

ORIGINAL ARTICLE

Continuous tension reduction technique in facial scar management: A comparison of W-plasty and straight-line closure on aesthetic effects in Asian patients

Danying Wang¹ | Jinping Ding² | Yongkang Jiang³ | Yuanbo Liu¹ | Bo Chen¹

¹Department of Plastic and Reconstructive Surgery, Plastic Surgery Hospital, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China

²Department of Plastic Surgery, Beijing Hospital, National Center of Gerontology, Beijing, China

³Department of Plastic and Reconstructive Surgery, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China

Correspondence

Bo Chen, MD, PhD and Yuanbo Liu, MD, Department of Plastic and Reconstructive Surgery, Plastic Surgery Hospital, Chinese Academy of Medical Sciences & Peking Union Medical College, No. 33 Ba-Da-Chu Road, Beijing 100144, China.

Email: chenboys@hotmail.com (B. C.) and ybpumc@sina.com (Y. L.).

Yongkang Jiang, MD, PhD, Department of Plastic and Reconstructive Surgery, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, No. 639 Zhi Zao Ju Road, Shanghai 200011, China.

Email: flamy206@hotmail.com

Abstract

W-plasty is a very popular scar excisional revision technique. The core of the technique is to break up the scar margins into small triangular components, so as to cause light scattering and make the scar less noticeable. However, due to skin tension, facial incision scars tend to spread. Applying W-plasty alone cannot achieve the ideal repair effect of facial scars. In this study, we proposed a scar revision technique combined W-plasty with continuous tension-reduction (CTR) technique to improve the appearance of facial scars. Sixty patients with facial scar were comprised in this retrospective study. Scars were assessed independently using the scar scale before and at 12-month follow-up. Clinical results showed a significant difference in scar appearance between different groups at 12-month follow-up. Vancouver scar scale (VSS), visual analogue scale (VAS) scores, and patient satisfaction were significant better in W-plasty and CTR than other groups at 12-month follow-up. No severe complications were reported. The application of the tension offloading device provides an environment where the tension is continuously reduced, which could greatly decrease tension on the surgical incision. Combined with W-plasty, this technique could significantly improve the scar's aesthetic appearance.

KEYWORDS

continuous tension reduction, scar, straight-line closure, W-plasty

Key Messages

- W-plasty has achieved good clinical results, because many small segments of the W-plasty do run parallel with relaxed skin tension lines (RSTLs) and broken-line scars are easily accepted by the human eye
- W-plasties cannot prevent tension across an incision, and a certain width of tissue must be given up in the revision procedure
- the technique of continuous tension reduction after facial scar revision using W-plasty could effectively prevent scar spread and hyperplasia

Danying Wang and Jinping Ding contributed equally to this work.

This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial-NoDerivs](https://creativecommons.org/licenses/by-nc-nd/4.0/) License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2021 The Authors. *International Wound Journal* published by Medicalhelplines.com Inc (3M) and John Wiley & Sons Ltd.

- for patients who cannot insist on applying tension offloading devices, there is still a lack of ideal alternatives

1 | INTRODUCTION

Scarring is a natural process of wound healing, such as from trauma, burns, acne, congenital disease, infections, and/or surgical excision. Disfiguring and ugly facial scars greatly affect a patients' quality of life. The ideal facial scar is thin, flat, difficult to distinguish, and parallel to a naturally occurring line, such as a relaxed skin tension line (RSTL).¹⁻³ However, a large proportion of scars are symptomatic, unsightly, and not ideally oriented on the skin. Scar revision is an important technique for creating a scar with a better tissue quality that is cosmetically and functionally more acceptable.^{3,4}

It is well known that incisions made parallel to Langer lines experience lower tension and tend to heal with less scarring than those placed perpendicular to them.^{5,6} Therefore, one of the central tenets of scar revision is to reorient the original scar towards an ideal position parallel to RSTLs.^{1,3} Surgeons have used multimodal surgical techniques for scar revision, including Z-plasty, W-plasty, or geometric broken-line closure for scar camouflage. The W-plasty procedure, which means to apply a series of small triangular advancement flaps on both sides of the scar, has been widely used in facial scar revision. W-plasty has achieved good clinical results, especially in patients with scars not aligned to an RSTL on curved surfaces, because many small segments of the W-plasty do run parallel with RSTLs and broken-line scars are easily accepted by the human eye.^{7,8} Previous studies have shown that the W-plasty technique demonstrates a better mean scar appearance compared with straight-line (SL) closure.⁹

