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ORIGINAL RESEARCH

Application of Remote Buried Dermal Super-Tension-Reducing Sutures for Incisional Scar Prevention

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Background: Scar hyperplasia is a common problem after surgical incision healing, and incision tension is an important factor affecting scar formation. Although the traditional super-tension-reducing suture method can improve incision scars, there are problems such as exposure of the needle entry and exit points, which may cause adverse reactions such as pigmentation and scar hyperplasia.
Methods: This prospective study proposes a new super-tension-reducing suture method-distal complete dermal undermining super-tension-reducing suture, which aims to reduce scar hyperplasia by reducing the needle entry and exit points on the incision. This method inserts the needle subcutaneously, undermines 1 cm in the dermis, and then withdraws the needle from the subcutaneous layer, which effectively avoids suture exposure and incision edge irritation. At the same time, by increasing the stress-bearing site, the maintenance time of the super-tension-reducing effect is prolonged.
Results: This study was clinically applied to 50 patients with oral and maxillofacial surgery. The results showed that the observation group was superior to the control group in terms of scar score, pigmentation, centipede-foot scars and delayed incision healing, indicating that this new suture technique can effectively reduce scar hyperplasia and improve incision healing.
Conclusion: This method provides a new technical option for surgical wound healing and has good clinical application prospects.
Keywords: tension-reducing suture, scar formation, dermal suture, aesthetic outcomes, flap donor site, subcuticular suture, surgical scar prevention

Introduction

Scars are common local lesions after surgical incision healing. Incisional tension is an important factor affecting scar formation.[1,2] The concept of super-tension suture has been widely accepted. At present, super-tension suture mainly includes the following types: vertical mattress suture and its improved suture technology, horizontal mattress suture (HMS) and its improved suture technology. These super-tension suture methods can improve incision scar hyperplasia to varying degrees, but all of the above methods require piercing the skin at the dermal anchor point, and inevitably there are obvious needle entry and exit points on the skin, resulting in suture exposure or pigmentation at the skin needle hole or even scar hyperplasia, affecting the appearance,[3,4] and there is a risk of epidermoid cysts at the skin entry and exit points.[5]

In order to improve the above problems while ensuring the tension-reducing effect, we improved the parallel mattress suture and proposed a new super-tension-reducing suture method, namely, distal complete dermal stealth super-tension-reducing suture. After the incision is sutured, the super-tension-reducing suture anchoring position has no needle entry and exit points on the skin. In theory, it can ensure the super-tension-reducing effect while avoiding problems such as suture exposure or pigmentation. Moreover, because the suture is stealthed 1 cm in the dermis, the stress-bearing part of the super-tension-reducing suture is changed from the original single point to a line, which greatly increases the stress-bearing parts and significantly increases the postoperative super-tension-reducing maintenance time, further reducing the influence of incision

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tension on scars. The anterolateral thigh flap and thoracodorsal flap are commonly used flaps for oral and maxillofacial surgery repair and reconstruction. The secondary wound after flap removal is large. Traditional sutures are often accompanied by obvious scar hyperplasia, poor wound healing, and even incision dehiscence after suture removal. This research team applied distal complete dermal undermining super-tension suture to the incision suture of the flap donor (skin graft) area and achieved satisfactory results.

Materials and Methods

Clinical Data

A total of 50 patients who underwent flap surgery at Meizhou People's Hospital from June 2023 to July 2024 were included in the prospective study. These patients required the removal of latissimus dorsi myocutaneous, anterolateral thigh, free fibula osteocutaneous flaps, or inguinal skin grafts. The patients were randomly assigned to two groups using a computer-generated random number table: the observation group (n=23) and the control group (n=27). The flaps had a width ranging from 3 to 8 cm, which suggesting high tension. There were no significant differences between the two groups in terms of gender, age, flap width, flap length, or BMI (Table 1). The tension-reducing effect of the suture in the observation group lasted for more than three months, and scar formation was evaluated six months post-surgery.

Inclusion and Exclusion Criteria

Inclusion criteria: 1) Patients who underwent flap surgery requiring chest-back, anterolateral thigh, calf free flaps, or inguinal skin grafts; 2) Patients with donor-site wounds requiring primary closure.

Exclusion criteria: 1) Patients lost to follow-up; 2) Patients with severe hypoalbuminemia; 3) Patients with a history of hypertrophic scars.

