# Impact of Comprehensive Postoperative Incisional Analgesia and Scar-Prevention Interventions on Rehabilitation Outcomes in Patients Undergoing Scar Revision Surgery

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AIM: Patients undergoing scar revision surgery have high expectations for both aesthetic restoration and functional recovery, with postoperative pain management and scar prevention being key factors that influence the quality of rehabilitation. This study, through a retrospective analysis, examined the impact of comprehensive postoperative incisional analgesia and scar-prevention intervention on rehabilitation outcomes in patients undergoing scar revision surgery, aiming to provide evidence for optimizing clinical postoperative management strategies.

METHODS: A retrospective analysis was conducted using the clinical data of 170 patients who underwent scar revision surgery in our hospital between March 2022 and August 2024. Based on the intervention approach, patients were assigned to a comprehensive intervention group (n = 90) and a control group (n = 80). Both groups received standardized optimal wound care, including layered suturing of incisions and routine dressing changes every 3 days, until suture removal. The comprehensive intervention group received multimodal analgesia combined with a comprehensive scar-management protocol, while the control group received routine analgesia combined with a basic scar-management plan. Visual Analog Scale (VAS) scores, Vancouver Scar Scale (VSS) scores, and complication rates were compared between the two groups.

RESULTS: Preoperative baseline characteristics showed no significant differences between the two groups ($p > 0.05$). Postoperative VAS scores in the comprehensive intervention group were significantly lower than those in the control group ($p < 0.001$). Furthermore, the total VSS score in the comprehensive intervention group was significantly superior to that in the control group ($p < 0.001$). Regarding complications, the overall complication rate in the comprehensive intervention group (25.56%) was significantly lower than in the control group (51.25%) ($p < 0.01$). Subgroup analyses based on scar type (hypertrophic vs. keloid) demonstrated consistent benefits of the intervention, with no significant interaction observed ($p > 0.05$).

CONCLUSIONS: Comprehensive postoperative analgesia and scar-prevention intervention can effectively alleviate postoperative pain, improve scar appearance, and enhance rehabilitation among patients undergoing scar revision surgery, indicating that such an approach is suitable for clinical application.

**Keywords:** scar revision surgery; postoperative analgesia; comprehensive intervention; scar prevention; rehabilitation outcome

## Introduction

Scar tissue is pathological fibrotic tissue formed during the repair process following skin trauma or surgery, characterized by marked differences from normal skin in histological structure, morphological properties, and physiological function [1]. Scar formation is a complex, multifactorial pathological process with notable clinical heterogeneity. Epidemiological evidence suggests that approximately 40 million individuals worldwide are affected by various types of scars annually [2]. The physical discomfort, functional impairment, and psychological stress caused by scars can significantly compromise patients' physical well-being and overall quality of life [3,4].

Among pathological scars, hypertrophic scars and keloids represent significant clinical challenges due to their high recurrence rates and symptoms such as pain and itching [5]. Scar development involves persistent inflammation, abnormal collagen accumulation, and an imbalance in the extracellular matrix [6], which is influenced by factors such as genetic predisposition, wound depth, and the quality of postoperative care [7].

Existing scar-prevention strategies, including silicone gel, pressure therapy, and pharmacological treatment, are widely used; however, the patients' adherence is often low, and robust evidence from large randomized clinical trials is limited [8]. Given the significant aesthetic and functional impairment caused by scar formation, the development of

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effective and practical prevention and treatment strategies is of considerable clinical significance [9]. However, integration of postoperative analgesia with scar prevention, addressing pain-scar interactions via reduced inflammation and minimized mechanical tension, remains underexplored. Therefore, this study retrospectively examined 170 patients undergoing scar revision surgery to evaluate the impact of comprehensive incisional analgesia combined with scar-prevention measures on postoperative pain, scar quality, and complication rates, providing evidence to support optimized postoperative management protocols.