W-plasty redirects the forces of contracture, converting the lines of distraction from perpendicular to oblique and relieving the bowstringing effect of linear scars.^{1,3,4} However, W-plasties cannot prevent tension across an incision and a certain width of tissue must be given up in the revision procedure. In the early stages of wound healing, if the newly formed matrix deposition does not withstand physiologic mechanical stimulation, force equilibrium across the wound may be disrupted. For immature scars, breaking the mechanical balance means that the scar gradually spreads along the direction of the forces acting upon it. For skin tissue, spread is characterised by pathological scarring, suggesting an active biological process.¹⁰⁻¹² For tension reduction, in our previous clinical practice, we achieved good,

aesthetic outcomes in keloid treatment at high-tension site with continuous tension-reduction (CTR) technique.¹³

In this study, we hypothesised that the use of a scar revision technique combined with W-plasty and CTR technique would better improve the appearance of facial scars. The effectiveness was assessed with Vancouver scar scale (VSS) score, visual analogue scale (VAS) score, and patient satisfaction at 12 months postoperation.

2 | METHODS

2.1 | Study design

This retrospective study included 65 patients who underwent facial scar excision between April 2017 and November 2020 in the Department of Plastic and Reconstructive Surgery, Plastic Surgery Hospital, Chinese Academy of Medical Sciences. Written informed consent was obtained from each participant prior to all study-related procedures. All procedures were approved by the Ethics Committee of Peking Union Medical College, and the study was conducted in compliance with the 1975 Declaration of Helsinki. SL resection was performed before August 2018, and W-shaped resection was performed after August 2018. After being fully informed, the patient voluntarily chose whether or not to apply continuous tension-reduction therapy after the operation. The VSS score (0-15 points),¹⁴ VAS (0-100 points),¹⁵ and patient satisfaction were used to evaluate the therapeutic effect.¹⁶

2.2 | Patients

Patient records were searched, and those meeting the inclusion criteria were included in the study. Male and female patients aged 9 to 43 years undergoing facial scar excision under local anaesthesia were eligible according to inclusion criteria if their scar(s) was at least 2 inches in length and suitable for revision by excision and direct closure. Exclusion criteria included subjects with chronic or currently active skin disorders, ongoing litigation in connection with the scar to be revised, a history of collagen vascular disease, diagnosis of scleroderma, any medical disorder, or use of medication that could affect wound healing.

2.3 | Operative techniques and device

All operations were performed under local anaesthesia. Sixty patients were divided into three groups. Group 1 underwent a linear closure of the incision and CTR treatment. A SL closure incision was performed by drawing elliptical lines along the length of the scar. Then, an incision was made to extirpate the scar completely. After subcutaneous separation and adequate haemostasis, the incision was closed by applying subcutaneous/superficial fascial sutures using 5-0 PDS II (Ethicon) and superficial sutures using 6-0 or 7-0 Prolene (Ethicon). CTR treatment began immediately after suture removal, using a tension offloading device (3 M Steri-Strip) on the skin surface for at least 6 months. Before application, clean the skin adjacent to the incision. Then, 1) cut the tape to a suitable length; 2) stick the tape on one side of the incision; 3) gently squeeze the skin on both sides of the incision towards the middle; and 4) stick the tape on the other side of the incision. After that, the incision is at a zero-tension state. Group 2 underwent the W-plasty incision method and CTR treatment. The W-plasty incision method was performed by drawing isosceles triangles spanning the length of the scar. The facial scar was completely excised and fully loosened. Following excision, the flaps were advanced such that the tips of the flaps on one side corresponded exactly to the angles made at the base of the triangles on the opposite side, resulting in a W closure pattern.¹⁷ The incision was then closed by

applying subcutaneous/superficial fascial sutures using 5-0 PDS II (Ethicon) and superficial sutures using 6-0 or 7-0 Prolene (Ethicon). After removing the stitches, a tension offloading device (3 M Steri-Strip) was used immediately on the skin surface for tension reduction for a minimum of 6 months. Group 3 underwent the W-plasty incision method without CTR treatment and served as a control.

