An Algorithm for Prevention of Unsightly Facial Scars Considering the Newest Research Insights

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Background: Unsightly scars after facial surgery might be a worry for patients and surgeons alike. To prevent unfavorable scars after facial operations, it is inevitable for the surgeon to adhere to different principles and to follow an algorithm: patient assessment, incision planning, surgical technique, suture material, and postoperative scar management. A defined knowledge about the pathophysiology of wound healing is required. The aim of this report is to serve as a teaching purpose and to verify the well-known empirical practices in scar prevention with the corresponding explanatory research. Based on these findings, the suggestion of an appropriate algorithm for the best scar management will be elaborated.

Methods: This article elucidates the basics of unsightly scar prevention and the concomitant scientific proofs in detail by reviewing the literature and newest research published in PubMed.

Results: The preoperative, intraoperative, and postoperative guidelines for the achievement of acceptable facial scars will be distinguished regarding the valid state of knowledge. Special attention is drawn to the “flat incision technique” as the first surgical step. Based on the newest research, an algorithm of the important preoperative, intraoperative, and postoperative features to achieve scar improvement is presented.

Conclusions: To prevent unsightly facial scars, a well-defined algorithm must be followed. In summary, three well-established, empirically proven measures are documented now by the equivalent physiological scientific proof: (1) the flat incision technique, (2) the wound closure with maximal tension reduction, and (3) the postoperative scar management with further tension reduction and more moisturizing of the scar. (Plast Reconstr Surg Glob Open 2022;10:e4635; doi: 10.1097/GOX.0000000000004635; Published online 7 November 2022.)

INTRODUCTION

Regardless of the indication, whether for reconstructive or aesthetic reasons, facial surgery often leaves the patients with unsightly scars.1,2 The prevention of unsightly facial scars so far has been achieved by the knowledge of empirical data, but with the lack of physiological scientific proof. The aim of this work is to present the newest physiological scientific aspects and a complete overview of all features which might influence the final outcome of the facial scar quality.

According to the basics of a Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) analysis, all aspects that might influence the final outcome of facial scars are allegorized and step by step analyzed. These are, in detail, patient assessment, planning of incision location, kind of incision, wound closure, and postoperative scar management. Every detail is discussed by presenting the relevant literature.

Patient Assessment

First of all, there might be a genetic tendency of the skin to react in form of hypertrophic scarring or even keloid formation after surgery.3,4 For example, Asian or African people are well known to be candidates and risk patients for bad scarring.5,6 Furthermore, medical conditions such as diabetes mellitus or metabolic diseases, nicotine abuse, and the need of medications that bear a secondary risk for bad scarning may play an important role in the scar formation.

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Quality. Additionally, patients’ compliance preoperatively and postoperatively should not be underestimated.

Planning of Incision Location

Before performing a facial surgery, the surgeon must be aware which location would be the best for the placement of the skin incision.

Kind of Incision

Except for existing medical conditions which bear the risk of a diminished microcirculation, like in smokers or diabetic patients, it is advisable to perform the skin incision in the face with the flat incision technique (FIT).

Herein, the scalpel is beveled against the skin surface in an angle of about 20 degrees (Fig. 1).

Wound Closure

An anatomical and surgical correct wound closure is essential for the development of an acceptable scar. Three requirements are inevitably necessary: (1) the closure of the wound without marked tension on the upper dermal and epidermal layers, (2) the exact adaption of the wound layers without any steps (Fig. 2), and (3) the use of appropriate suture material.

Postoperative Scar Management

During the initial wound healing, it is mandatory to prohibit any kind of infection. After completed wound healing, several procedures are useful as adjuncts: sun protection over 6 months; covering of the scar with a plaster for 3 to 6 weeks or even longer, depending on the scar location and on the skin type; and alternative application of silicone gel or sheets as long as the scar needs to fade.

Preventively, it might also be useful to inject local effective corticosteroids in 3-to-4-time intervals of several weeks, especially in patients with known risk for hypertrophic scarring or keloids.

METHODS

A literature review of PubMed of the most significant risk factors of the relevant scar pathophysiology and the latest published research-based evidence on existing scar management options has been performed. Herein, the newest preoperative, intraoperative, and postoperative guidelines for the achievement of acceptable facial scars will be emphasized. Only prospective studies with adequate control groups and literature with evidence-based recommendations have been taken under consideration. We acquired our algorithm for optimization of facial scars according to the basics of a PRISMA analysis.

DISCUSSION

All skin damage that involves the dermal layers leads as a natural healing process to the formation of a scar. Hence, any kind of surgery in the face might bear the risk for the development of unsightly scars. Figures 3 and 4 present

Takeaways

Question: How can we improve the outcome of facial scars?