## Methods

*Study Subjects*

A retrospective analysis was conducted on the clinical data of 170 patients who underwent scar revision surgery in the Department of Burn Plastic Surgery and Wound Repair, Ganzhou People's Hospital between March 2022 and August 2024. The inclusion criteria were as follows: (1) Age ≥18 years; (2) Elective scar-repair surgery (e.g., linear scar excision, Z-plasty, local flap transplantation); (3) Incision site located on limbs, trunk, or face (non-articular regions); (4) Scar type being hypertrophic scar or keloid (hypertrophic scars are defined as elevated lesions confined to original wound margins; keloids are defined as scars extending beyond the original wound margins with claw-like projections) [5]; (5) Follow-up completeness: postoperative follow-up ≥6 months with complete data. Exclusion criteria included: (1) Conditions affecting wound healing, such as diabetes, immunodeficiency, or connective tissue diseases; (2) Long-term use of glucocorticoids or immunosuppressants; (3) Postoperative incision infection or delayed healing (>14 days); (4) Incomplete records of key variables.

Patients were allocated into a comprehensive intervention group (n = 90) and a control group (n = 80) based on the postoperative intervention strategy. Because this study involved retrospective data analysis, posed no risk to patients, and protected their privacy, ethical approval was waived by Ganzhou People's Hospital in accordance with local regulations. This study has no commercial purpose and adheres to the principles outlined in the Declaration of Helsinki.

Both groups received identical optimal wound care. All incisions were closed using layered suturing techniques (subcutaneous, dermal, and epidermal layers). Standard sterile dressings were changed every 3 days postoperatively until suture removal (typically 7–14 days postoperative). For cases with exudation or suspected infection, dressing changes were increased to daily, with antibiotic administration if infection was confirmed. For keloid patients, postoperative adjuvant therapy (superficial X-ray radiation within 24 h or intralesional triamcinolone injections every 4 weeks for 3 months) was standardized in both groups, per institutional protocol, to minimize recurrence bias. No postoperative radiation therapy or intralesional injections were used for hypertrophic scars.

*Comprehensive Intervention Group*

Patients in this group received multimodal analgesia combined with a comprehensive scar-management protocol. The postoperative analgesia plan included pharmacological and physical measures. Pharmacological analgesia consisted of preoperative oral celecoxib 200 mg taken 1 hour preoperatively, intraoperative local infiltration with 0.2 mL/cm of 0.5% ropivacaine along the incision, and postoperative administration of intravenous parecoxib sodium 40 mg every 12 h for 2 days combined with oral loxoprofen sodium 60 mg every 8 h for 5 days. These regimens followed Enhanced Recovery After Surgery (ERAS) guidelines for minor procedures. Proton pump inhibitors were administered when gastrointestinal risk factors were present, and renal function was monitored using serum creatinine levels. Breakthrough pain was managed with tramadol 50 mg intramuscular injection pro re nata (PRN).

Physical analgesia included cold compresses applied within 24 hours postoperatively for 15 minutes per session at 2-hour intervals, using a wrapped towel to avoid direct skin contact and frostbite, and low-frequency electrical stimulation starting 3 days postoperatively, performed once daily for 20 min with a frequency of 2–10 Hz and intensity of 10–20 mA. Electrodes were positioned adjacent to the incision site.

Scar prevention and treatment measures covered silicone-based therapy, pressure therapy, and functional rehabilitation. Silicone gel was initiated 3 days after suture removal and applied twice daily for 6 months, while silicone sheets were worn for at least 8 hours nightly for 3 months. Pressure therapy was introduced 2 weeks after surgery using elastic bandage compression at 15–25 mmHg for at least 12 h daily. Functional rehabilitation involved scar massage starting 7 days postoperatively, performed twice daily with Vitamin E cream, as well as progressive joint-activity exercises supervised by a physiotherapist 3 times per week.

All interventions were monitored by dedicated nursing staff during follow-up visits, and adherence was documented through standardized follow-up logs.