Surgical Technique

Under general anesthesia, the patient was placed in the supine position for surgery. After the corresponding tissue was removed from the tumor patient, the flap or skin graft was routinely designed and cut. A subcutaneous drainage tube was placed in the secondary wound, and traditional layered suture or distal complete dermal undermining super tension suture was used according to the grouping.

Traditional layered interrupted suture: The subcutaneous muscle layer was sutured with 2–0 absorbable sutures, and the skin was sutured with No. 4 silk thread in the whole layer.

Distal complete dermal undermining super tension suture (Video S1 and Video S2): In this method, the needle is inserted from the subcutaneous layer, and after reaching the dermis, it does not penetrate the epidermis and remains stealthed in the dermis for about 1 cm before being withdrawn from the subcutaneous layer. No. 7 silk thread was used to insert the needle from the subcutaneous layer to the dermis layer (1 cm away from the skin incision edge), and the needle was returned to the subcutaneous layer for 1 cm in the direction parallel to the skin incision edge (Figure 1), and then the needle was returned to the subcutaneous layer. The opposite side was sutured in the same way, and the subcutaneous knot was tied (interrupted method) or returned to the adjacent needle insertion point on the starting side to continue (continuous method) until the entire incision was sutured without tension. The skin was sutured continuously with 5–0 suture thread (Figure 1).

Table 1 Basic Clinical Data of Enrolled Patients

Items	Observation Group (n=23)	Control Group (n=27)	t-value/Chi-Square Value	P value
Gender (male)	19	19	1.020	0.251
Age (years)	56.09±17.00	58.44±13.30	−0.550	0.585
Skin flap width	4.46±1.17	4.69±1.16	0.709	0.482
Skin flap length	8.35±2.12	8.85±2.94	−0.673	0.504
BMI (kg/m^2)	22.84±4.06	21.32±2.74	1.570	0.123

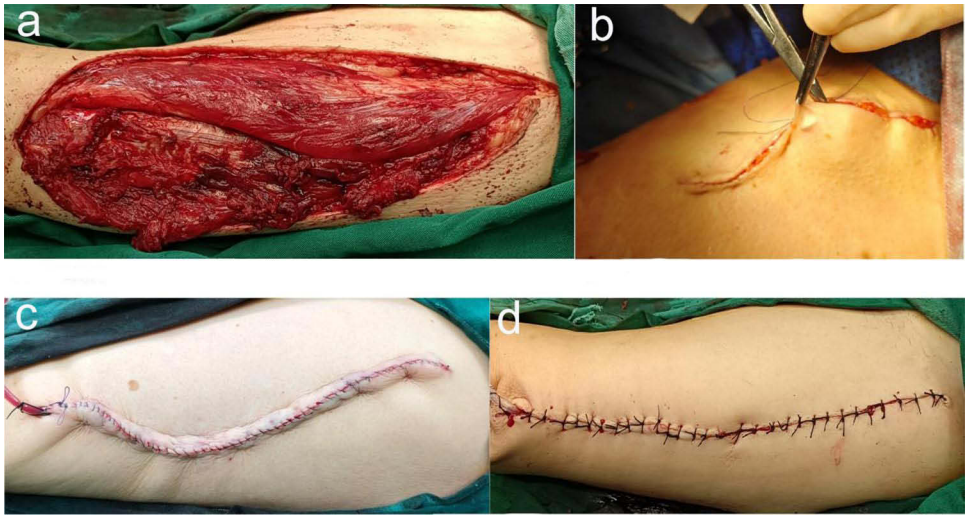

Figure 1 Condition of the donor area during surgery and immediately after suturing. (**a**) Secondary wound at the donor site. (**b**) Demonstration of distal complete dermal undermining super-tension-reducing suture operation, the suture needle is faintly visible but does not penetrate the skin. (**c**) Distal complete dermal undermining super-tension-reducing suture immediate. (**d**) Traditional layered interrupted suture immediate.

Postoperative Management

Patients underwent routine disinfection and dressing changes. Drains were removed when the drainage output was less than 5 mL/day. Skin sutures were removed 2–4 weeks postoperatively, depending on wound healing. Postoperative scar management did not include laser treatment, silicone gel, or radiation therapy to avoid interference with scar evaluation. Follow-up was conducted at six months to assess wound healing, pigmentation, hematoma, and scar formation using the Vancouver Scar Scale.

Statistical Analysis

Data were processed using SPSS 29.0 software. Continuous variables were expressed as means ± standard deviation (x ±s) and compared using independent samples t-tests. Categorical variables were analyzed using frequency and percentage and compared using the chi-square test. A p-value of <0.05 was considered statistically significant.