Findings: With an extensive literature search, three well-established, empirically proven measures are documented now by the equivalent physiological scientific proof: (1) the flat incision technique; (2) The wound closure with maximal tension reduction; and (3) the postoperative scar management with further tension reduction and more moisturizing of the scar.

Meaning: The flat incision technique is recommended for all facial incisions. The importance of wound closure with maximal tension reduction on the wound edges and the postoperative wound management with the aim of further tension reduction and more moisturizing of the scar is highlighted.

Fig. 1. The “flat incision” with a 20-degree angle to the skin surface will enhance the surface of the dermal layers in the wound more than factor 2 compared with the standard incision (see the red-lined markings). More hair follicles can be saved in the wound for the later regrowth.
histological specimens of unsightly scars with inversion of the epidermal and dermal wound layers.

The risk for the development of unpleasant scars depends on multiple patient- and surgeon-related circumstances.

Patient Assessment

The patient-related factors depend on individual genetics and medical and behavioral patterns alike. Bearing these factors in mind, several pre-emptive procedures are available to prevent bad scarring. Pre-existing and innate conditions with medical risk factors such as first-grade diabetes mellitus, nicotine abuse, or dependence on medication which may lead to insufficient or prolonged wound healing can be improved preoperatively.

Furthermore, patient compliance preoperatively and postoperatively should not be underestimated. For example, if a patient is asking for an aesthetic surgical intervention but seems to be without compliance and lacks the understanding of the proposed procedure or has self-destructive psychological problems, there might be some likelihood that the preoperative and postoperative required behavior pattern will not be followed. It might be worthwhile to include more intensive explanations and preoperative education of the patient.

Fig. 2. Suture technique in wound irregularity. Every irregularity along the epidermal layers within the final wound closure should be avoided. The needle of the suture has to grasp the inverted part of the wound edge deeper than the upper laying part to compensate the irregularity. If ever possible, the sutures should be placed subcuticular with the knot away from the surface.

Fig. 3. Representative histology of an unsightly surgical scar with severe epidermal inversion and wide dermal scarring.
Planning of Incision Location

The next step in scar prevention adheres to the ideal planning of the skin incision on the face. If ever possible, the incision should be placed along the Langer’s skin tension lines.7–9 If there is the choice, it is furthermore desirable to place the incision in between two aesthetic units, along or into the hairline,16–18 which makes the final scar even more inconspicuous.

Kind of Incision

The kind of incision angle also can make a big step forward to finally achieve an inconspicuous scar. In 1997, Camirand et al17 presented a technique where the scalpel was beveled with a 45-degree angle to the skin surface into the hairline border when performing facelifts. Herewith, hair follicles could be saved for the later regrowth through the final scar, making it less visible. In 2012 and 2016, the FIT was introduced for the direct brow lift and for the correction of different brow deformities.8,18 By beveling the skin incision 20 degrees to the underlying surface, the dermal layers in the wound edges were doubled in diameter compared with the conventional vertical skin incision in a 90-degree angle. This led to a marked improvement of the scar quality. Incisions that have been placed along the hairlines led to less visible scars because of the excellent regrowth of hair follicles through the final scar. Compared with an incision angle of 45 degrees, an incision angle of 20 degrees saves even more hair follicles for the later regrowth, which makes the final scar even more inconspicuous (Fig. 1). Another advantage of flattening the incision angle to 20 degrees is that the distance for the regrowing hair to reach the skin surface is strongly reduced, which provides a denser regrowth of hairs. Assuming that a patient bears no risk for vascular compromise, the thinning of the dermal wound layers does not lead to a higher risk of skin necrosis because of the dense intradermal and subdermal vascular plexus along the facial skin.19–22

With a histomorphological study, the hypothesis of scar improvement by strongly increasing the dermal layers could be confirmed (Fig. 4).23 If one considers the physiology of the wound healing and the role of the dermal layers within it, one recognizes the big advantage for wound healing by increasing the dermal wound layers. The three-dimensional structure of the dermis acts as a template for regulation of the properties of reparative cells.24 The dermal layers are of particular importance in the wound healing process, primarily the fibroblasts and the extracellular matrix.25–28 The degree of any dermal injury defines the natural process of wound healing. The hypothesis is that with increasing the dermal wound layers about factor 2, the wound could heal faster and help the healing tissue in early resistance to tension. Tension reduction along the wound edges is mandatory for a good scar quality (see below).

Figure 5 presents the big difference of scar quality in the temporal region of a patient after facelift where one
side was incised with the FIT and the other with the standard vertical incision.