*Control Group*

Patients in the control group received standardized postoperative management. Analgesia was provided using oral ibuprofen sustained-release capsules at a dose of 400 mg, taken every 8 hours as needed for up to 3 days. For breakthrough pain with Visual Analog Scale (VAS) ≥7, tramadol was administered as the first-line rescue medication. If tramadol failed to achieve adequate pain relief, pethidine 50 mg via intramuscular injection was administered as a second-line option. All patients received standardized education on potential side effects, delivered verbally and supplemented with written materials.

**Table 1. Comparison of baseline characteristics between groups.**

| Variables | Total (n = 170) | Control group (n = 80) | Comprehensive intervention group (n = 90) | Statistic | *p*-value |
|---|---|---|---|---|---|
| Age (years), $\bar{x} \pm$ SD | 36.32 ± 6.20 | 36.39 ± 6.30 | 36.26 ± 6.14 | $t = 0.14$ | 0.890 |
| BMI (kg/m$^2$), $\bar{x} \pm$ SD | 22.71 ± 1.71 | 22.54 ± 1.72 | 22.86 ± 1.70 | $t = -1.22$ | 0.224 |
| Preoperative VSS scores, $\bar{x} \pm$ SD | 7.36 ± 1.06 | 7.42 ± 1.08 | 7.31 ± 1.05 | $t = 0.70$ | 0.484 |
| Incision length (cm), $\bar{x} \pm$ SD | 5.71 ± 1.00 | 5.73 ± 1.07 | 5.68 ± 0.95 | $t = 0.34$ | 0.734 |
| Gender, n (%) | | | | $\chi^2 = 0.13$ | 0.715 |
| Male | 74 (43.53) | 36 (45.00) | 38 (42.22) | | |
| Female | 96 (56.47) | 44 (55.00) | 52 (57.78) | | |
| Scar type, n (%) | | | | $\chi^2 = 1.81$ | 0.178 |
| Hypertrophic scar | 117 (68.82) | 51 (63.75) | 66 (73.33) | | |
| Keloid | 53 (31.18) | 29 (36.25) | 24 (26.67) | | |
| Surgical type, n (%) | | | | $\chi^2 = 2.37$ | 0.305 |
| Linear scar excision | 125 (73.53) | 59 (73.75) | 66 (73.33) | | |
| Z-plasty | 29 (17.06) | 16 (20.00) | 13 (14.44) | | |
| Local flap transfer | 16 (9.41) | 5 (6.25) | 11 (12.22) | | |
| Operative time (min), M ($Q_1$–$Q_3$) | 67.50 (47.50–87.75) | 68.00 (45.00–86.00) | 66.50 (50.00–89.50) | Z = –0.64 | 0.525 |
| Surgical site, n (%) | | | | $\chi^2 = 0.65$ | 0.722 |
| Limbs | 71 (41.76) | 36 (45.00) | 35 (38.89) | | |
| Head & Face | 27 (15.88) | 12 (15.00) | 15 (16.67) | | |
| Chest & Back | 72 (42.35) | 32 (40.00) | 40 (44.44) | | |

SD, standard deviation; M, median; $Q_1$, 1st Quartile; $Q_3$, 3rd Quartile; BMI, body mass index; VSS, Vancouver Scar Scale.
*t*, *t*-test; Z, Mann–Whitney U test; $\chi^2$, chi-square test.

Wound care consisted of the application of petroleum jelly once daily for 4 weeks following suture removal. At this stage, the wound was considered sufficiently healed to eliminate the need for sterile dressings. Petroleum jelly was recommended to maintain a moist environment that promotes ongoing epithelialization and prevents drying or cracking, which is superior to leaving the wound exposed. Scar intervention strategies included the use of silicone gel for scars located on non-chest and non-back regions, while pressure garments were recommended for scars on the chest or back. Patients were also advised to avoid sun exposure to the incision area for 6 months postoperatively, with written education materials provided to reinforce compliance.