Results

A total of 50 patients completed the follow-up, with 23 patients in the observation group and 27 in the control group. The average width of the defect area for all patients is 3.8 ± 1.1 mm. All wounds healed successfully. The average scar score in the observation group was 5.96 ± 2.03, significantly lower than the control group (10.11 ± 2.47, $p < 0.001$). Additionally, the observation group had significantly fewer complications (Figures 2 and 3), including pigmentation (5.0% vs 70.4%, $p < 0.001$), "cobblestone" scars (0.0% vs 44.4%, $p < 0.001$), and delayed wound healing (0.0% vs 25.9%, $p = 0.009$). No significant differences were found in the occurrence of subcutaneous hematomas between the two groups (Table 2).

Discussion

The formation of surgical incision scars is an inevitable issue in surgical procedures, and incision tension is considered one of the key factors influencing scar hyperplasia. The distal subcutaneous buried ultra-tension-reduction suture technique proposed in this study significantly reduces scar scores and the incidence of complications through an improved suturing method, offering a new technical option for clinical scar prevention.

There are many factors that affect the hyperplasia of incisional scars, and their pathogenesis is not fully understood.[6] It is generally believed that infection,[7] genetic factors[8] and skin suture tension[2,9] are important factors affecting the formation of incisional scars. Appropriate tension-reducing methods can significantly reduce incision tension, thereby achieving the purpose

Figure 2 Comparison of scars after two suturing methods. (**a**) The incision scar after six months of distal complete dermal undermining hypertension-reducing suture from representative two cases. (**b**) The incision scar after six months of traditional layered suture from representative two cases.

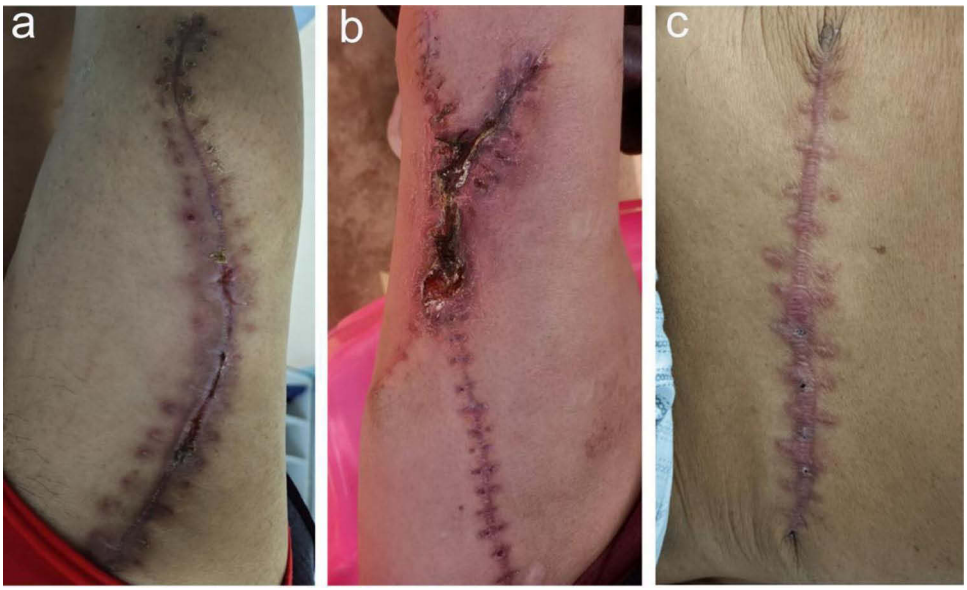

Figure 3 Complications of traditional layered interrupted suture cutting. (**a**) Pigmentation. (**b**) Delayed wound healing. (**c**) Centipede-foot scar.

of inhibiting scar hyperplasia. Since William Halsted proposed the idea of layered suture,[10] the concept of simply closing the incision has gradually formed. The traditional suturing method sutures the incision edge in layers, and each layer of suture is perpendicular to the incision edge and passes through the incision edge, resulting in greater irritation to the incision edge and easy

Table 2 Comparison of Incision Scar Scores and Complications Between the Two Groups

