture of the treatment group is presented in Figure 5 for preoperative and in Figure 6 for postoperative views.

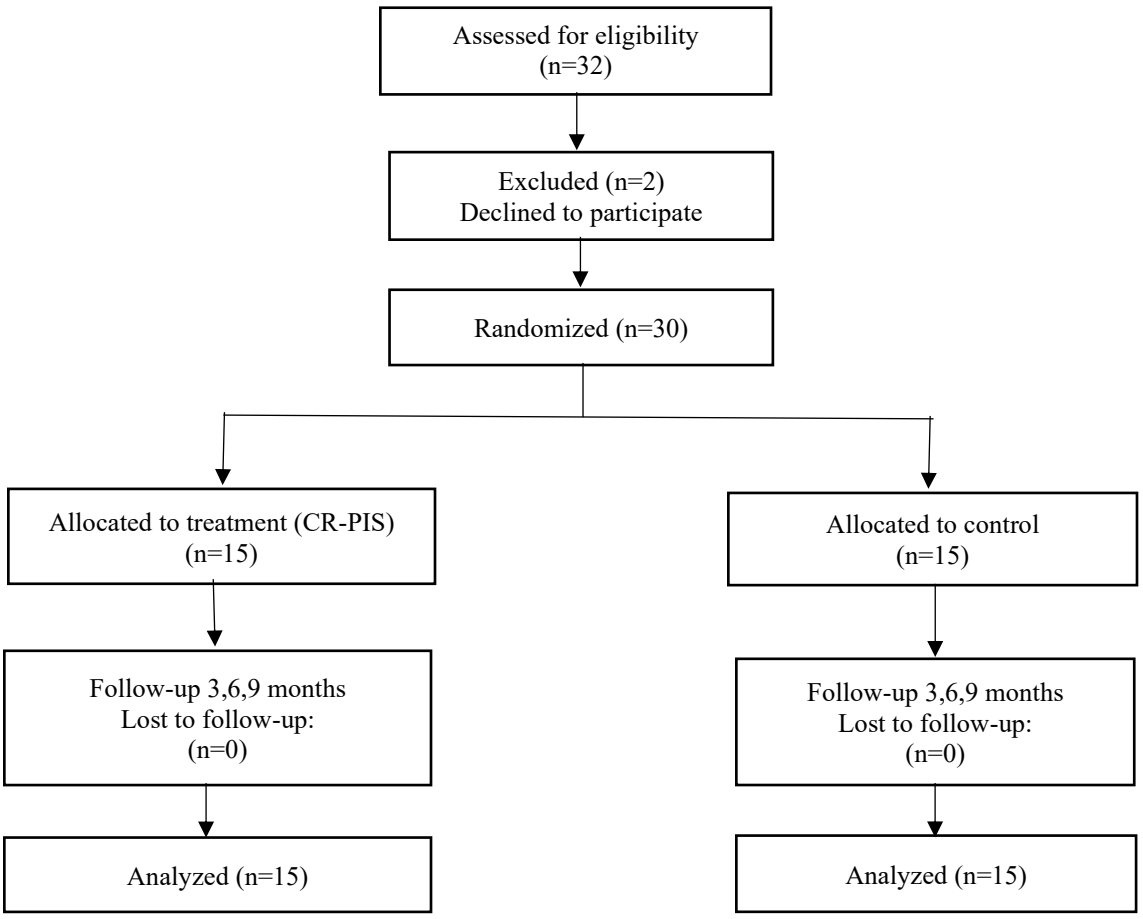

Figure 1. Flow chart of the participants

Table 1. Baseline demographics and scar description by treatment group

Variables	Intradermal suture treatment using the CR-PIS (n=15)	Intradermal suture treatment with simple knots (n=15)	p value
Age (years)	35.67± 8.52	35.80 ± 8.94	0.967
Gender			
Male	8 (53.3)	8 (53.3)	1.000
Female	7 (46.7)	7 (46.7)	
Scar site			
Trunk	7 (46.7)	7 (46.7)	1.000
Extremities	8 (53.3)	8 (53.3)	

Note : data presented as n (%) except for age mean ± SD; CRPIS : cross-running polypropylene intradermal suture