### *Observation Indicators*

General patient information was collected, including gender, age, body mass index (BMI), preoperative Vancouver Scar Scale (VSS) score, incision length, scar type, surgical type, operative duration, and surgical site. All data were obtained from the electronic medical record system of the hospital.

### *Postoperative Pain Assessment*

Postoperative pain was assessed using the VAS [10]. The VAS is a subjective tool for evaluating pain intensity in which patients self-indicate their perceived level of pain. It is widely used in postoperative and chronic pain assessments. Scores range from 0 to 10, with higher values indicating more severe pain.

### *Scar Assessment*

Scar quality after the implementation of the intervention protocol was evaluated using the VSS [11]. This scale is suitable for assessing pathological scars such as hypertrophic scars and keloids. It evaluates scar pigmentation, thickness, vascularity, and pliability, with total scores ranging from 0 to 15; higher scores indicate more severe scarring. Assessments were performed during postoperative follow-up at 1, 3, and 6 months.

### *Complications*

Postoperative complications included scar hypertrophy (defined as a VSS thickness or pliability score $\geq$3), incision infection (clinical erythema or purulent discharge confirmed by culture), wound dehiscence (partial or full wound separation $>$2 mm), pigmentation abnormalities (visible hyperpigmentation or hypopigmentation), and hematoma (clinically evident collection requiring aspiration or drainage). Infections were analyzed independently but included when related to scar formation. The complication rate during the follow-up period was calculated using the following formula:

Complication rate (%) = (Number of complications in each group / Total number of patients in each group) $\times$ 100.

### *Statistical Analysis*

Data processing was performed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to evaluate the normality of the data distributions. Measurement variables conforming to a normal distribution (e.g., age, BMI, preoperative VSS score, incision length) are presented as $\bar{x} \pm$ standard deviation

**Table 2. Comparison of postoperative VAS scores.**

| Group | Postoperative time | VAS score (Mean ± SD) | *F* | *p*-value | Post-hoc comparison (Bonferroni) |
|---|---|---|---|---|---|
| Comprehensive intervention group (n = 90) | 24 h postop | 2.06 ± 0.49 | 253.039 | <0.001 | $p < 0.001$ (24 h vs. 48 h, 48 h vs. 7 d) |
| | 48 h postop | 1.41 ± 0.38 | | | |
| | 7 d postop | 0.80 ± 0.27 | | | |
| Control group (n = 80) | 24 h postop | 5.31 ± 0.70 | 685.772 | <0.001 | $p < 0.001$ (24 h vs. 48 h, 48 h vs. 7 d) |
| | 48 h postop | 3.82 ± 0.60 | | | |
| | 7 d postop | 1.92 ± 0.46 | | | |
| *F* (Time) | | 1035.261 | | | |
| *p* (Time) | | <0.001 | | | |
| *F* (Time × Group) | | 255.937 | | | |
| *p* (Time × Group) | | <0.001 | | | |

VAS, Visual Analog Scale.

[SD], and intergroup comparisons were conducted using the independent samples *t*-test. Measurement variables not meeting normality assumptions are expressed as median [1st Quartile–3rd Quartile] (M [$Q_1$–$Q_3$]), and intergroup comparisons were made using the Mann-Whitney U test. Categorical variables are expressed as frequency (n) and percentage (%), and were compared using the chi-square ($\chi^2$) test or Fisher's exact test as appropriate. For within-group longitudinal changes, repeated measures Analysis of Variance (ANOVA) with Bonferroni post-hoc correction was performed; non-parametric tests (Wilcoxon signed-rank) were used to confirm the robustness of findings. A $p$-value $< 0.05$ was considered statistically significant.