Items	Observation Group (n=23)	Control Group (n=27)	t-value/Chi-Square value	P value
Total scar score (Vancouver Scar Scale)	5.96±2.03	10.11±2.47	−6.420	<0.001
Scar width	0.20±0.08	0.58±0.24	−7.092	<0.001
Pigmentation	1 (5.0%)	19 (70.4%)	22.558	<0.001
Centipede-foot scar	0 (0.0%)	12 (44.4%)	13.450	<0.001
Delayed wound healing/wound dehiscence	0 (0.0%)	7 (25.9%)	6.934	0.009
Subcutaneous hematoma	0 (0.0%)	2 (7.4%)	1.775	0.287

scar formation.[11] The tension-reducing and maintenance effect of layered interrupted suture is also unsatisfactory, and it often loses most of its tension after 8 weeks.[11] With the improvement of living standards, the aesthetics of incision healing has received more and more attention. Various tension-reducing sutures have emerged. For example, the early buried vertical mattress suture (BVMS)[12] can effectively evert the skin, but this method has a weak tension-reducing effect and is only suitable for wounds with low tension such as the face. Sadick improved on this and developed the percutaneous in situ vertical mattress suture (MBVMS) technique. Collins and Maher further improved the MBVMS suture technique in their respective practices.[11] Chinese doctors Zhang et al took the traditional BVMS a step further and proposed the wedge resection + modified BVMS (WEMVMS) method.[13] These methods can make the incision everted more fully and have a better tension-reducing effect. However, the above methods all require the suture to pass through the incision edge. Regardless of whether absorbable or non-absorbable sutures are used, the sutures passing through the incision edge will cause continuous irritation to the wound, causing local redness and swelling, non-bacterial inflammatory reactions, etc., increasing the risk of scar hyperplasia. Therefore, in 2010, Daneshpazhooh et al proposed the back-withdrawal vertical mattress suture (SBDS) method.[14] This method innovatively inserts and removes the needle 2–3 mm away from the wound edge, effectively avoiding the irritation of the wound edge by the suture. However, the amount of dermis anchored by this method is uncertain, and the tension-reducing effect may be affected.[5] Moreover, this method still belongs to the category of vertical mattress suture. The suture direction is perpendicular to the incision. The local force at the anchor point of the tension release dermis is large, the anchor point range is small, and the tension release is uneven. As time goes on, the dermis at the anchor point gradually tears, and the tension relief effect is rapidly weakened until it disappears. Therefore, the tension relief effect is limited. In contrast, parallel mattress suture can improve the above problems to a certain extent. In fact, horizontal mattress suture (HMS) and its improved suture techniques have also been widely used in clinical practice. These include buried horizontal mattress suture,[15] percutaneous in situ buried horizontal mattress suture (PBHMS),[16] completely buried horizontal mattress suture (FBHMS),[17] butterfly suture (IBS),[18] etc. In addition, there are Zhang's super tension relief suture[3] and Zunyi suture method.[4] These methods basically require the needle to be removed from the skin and then inserted again, which inevitably leaves needle holes in the skin. In the later stage, it is easy to form exposed sutures, local pigmentation, epidermal cyst formation and other problems, affecting the appearance.[5] Among them, FBHMS can effectively close the wound without a skin needle entry point, but because the suture passes through the skin incision edge and the degree of tension reduction is small, it still cannot achieve the effect of super tension reduction suturing. Therefore, in order to effectively reduce tension and avoid the above problems, we proposed a distal complete dermal undermining super tension reduction suturing technique. This suturing method is improved from the horizontal mattress suture. The needle is inserted from the subcutaneous fat layer of the incision. After the suture needle moves toward the skin to the dermis, it is undermined for 1 cm in the dermis without penetrating the skin, and then returns to the subcutaneous fat layer to withdraw the needle. After the contralateral incision edge is sutured in the same way, the knot is buried in the fat layer. While super tension reduction suturing, the needle is avoided from entering and withdrawing from the skin and the incision edge. Burying the knot in the fat layer can minimize the chance of knot exposure in the later stage, effectively achieving the super tension reduction effect while significantly improving the defects of many of the above methods. At the same time, because the suture is inserted into the dermis for 1 cm, the stress-bearing part of the super-tension reduction changes from a single point to a linear shape, which greatly increases the stress-bearing part, significantly prolongs the maintenance time of the postoperative super-tension reduction, and further reduces the impact of incision tension on scars.