2.4 | Outcome and assessment

Demographic and clinical variables such as patient age and sex, size of the facial hypertrophic scar, and postoperative complications were collected for all patients. The primary outcome measurements were the change in VSS score, VAS score, and patient satisfaction preoperatively and 12 months postoperatively. Two blinded plastic surgeons (Jinping Ding and Yongkang Jiang) separately rated the scar preoperatively and 12 months postoperatively. The VAS is a 100-mm line, with the worst possible scar represented by a score of 0, located at the far-left end, and the best possible scar represented by a score of 100, located at the far-right end. Patient satisfaction was graded using the following scale: unsatisfied (the patient perceived 0%-25% improvement in the appearance of the scar), slightly satisfied (the patient perceived 26%-50% improvement), satisfied (the patient perceived 51%-75% improvement and without recurrence), or very satisfied

Patients	Group 1	Group 2	Group 3
Age, year	23.85 ± 10.18	23.05 ± 10.9	21.5 ± 7.98
Sex			
Female	16	15	18
Male	4	5	2
Follow-up, months	12	12	12
Excision width (mm)	4.82 ± 2.46	4.38 ± 2.53	4.78 ± 2.08
Scar length (cm)	8.45 ± 2.37	9 ± 2.84	8.58 ± 2.24
Preoperative VAS score	45.5 ± 13.37	44.3 ± 10.23	48.5 ± 10.27
Postoperative VAS score	81.65 ± 4.48	89.9 ± 3.9	76.65 ± 5.29
Preoperative VSS score	8.55 ± 1.85	8.85 ± 2.11	8.60 ± 1.66
Postoperative VSS score	2.65 ± 0.75	1.7 ± 0.66	4.05 ± 1.10
Patient satisfaction			
Very satisfied	11 (55)	16 (80)	3 (15)
Satisfied	7 (35)	4 (20)	8 (40)
Slightly satisfied	1 (5)	0 (0)	7 (35)
Unsatisfied	1 (5)	0 (0)	2 (10)

TABLE 1 Patient and facial scar demographics

Note: Group 1: linear closure of the incision and CTR treatment; Group 2: W-plasty incision method and CTR treatment; Group 3: W-plasty incision method without CTR treatment.

(the patient perceived 76%-100% improvement and without recurrence).

2.5 | Statistical analysis

All data are reported as mean \pm SD. One-way analysis of variance (ANOVA) was used to analyse the differences among the three groups. All analyses were performed using SPSS (IBM Corp., Armonk, NY, USA 19.0). Statistical significance was set at $P < 0.05$.

3 | RESULTS

3.1 | Demographics and characteristics

Between 2017 and 2020, sixty-nine patients were recruited, and 65 patients enrolled and underwent facial

scars excision surgery. Sixty patients (11 men and 49 women) aged 9 to 43 years (mean = 22.8 years, SD = 9.57) completed 12-month follow-up. Table 1 summarises the demographic characteristics of the participants. There were no significant differences in demographic data between the three groups. The mean (\pm SD) excision width was similar between groups and was 4.82 ± 2.46 mm in group 1, 4.38 ± 2.53 mm in group 2, and 4.78 ± 2.08 mm in group 3 ($P > 0.05$).

3.2 | Scar assessment results

For groups 1 and 2, after suture removal, the tension offloading device was used immediately. The wounds healed primarily, in all 60 cases, without hematoma, dehiscence, or incisional wound infection. Preoperative VSS scores in different groups were similar: 8.55 ± 1.85 in group 1, 8.85 ± 2.11 in group 2, and 8.60 ± 1.66 in

FIGURE 1 Representative clinical photographs of group 1. A 31-year-old man with facial scar, who underwent a SL closure of the incision and CTR treatment. A, Preoperative, B, at 12 months postoperative. VSS scores were 10 for preoperative and 3 for postoperative; VAS scores were 35 for preoperative and 80 for postoperative