## Results

### *Comparison of Baseline Data*

A total of 170 individuals were included in this study, with 80 in the control group (47.06%) and 90 in the comprehensive intervention group (52.94%). There were no statistically significant differences in baseline characteristics between the two groups, including age (years), BMI (kg/m$^2$), preoperative VSS score, incision length (cm), gender, scar type, surgical type, operative time (min), or surgical site ($p > 0.05$, Table 1).

### *Visual Analog Scale (VAS) Score Comparison*

The postoperative pain scores between the two groups are presented in Table 2. The main effect of time was significant ($F = 1035.261$, $p < 0.001$), indicating that, regardless of group, patients' VAS scores changed significantly over time, showing an overall downward trend. The time × group interaction effect was also significant ($F = 255.937$, $p < 0.001$), demonstrating that the pattern of VAS score change over time was significantly different between the two groups, suggesting that the intervention effect was time-dependent. Within each group, improvements across time were significant (all $p < 0.001$).

### *VSS Comparison*

Scar assessment scores for the two groups are summarized in Table 3. A significant time effect ($F = 1286.552$, $p < 0.001$) indicated that, irrespective of group, VSS scores changed significantly over time, with an overall decreasing trend. The time × group interaction was significant ($F = 87.336$, $p < 0.001$), indicating that the trends in VSS score change over time differed markedly between the two groups, supporting a time-dependent intervention effect. Within each group, improvements over time were significant (all $p < 0.001$).

### *Complication Rate Comparison*

Postoperative complication rates for the two groups are shown in Table 4. The overall complication rate in the comprehensive intervention group (25.56%) was significantly lower than in the control group (51.25%), representing a statistically significant difference ($p < 0.01$).

### *Subgroup Analysis by Scar Type*

In the overall model, the intervention reduced the odds of complications by 67% (odds ratio [OR] = 0.33, 95% confidence interval [CI]: 0.17–0.62, $p < 0.001$). Subgroup analyses demonstrated consistent benefits in both hypertrophic scars (OR = 0.36, 95% CI: 0.14–0.95, $p = 0.040$) and keloids (OR = 0.12, 95% CI: 0.02–0.65, $p = 0.013$). The non-significant interaction ($p$ for interaction = 0.268) suggests that the intervention effect was generally consistent across scar types (Table 5).

## Discussion

This retrospective analysis found that, compared to patients receiving conventional postoperative care, those undergoing scar revision surgery who received comprehensive postoperative incisional analgesia and scar-prevention interventions demonstrated superior rehabilitation outcomes in pain control, scar repair quality, and complication prevention. These findings further support the clinical application value of this comprehensive intervention model.

**Table 3. Comparison of postoperative VSS scores between groups.**

| Group | Postoperative time | VSS score (Mean ± SD) | F-value | *p*-value | Post-hoc Comparison (Bonferroni) |
|---|---|---|---|---|---|
| Comprehensive intervention group (n = 90) | 1 month | 6.58 ± 0.71 | 822.532 | <0.001 | $p < 0.001$ (1 month vs. 3 months; 3 months vs. 6 months) |
| | 3 months | 4.24 ± 0.56 | | | |
| | 6 months | 2.83 ± 0.56 | | | |
| Control group (n = 80) | 1 month | 7.75 ± 0.91 | 259.200 | <0.001 | $p < 0.001$ (1 month vs. 3 months; 3 months vs. 6 months) |
| | 3 months | 6.49 ± 0.78 | | | |
| | 6 months | 4.89 ± 0.65 | | | |
| Main effects | Time | — | 1286.552 | <0.001 | — |
| | Time × Group | — | 87.336 | <0.001 | — |

VSS, Vancouver Scar Scale.