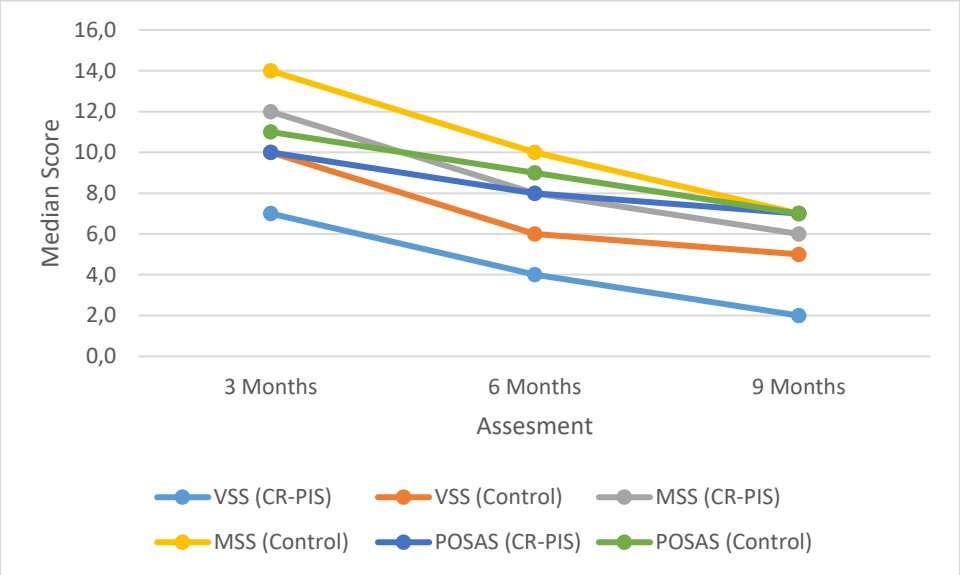

Figure 2. Line graph comparing the median scores of VSS, MSS, and POSAS between the CR-PIS and control groups (simple knots) at 3, 6, and 9 months post-operation

Figure 3. Control group (A) Pre-op view of chin keloid (B) Pre-op view of breast keloid (C) Pre-op view of neck keloid

Figure 4. Control group (A) Post-op view of chin keloid (B) Post-op view of breast keloid (C) Post-op view of neck keloid

Figure 5. Treatment group (A) Pre-op view of abdominal keloid (B) Pre-op view of temporoparietal keloid (C) Pre-op view of upper back keloid

Figure 6. Treatment group (A) Post-op view of abdominal keloid (B) Post-op view of temporoparietal keloid (C) Post-op view of upper back keloid

Table 2. Comparison of VSS, MSS, and POSAS scores after 3, 6, and 9 months operative treatment, by treatment groups

Assessment	Intradermal suture treatment using the CR-PIS (n=15)	Intradermal suture treatment with simple knots (n=15)	p value
	Median (Q1-Q3)	Median (Q1-Q3)	
3 mo			
VSS	7.0 (6.0-8.0)	10.0 (8.0-12.0)	< 0.001
MSS	12.0 (10.0-13.0)	14.0 (12.0-16.0)	0.004
POSAS	10.0 (9.0-11.0)	11.0 (10.0-12.0)	0.028
6 mo			
VSS	4.0 (3.0-5.0)	6.0 (5.0-7.0)	< 0.001
MSS	8.0 (7.0-9.0)	10.0 (8.0-9.0)	0.016
POSAS	8.0 (7.0-9.0)	9.0 (8.0-10.0)	0.006
9 mo			
VSS	2.0 (1.0-3.0)	5.0 (4.0-6.0)	< 0.001
MSS	6.0 (5.0-7.0)	8.0 (7.0-9.0)	0.003
POSAS	7.0 (6.0-8.0)	7.0 (8.0-9.0)	0.004

Note: data presented as median (range); CR-PIS: cross-running polypropylene intradermal suture; VSS: Vancouver scar scale; MSS: Manchester scar scale; POSAS: patient and observer scar assessment scale

Statistical analysis using the Mann-Whitney U test showed significant differences in VSS, MSS, and POSAS scores between the two groups throughout the observation period ($p<0.05$). The detailed comparisons between the groups at each time point (3, 6, and 9 months) are shown in Table 2. The VSS scores showed significant differences between the groups at all observation times. At 3 months, the CR-PIS group had a significantly lower median score of 7.0 (6.0-8.0) compared with the control group's median of 10.00 (8.0-12.0) ($p<0.001$). This significant difference continued at

6 months [CR-PIS: 4.00 (3.0-5.0) vs. control: 6.0 (5.0-7.0); (p<0.001)] and was maintained at 9 months [CR-PIS: 2.0 (1.0-3.0) vs. control: 5.0 (4.0-6.0); (p<0.001)].

Similar to VSS, the MSS scores were significantly different at all time points. The CR-PIS group demonstrated significantly better results at 3 months [CR-PIS: 12.0 (10.0-13.0) vs. Control: 14.0 (12.0-16.0); (p=0.004)]. This significant difference persisted at 6 months [CR-PIS: 8.0 (7.0-9.0) vs. control: 10.0 (8.0-9.0); (p= 0.016)] and 9 months [CR-PIS: 6.0 (5.0-7.0) vs. control: 8.0 (7.0-9.0); (p=0.003)].