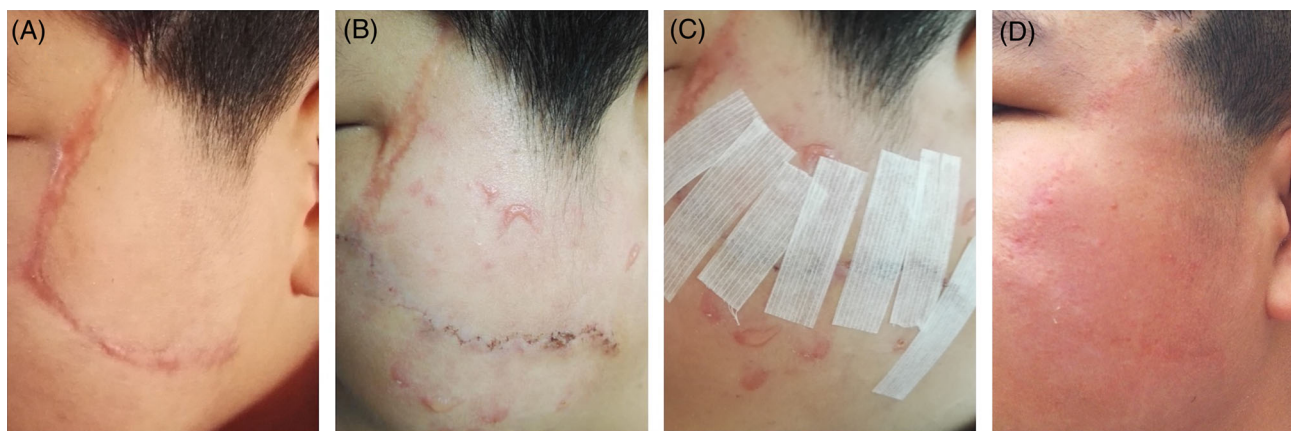


FIGURE 2 Representative clinical photographs of group 2. A 12-year-old man with facial scar, who underwent W-plasty incision method and CTR treatment. A, Preoperative, B, at 3 weeks postoperative without tension offloading device, C, at 3 weeks postoperative with tension offloading device, D, at 12 months postoperative. Tension vesicle were visible around the tape. VSS scores were 10 for preoperative and 1 for postoperative; VAS scores were 35 for preoperative and 94 for postoperative

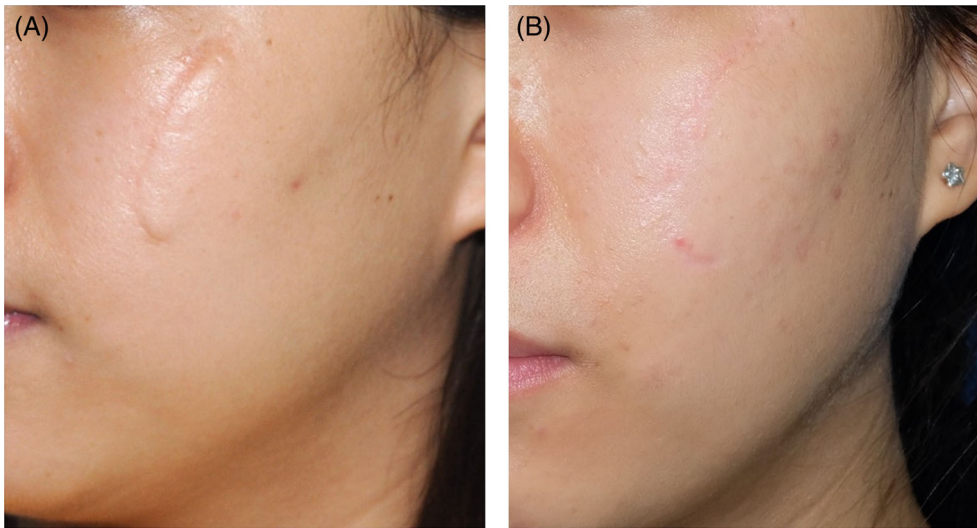


FIGURE 3 Representative clinical photographs of group 2. A 24-year-old woman with facial scar, who underwent W-plasty incision method and CTR treatment. A, Preoperative, B, at 12 months postoperative. VSS scores were 5 for preoperative and 1 for postoperative; VAS scores were 60 for preoperative and 95 for postoperative