The choice of suture for super-tension reduction suture is also an important factor. Sutures that are absorbed too quickly are difficult to maintain a long-lasting tension-reducing effect. Commonly used absorbable sutures include Vicryl[19] and PDS.[20] The tension maintenance time of the former is only 28 days, which is completely unable to achieve the maintenance time required for super-tension reduction. Although the tension of the latter can be maintained for 90 days, the suture is smooth and the knot is easy to slip off, which also affects the maintenance of tension. Silk thread is a non-absorbable suture that can avoid the loss of tension due to the decrease in the strength of the suture itself, but it was once considered unsuitable because it could not be absorbed and continued to irritate the incision edge.[20] In recent years, the emergence of new materials has led to the emergence of new methods. Zhang and his team used barbed wire for suture and achieved relatively ideal results.[3] However, the reported tension reduction duration was 4–26 weeks, with an average of 11.2 weeks, which still did not exceed 3 months. In the distal complete dermal undermining super tension reduction suture, since the suture does not pass through the incision edge, it will not irritate the incision edge, and the non-absorbable silk thread has become the most ideal choice. In our study, all super tension reduction cases were sutured

with silk thread. Since the silk thread is non-absorbable, the super tension reduction tension was maintained for more than 3 months, and the incision edge had no knot reaction and scar hyperplasia was not obvious. It is confirmed that silk thread is a suitable choice under this method. In addition, the cases in this study were all secondary wounds with wide wounds and high tension, and it was crucial to maintain the super tension reduction time.

From the results of this study, the average scar score of the observation group was 5.96±2.03, while that of the control group was as high as 10.11±2.47, and the scar widths were 0.20±0.08 and 0.58±0.24, respectively. The p values were all less than 0.001, and the observation group had a significant advantage in the effect of preventing scars. At the same time, the observation group had great advantages in terms of pigmentation, centipede-foot scars, delayed wound healing/wound dehiscence (see Table 2). It is worth noting that in all cases of this study, no scar prevention treatments such as laser, silicone gel, and radiotherapy were used after surgery to eliminate the influence of other treatments on scar evaluation as much as possible.

The distal subcuticular buried super tension-reducing suture technique employed in this study features a unique design of "intradermal tunneling for 1 cm", which fundamentally distinguishes it from traditional buried vertical mattress suture (BVMS) or horizontal mattress suture (HMS). Although the modified buried subcuticular horizontal mattress suture can reduce dermal tension, it still requires penetration through the epidermal layer.[21] In contrast, our technique, by being completely buried subcutaneously, avoids the issue of pigmentation caused by suture exposure.[22] A systematic review has indicated that different tension-reducing suture techniques each have their own optimal indications.[23] This study focuses on flap surgery in oral and maxillofacial surgery, whereas techniques such as SBDS and PBHMS mentioned in the literature are primarily applied to orthopedic incisions[24] or breast surgery.[25] Significant differences exist in tension distribution requirements across various anatomical sites.[26]

This study primarily validates two innovative features of the new technique: (1) avoidance of suture track exposure through completely buried sutures (the importance of subcutaneous burial);[27] and (2) enhancement of sustained tension reduction by extending the intradermal suture course (Reference 1 demonstrates that mechanical resistance to tension is correlated with suture depth). These features have not been reported in existing techniques. The choice of traditional layered suture as a control was based on clinical practicality. Validation of new techniques typically begins with comparison against current standard methods.[28] Furthermore, when a new technique incorporates multiple modifications, comparison with basic methods better highlights its overall advantages.[29] Finally, comparative studies of tension-reducing suture techniques require strictly controlled experimental conditions.[30] We have included the comparison of this technique with other tension-reducing sutures (such as BVMS, WEMVMS, SBDS, etc.) in our subsequent research plan, employing multiple tension-testing methods to systematically compare the biomechanical properties of various techniques.

There are also some limitations in this study. Firstly, scar formation assessments were examined at six months, and this time is too short for scar maturation. Secondly, the sample size is small. To further validate the generalizability of this technique, future studies should involve larger sample sizes and extended follow-up periods. Additionally, multi-modal scar management strategies could be explored by integrating adjunctive treatments such as botulinum toxin injection. Future research may also focus on optimizing the suturing parameters of this technique for different anatomical regions (eg, joint areas).

Conclusion

The distal complete dermal subcuticular tension-reducing suture is an effective method for preventing hypertrophic scar formation in high-tension wounds. It minimizes complications such as pigmentation, "cobblestone" scars, and delayed wound healing while providing long-lasting tension relief. This technique represents a significant advancement in scar prevention and cosmetic surgery.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments. The study was approved by the ethics committee of Meizhou People's Hospital and written informed consent was taken from all the patients.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no conflicts of interest in this work.

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