**Table 4. Comparison of postoperative complication rates between groups.**

| Variables | Total (n = 170) | Control group (n = 80) | Comprehensive intervention group (n = 90) | Statistic | *p*-value |
|---|---|---|---|---|---|
| Scar hypertrophy | 25 (14.71) | 16 (20.00) | 9 (10.00) | | |
| Incision infection | 12 (7.06) | 8 (10.00) | 4 (4.44) | | |
| Incision dehiscence | 6 (3.53) | 4 (5.00) | 2 (2.22) | | |
| Pigmentation | 12 (7.06) | 7 (8.75) | 5 (5.56) | | |
| Hematoma formation | 9 (5.29) | 6 (7.50) | 3 (3.33) | | |
| Overall complications, n (%) | 64 (37.65) | 41 (51.25) | 23 (25.56) | $\chi^2 = 11.91$ | 0.001 |

Notes: $\chi^2$, Chi-square test.

**Table 5. Overall and subgroup analysis by scar type.**

| Subgroup | n (%) | Control group complications, n/N | Comprehensive intervention group complications, n/N | OR (95% CI) | *p*-value | *p* for interaction |
|---|---|---|---|---|---|---|
| All patients | 170 (100.00) | 41/80 | 23/90 | 0.33 (0.17–0.62) | <0.001 | |
| Scar type | | | | | | 0.268 |
| Hypertrophic scar | 117 (68.82) | 14/51 | 8/66 | 0.36 (0.14–0.95) | 0.040 | |
| Keloid | 53 (31.18) | 27/29 | 15/24 | 0.12 (0.02–0.65) | 0.013 | |

Abbreviations: OR, odds ratio; CI, confidence interval; N, number of subjects in the group.

Notably, the pathological process of scar formation has clear histological boundaries: pathological scars develop only when skin injury involves the reticular dermis and deeper tissues, whereas superficial wounds limited to the epidermis or papillary dermis can achieve scarless healing through complete regeneration mechanisms [12]. Although the precise molecular mechanisms underlying wound healing and scar hyperplasia are not yet fully elucidated, Transforming Growth Factor-$\beta$ (TGF-$\beta$) is widely recognized as one of the most critical regulatory factors [13]. TGF-$\beta$, as a key biological response modifier, regulates the synthesis and degradation of the extracellular matrix and plays a central role in the tissue repair process [14]. In addition to cytokines and the extracellular matrix, mechanical tension at the wound edges has also been confirmed as a crucial biomechanical factor influencing the quality of healing and scar development [15].

The progression of scars can generally be divided into three stages: the proliferative phase, the stable phase, and the maturation/regression phase [16]. Clinically, the key window for scar prevention and treatment lies in the proliferative phase, during which timely intervention can significantly inhibit excessive scar formation. Corticosteroid injection is currently a common approach for preventing and treating hypertrophic scars, although it may lead to adverse reactions such as pain and pruritus [17]. Furthermore, combination pharmacological therapies and regimens that integrate drugs with physical treatments have also demonstrated favorable therapeutic effects [18].

Overall, the efficacy of the interventions in this study likely results from the synergistic mechanisms of its components. Multimodal analgesia, incorporating ropivacaine infiltration and cryotherapy, reduces acute postoperative inflammation by suppressing the release of prostaglandin E2 (PGE2) and downstream nuclear factor kappa B (NF-$\kappa$B) activation, thereby diminishing TGF-$\beta$1 expression and early fibroblast proliferation, which suppresses pathological scar formation [19,20]. Ropivacaine further modulates Smad pathway activation to promote M2 macrophage polarization, fostering a pro-resolving microenvironment that supports tissue repair and limits fibrotic progression [21]. Similarly, cryotherapy attenuates local hyperemia

and edema, further reducing the proliferative phase of wound healing and preventing excessive collagen synthesis through the decreased release of inflammatory mediators [22]. Moreover, silicone gel and pressure therapy alleviate mechanical tension at wound edges, a pivotal driver of scar development that influences fibroblast proliferation and extracellular matrix (ECM) deposition. Exogenous mechanical tension regulates *Homeobox (HOX)* gene expression, highlighting the mechanotransductive core of scar pathogenesis, whereas silicone gel indirectly modulates the sub-stratum corneum microenvironment through hydration, thereby suppressing fibroblast hyperactivity [23,24]. Additionally, progressive joint mobility training was implemented to maintain skin elasticity and prevent subcutaneous adhesions. Even for scars in non-articular regions, functional movement promotes mechanotransduction, which guides collagen fiber alignment along lines of stress and reduces the risk of contracture-induced functional impairment. Collectively, our study demonstrates that this integrated multimodal regimen significantly enhances rehabilitation outcomes by optimizing pain control and scar quality, while effectively reducing the incidence of postoperative complications.