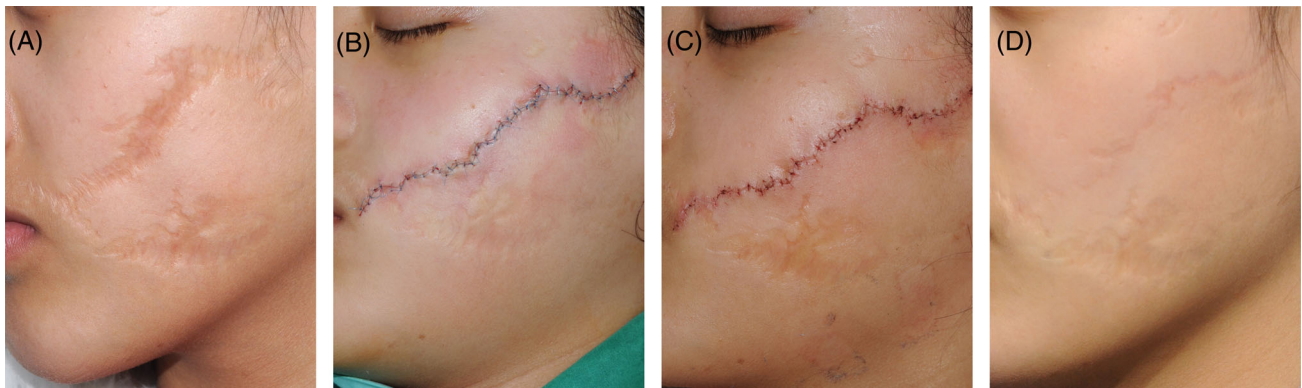


FIGURE 4 Representative clinical photographs of group 3. A 14-year-old woman with facial scar, who underwent W-plasty incision only. A, Preoperative, B, immediately after surgery, C, removing the stitches at 1 week postoperative, D, at 12 months postoperative. VSS scores were 7 for preoperative and 4 for postoperative; VAS scores were 40 for preoperative and 75 for postoperative

group 3 ($P > 0.05$). At 12 months postoperatively, the VSS scores were significantly lower in all groups compared with baseline: 2.65 ± 0.75 ($P < 0.01$) in group 1, 1.7 ± 0.66 ($P < 0.01$) in group 2, and 4.05 ± 1.10 ($P < 0.01$) in group 3. Furthermore, the mean postoperative VSS score in group 2 was significantly lower than groups 1 or 3 ($P < 0.01$).

Preoperative VAS scores were similar between different groups and were 45.5 ± 13.37 in group 1, 44.3 ± 10.23 in group 2, and 48.5 ± 10.27 in group 3 ($P > 0.05$). Scores were significantly improved in all groups at 12 months compared with baseline and were 81.65 ± 4.48 , ($P < 0.01$) in group 1, 89.9 ± 3.9 , in group 2 ($P < 0.01$), and 76.65 ± 5.29 , ($P < 0.01$) in group 3. Furthermore, the postoperative VAS score in group 2 was significantly higher than that in group 1 or 3 ($P < 0.01$). After the surgery and 12-month follow-up, 16 patients (80%) were very satisfied with the therapeutic effect in group 2, eleven patients (55%) were very

satisfied in group 1, and only 3 patients (15%) were very satisfied in group 3. Representative clinical photographs are illustrated in Figures 1 to 4.

No severe complications were observed in our study. In the early postoperative period of using tension offloading devices, 28 patients (46.7%) developed mild skin reactions with erythema, pruritus, and tension vesicle, which disappeared in most patients within 2 to 3 weeks without any medical intervention (Figure 2). No other adverse events were reported during the follow-up period.

4 | DISCUSSION

Although several studies have sought to achieve the ideal scar appearance after surgery, scar formation is an inevitable consequence of wound healing, which can result in poor cosmetic results and functional loss.¹⁷ Scar

formation, as opposed to regenerative healing, is a result of tissue repair and remodelling during the next several months to years. Obtaining a scarless appearance of surgical incisions has always been a challenge for plastic surgeons.¹³

In this study, we demonstrated that the combined application of W-plasty and CTR could significantly reduce scar spreading and improve appearance. Compared with the linear closure with CTR and the only W-plasty group, W-plasty combined with CTR had better mean VSS and VAS scores at 12 months after surgery. No significant differences were observed in complication rates between the groups, and the overall complication rate was very low.