The POSAS scores show that the effectiveness of CR-PIS is evident from the earliest follow-up period. At 3 months, the CR-PIS median score of 10.0 (9.0-11.0) was significantly lower than that of the control group of 11.0 (10.0-12.0) (p=0.028). This significant difference continued at 6 months [CR-PIS: 8.0 (7.0-9.0) vs. control: 9.0 (8.0-10.0); (p=0.006)] and was maintained until 9 months [CR-PIS: 7.0 (6.0-8.0) vs. control: 7.0 (8.0-9.0); (p=0.004)]. This indicates that CR-PIS produced a significant improvement in POSAS scores compared to controls at all time points.

DISCUSSION

This study aimed to evaluate the CR-PIS technique, compared with the simple interrupted technique, for treating keloids. The findings of this study showed that the CR-PIS group achieved significantly better wound-healing outcomes than the control group. This was evidenced by consistently lower scores on VSS, MSS, and POSAS at all post-operative evaluation points (3rd, 6th, and 9th months) and when compared to the control group (Figure 2). Clinically, the scars in the treatment group showed better morphological quality, with patients reporting a significant reduction in pain, itching, and stiffness. According to Grabowski et al.,[27] good suturing can be identified by several criteria: absence of trauma, optimal tissue removal, minimal skin tension, skin eversion, proper suture placement, and prevention of hematoma.

The intradermal running suture technique has long been associated with better cosmetic results than interrupted sutures. Therefore, this technique is preferred by surgeons and patients alike for improving the appearance of scars, as noted by Luo et al.,[28] who highlighted its ability to reduce the risk of dehiscence. The CR-PIS technique used in this study is a modification of the cross-running intradermal suture (CRIS) technique described initially by Xiong et al.,[20] which aims to improve wound closure strength. However, a crucial difference in our study is the use of non-absorbable suture material (polypropylene), rather than absorbable polylactic acid as used in previous studies. This modification supports the findings of Ario et al.[21] and animal studies by Gouletsou et al.,[29] which suggest that non-absorbable monofilament sutures offer the advantages of minimal tissue traction and smoother application.

The superior results observed in the CR-PIS group can be attributed to the specific mechanical advantages of the technique and materials used. Keloid recurrence is often triggered by high skin tension.[7] While absorbable sutures lose their tensile strength over time, polypropylene provides permanent and stable mechanical support to the dermis, effectively withstanding the tension that typically causes scar widening and recurrence.[30] In addition, the cross-running pattern ensures even tension distribution along the incision line and facilitates optimal wound edge eversion, which is a critical factor for good scar formation.[31] As a monofilament material, polypropylene triggers a lower inflammatory response compared to braided sutures due to its low friction coefficient and minimal tissue reactivity.[32]

This study has several limitations. First, this research was conducted as a single-center study, which may limit the generalization of findings to a broader population. Further research with larger cohorts and a multi-center design is recommended to validate the superiority of the CR-PIS technique. In addition, future studies with assessment periods longer than 9 months would be useful for evaluating the long-term consistency of scar results with the CR-PIS method. Despite several limitations, this study's results provide strong clinical support for the use of the CR-PIS technique in the treatment of keloid scars, especially in areas of high tension. The CR-PIS is considered the standard procedure for keloid closure due to its significant advantages in reducing objective scar parameters (VSS, MSS) and subjective parameters (POSAS), especially when combined with non-absorbable monofilament sutures, such as polypropylene. Practitioners confidently recommend CR-PIS as a surgical procedure that significantly improves patients' quality of life and produces better aesthetic results.

CONCLUSIONS

The CR-PIS technique demonstrated superior effectiveness compared to conventional simple interrupted sutures in keloid scar repair. The CR-PIS technique resulted in better wound healing outcomes, both visually and functionally, and was associated with improved morphological features, reduced scar elevation, and enhanced patient satisfaction. These findings support the adoption of CR-PIS as a reliable surgical technique for optimizing aesthetic and clinical results in keloid excision.

Conflict of Interest

The authors declare no conflict of interest.

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Author Contributions

HYLW: conceptualization, methodology, supervision of the research, and review of the manuscript. ESR: data collection, data analysis, original draft preparation. A and YS: methodology, data collection, validation, and editing of the manuscript. WA and EPS: methodology, data analysis validation, and writing the manuscript. All authors have read and approved the final manuscript.

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Data Availability Statement

The data attached to this manuscript are pure research data.

Declaration the Use of AI in Scientific Writing

None.

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