Limitations of this study: (1) As a retrospective, non-randomized study without blinding, selection bias (e.g., surgeon preference) and information bias may influence results; thus, future randomized trials are essential. The intensity of conventional treatment received by the control group differed from that provided to the comprehensive intervention group. Although this highlights the potential advantages of comprehensive intervention, it may also amplify the magnitude of the between-group differences. Future studies may consider establishing a "medium-intensity intervention group" to more precisely evaluate the independent contribution of various measures. (2) The follow-up period in this study was only 6 months postoperatively, whereas biological scar maturation typically requires 12–18 months to complete. Although a 6-month observation period can reflect early scar formation and the effects of intervention, it may be insufficient to fully characterize the medium- to long-term evolution of scars or the sustained efficacy of the intervention. For example, some scars exhibit significant early hyperplasia but later stabilize or improve naturally, while others may not yet show their final pigmentation, texture alterations, or functional limitations at 6 months. Therefore, short-term follow-up may under- or overestimate the true effect of the intervention, limiting the external generalizability and clinical utility of the study conclusions. Future research should extend follow-up to at least 12–18 months and incorporate objective quantitative tools and patient-reported outcomes to more comprehensively evaluate the long-term value of comprehensive intervention in scar prevention and treatment. A prospective study with an 18-month follow-up is proposed to assess long-term maturation. (3) The primary outcome measures used in this study, VAS and VSS, both contain significant subjective assessment components. The VAS relies entirely on the patient's self-reported pain intensity, which is susceptible to individual tolerance, emotional state, treatment expectations, and social desirability bias. Although the VSS is completed by clinicians, assessments of dimensions such as 'pigmentation' and 'pliability' may still be affected by inter- and intra-rater variability. While both tools are widely used in clinical practice and research and have good face validity, their subjective nature may introduce "expectation effects", potentially over- or underestimating the true condition and thereby affecting the objectivity of intergroup comparisons. To further enhance scientific rigor and reliability of the results, future studies should incorporate objective measurement methods, such as high-frequency ultrasound imaging for precise quantification of scar thickness and echogenicity, chromameters for pigmentation assessment, and cutometers for biomechanical evaluation, to effectively reduce subjective bias and provide more reliable data support. (4) Although the sample size was adequate for primary analyses, it limited the statistical power of subgroup evaluations. Therefore, larger multi-center studies are recommended.

## Conclusions

The results of this study indicate that comprehensive postoperative incision analgesia and scar-prevention intervention are an effective strategy that can significantly improve rehabilitation outcomes in patients undergoing scar revision surgery. Future large-sample, multi-center, long-term follow-up prospective randomized controlled trials are warranted to further verify the reliability of these findings and clarify the specific contributions of each measure within the comprehensive intervention protocol.

## Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Author Contributions

JHL and MYG designed the research study. JHL and MYG performed the research. JHL analyzed the data. MYG drafted the manuscript. Both authors contributed to the critical revision of the manuscript for important intellectual content. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

## Ethics Approval and Consent to Participate

As this study was a retrospective analysis that protected patient privacy and caused no harm to them, ethical approval and the requirement for informed consent were waived by Ganzhou People's Hospital in accordance with local regu-

lations. This study adheres to the relevant principles of the Declaration of Helsinki.

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## Conflict of Interest

The authors declare no conflict of interest.

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