Long linear scars homogeneously reflect light and, as such, are obvious and unnatural. The literature reports and the results of this study show that although the SL incision combined with CTR technique can make the incision scar very thin, it is still unsatisfactory.^{4,7,18} In contrast, W-plasty had a camouflaging effect in relation to RSTLs. After surgery, a 'broken-line' or accordion appearance allows the scar to break down into smaller triangles with at least one side parallel to a poorly defined RSTL, which causes light scattering and leads to a scar that is less noticeable to observers.^{1,17,18} Our results confirmed this point. The W-plasty group had more ideal VSS and VAS scores and better patient satisfaction than the SL group. In addition, the incision scar after W-plasty was gradually turned into a SL, thus greatly improving the unsightly appearance caused by SL scar contracture, which reflects the ability of W-plasty to resist contracture from the axis of the incision and alleviate the bowstring effect of linear scarring.^{19,20}

Tension across a wound is a key factor in scar spreading and pathological scar formation especially for young Asian patients. The skin tension environment of the face is more complicated owing to the different movement directions of facial muscles.^{1,13} Although W-plasty reorients the incision tension direction from perpendicular to RSTLs to partially parallel or oblique to RSTLs, owing to increased tension caused by the requirement of the removal of additional normal tissue, W-plasty should be performed only if there is sufficient laxity in that area of the face.¹⁷ Because of this, some studies have reported inconsistent clinical results when comparing the W-plasty and SL techniques. Some studies have found that the W-plasty technique is significantly better than SL resection, and other studies have shown that there is no statistical difference between the two methods of skin closure.^{4,8,9} In our previous study, we confirmed that the technique of CTR with a tension offloading device could effectively decrease the tension across the surgical incision and significantly reduce the keloid recurrence rate and achieve therapeutic efficacy.¹³ In the research presented here, we

first introduce the concept of CTR into traditional W-plasty, aiming to overcome the drawbacks of using W-plasty technology alone. The results showed that group 2 performed significantly better, obtaining a more ideal VSS and VAS score compared with group 3.

Due to the skin characteristics of Asian patients who are more prone to scar formation and longer healing time after injury, the key point of this treatment was the continuous application of a tension offloading device over 6 months or until incision scar maturation.¹³ Once the tension offloading device is loosened, it must be replaced immediately, which requires high patient compliance. In addition, patients should take care to use UV protection, to avoid tan-and-tape-like traces. In this study, three male patients had tape-like traces due to a lack of UV protection, such as shown in Figure 1 and Figure 2.

This study had some limitations. This study is the first to compare the surgical effects of SL resection and W-plasty under the condition of CTR reduction in Asian patients. The aim of this study was to propose a more optimised surgical method to minimise facial scarring. However, the sample size was small. A randomised controlled trial with a larger sample size is necessary to confirm these results. In addition, with this treatment technique, high patient compliance is important. Skin tension is always present, so the patient must apply the tape for 24 hours. This therapeutic strategy requires a long cycle, and the replacement of tension offloading devices must be completed by the patients themselves every day during treatment. For patients who cannot insist on applying tension offloading devices, there is still a lack of ideal alternatives. Further research may focus on a newer design of the tension-reduction device that is more comfortable and, therefore, more acceptable to patients, which facilitates greater compliance during the healing process. At the same time, we will also accurately measure the level of degree of CTR.

5 | CONCLUSION

The technique of CTR after facial scar revision using W-plasty could effectively prevent scar spread and hyperplasia. For patients with facial scars not aligned to RSTL who can tolerate long-term tension-reduction therapy, this therapeutic technique can significantly improve the appearance of scars.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

The authors declare no potential conflict of interests.

AUTHOR CONTRIBUTIONS

Bo Chen contributed to conception or designed the work. Danying Wang and Jinping Ding involved in acquisition, analysed, or interpreted the data for the work. Bo Chen, Yongkang Jiang, and Yuanbo Liu drafted the work or revised it critically for important intellectual content. All authors involved in the final approval of the version to be published.

ETHICAL APPROVAL

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Peking Union Medical College.

CONSENT TO PARTICIPATE

Written informed consent has been obtained from all participants.

DATA AVAILABILITY STATEMENT

All data generated or analyzed during this study are included in this published article.

REFERENCES

- Vincent AG, Kadakia S, Barker J, Mourad M, Saman M, Ducic Y. Management of Facial Scars. *Facial Plast Surg*. 2019; 35(6):666-671.
- Boyce ST, Lalley AL. Tissue engineering of skin and regenerative medicine for wound care. *Burns Trauma*. 2018;6:4.
- Watson D, Reuther MS. Scar revision techniques-pearls and pitfalls. *Facial Plast Surg*. 2012;28(5):487-491.
- Roy S, Buckingham ED. Comparison of W-Plasty and straight-line Trichophytic closure on aesthetic outcomes of occipital hairline scars in Rhytidectomy. *JAMA Facial Plast Surg*. 2018; 20(1):14-18.
- Longaker MT, Rohrich RJ, Greenberg L, et al. A randomized controlled trial of the embrace advanced scar therapy device to reduce incisional scar formation. *Plast Reconstr Surg*. 2014; 134(3):536-546.
- Atkinson JA, McKenna KT, Barnett AG, et al. A randomized, controlled trial to determine the efficacy of paper tape in preventing hypertrophic scar formation in surgical incisions that traverse Langer's skin tension lines. *Plast Reconstr Surg*. 2005;116(6):1648-1656.
- Shockley WW. Scar revision techniques: z-plasty, w-plasty, and geometric broken line closure. *Facial Plast Surg Clin North Am*. 2011;19(3):455-463.
- Ratnarathorn M, Petukhova TA, Armstrong AW, Wang AS, King TH, Eisen DB. Perceptions of aesthetic outcome of linear vs multiple Z-Plasty scars in a National Survey. *JAMA Facial Plast Surg*. 2016;18(4):263-267.
- Jáuregui EJ, Tummala N, Seth R, et al. Comparison of W-Plasty vs traditional straight-line techniques for primary Paramedian forehead flap donor site closure. *JAMA Facial Plast Surg*. 2016; 18(4):258-262.
- Ogawa R, Okai K, Tokumura F, et al. The relationship between skin stretching/contraction and pathologic scarring: the important role of mechanical forces in keloid generation. *Wound Repair Regen*. 2012;20(2):149-157.
- Gurtner GC, Dauskardt RH, Wong VW, et al. Improving cutaneous scar formation by controlling the mechanical environment: large animal and phase I studies. *Ann Surg*. 2011;254(2):217-225.
- Wilhelmi BJ, Blackwell SJ, Mancoll JS, Phillips LG. Creep vs. stretch: a review of the viscoelastic properties of skin. *Ann Plast Surg*. 1998;41(2):215-219.
- Chen B, Ding J, Jin J, Song N, Liu Y. Continuous tension reduction to prevent keloid recurrence after surgical excision: preliminary experience in Asian patients. *Dermatol Ther*. 2020; 33(4):e13553.
- Yi JW, Kim JK. Prospective randomized comparison of scar appearances between cograft of acellular dermal matrix with autologous split-thickness skin and autologous split-thickness skin graft alone for full-thickness skin defects of the extremities. *Plast Reconstr Surg*. 2015;135(3):609e-616e.
- Kia KF, Burns MV, Vandergriff T, Weitzul S. Prevention of scar spread on trunk excisions: a rater-blinded randomized controlled trial. *JAMA Dermatol*. 2013;149(6):687-691.
- Wang LZ, Ding JP, Yang MY, Chen DW, Chen B. Treatment of facial post-burn hyperpigmentation using micro-plasma radiofrequency technology. *Lasers Med Sci*. 2015;30(1): 241-245.
- Goutos I, Yousif AH, Ogawa R. W-plasty in scar revision: geometrical considerations and suggestions for site-specific design modifications. *Plast Reconstr Surg Glob Open*. 2019; 7(4):e2179.
- Chen Z, Jin Y, Zou Y, et al. Prolonged usage of an adhesive wound closure device in postoperative facial scar management: a Split-wound randomized controlled trial. *Facial Plast Surg Aesthet Med*. 2021;5:389-392.
- Kelleher JC. W-plasty scar revision and its extended use. *Clin Plast Surg*. 1977;4(2):247-254.
- Yang L, Witten TM, Pidaparti RM. A biomechanical model of wound contraction and scar formation. *J Theor Biol*. 2013;332: 228-248.

How to cite this article: Wang D, Ding J, Jiang Y, Liu Y, Chen B. Continuous tension reduction technique in facial scar management: A comparison of W-plasty and straight-line closure on aesthetic effects in Asian patients. *Int Wound J*. 2022;19(5):1064-1070. doi:10.1111/iwj.13702