Wound Closure

To additionally reduce tension along the wound edges during closure, it is helpful to meticulously dissect the wound edges above the facial layers in kind of flaps along several centimeters. By tentatively pulling these flaps together, the surgeon can estimate whether the final wound closure is feasible without remarkable tension. By dissecting these flaps away from the wound edges, a further stabilization can be achieved due to the consecutive scarring between the dissected layers, either subcutaneous or subdermal, therefore reducing the long-term tension along the wound edges even more.

Recent studies revealed that mechanical forces, which lead to tension along the wound edges and the ensuing cellular mechanotransduction, may also influence the degree of scar formation, scar contracture, and the formation/progression of keloids and hypertrophic scars.\(^4\)

It was estimated that the mechanical force is a key regulator of hypertrophic scar formation. Jiahao et al\(^29\) found a novel mechanically activated cation, the Piezo1 channel. This is reportedly capable of regulating force-mediated cellular biological behaviors. Piezo1 was found to be overexpressed in myofibroblasts of human and rat hypertrophic scar tissues. In vitro, cyclic mechanical stretch increased Piezo1 expression and Piezo1-mediated calcium influx in human dermal fibroblasts. In addition, Piezo1 activity promoted human dermal fibroblast proliferation, motility, and differentiation in response to cyclic mechanical stretch. More importantly, intradermal injection of GsMT × 4, a Piezo1-blocking peptide, protected rats from stretch-induced hypertrophic scar formation. Together, Piezo1 was shown to participate in hypertrophic scar formation and might be a novel target for the development of promising therapies for hypertrophic scar formation.

In this consensus, the importance of a tension-reduced wound closure cannot be overestimated.\(^5,7,20-31\)

A meticulous adaption of the wound edges is also very important for the achievement of a pleasant scar. Every irregularity along the epidermal layers should be avoided.\(^35\) Quite often, the surgeon has to place the sutures during wound closure at different heights in the wound edges to compensate irregularities (Fig. 2). If ever possible, the sutures should be placed subcutaneous and or intracutaneous with the knot away from the surface. Lacerations of the outer skin should be avoided because they may lead to the formation of an everlasting visible penetration channel. But in case of very thin skin, for example, along the lips or in elderly patients and if there is not much tension involved, the sutures can be placed transcutaneous and stitch removal performed after some days. As a rule, it counts that the longer cutaneous stitches are left in place the higher the risk of lasting visible penetration channels.

The right choice of the appropriate suture material is mandatory. Eligible suture materials are smooth (monofil) or have a swirl surface (polyfil), are available in different calibers, and are nonresorbable or have different resorption times. This can range from some days to several weeks. Which kind of suture material should be used is dependent on the kind of tissue that has to be closed and the amount of tension that has to be compensated.

Sutures are placed either as single knots or in a running line. Generally, single knots are used into the deep dermal and subcutaneous layers (“subcuticular”) to reduce the tension along the wound edges and running epidermal sutures to achieve the exact final adaption of the wound edges.\(^30\)

In younger patients who have not yet undergone dermal atrophy and in tension exposed wound closure, it is always advisable to use subcuticular resorbable single-knot sutures like Biosyn (synthetic polyester composed of glycolide, dioxanone, and trimethylene carbonate) (Covidien, Medtronic, Minneapolis, Minn.) with a tensile strength of 21 days, as the first step to compensate mechanical forces during collagen synthesis. Alternatively, Monocryl (poliglecaprone), (Ethicon, Johnson&Johnson, New Brunswick, N.J.) could be used, but it has less grip, and therefore, the stability of the knot is less than with Biosyn (personal experience).

In every part of thin skin like the eyelids or lips, we recommend using either very thin (5-0, 6-0, or even 7-0) nonabsorbable Prolene TM (Polypropylene) (Ethicon, Johnson&Johnson, New Brunswick, N.J.) or Surgipro TM (Polypropylene and Polyethylene) (Covidien, Medtronic, Minneapolis, Minn.) intracutaneous or transcutaneous. For the closure of mucous membranes, we prefer either thin (3-0, 6-0, or even 7-0) Vicryl rapid TM (90% Glycolide and 10% L-lactide) (Ethicon, Johnson&Johnson, New Brunswick, N.J.) with 5 days 50% tensile strength or Catgut (from the serosal layer of selected bovines) (Frank Healthcare Co., China, also available in the US).

If wound closure can be accomplished without tension, we just use a running suture with Prolene or Surgipro 6-0, either intracutaneous or transcutaneous.

Postoperative Scar Management

The postoperative handling of the fresh scar has gained great importance, due to the knowledge of scar pathology.

Most reports about postoperative facial scar management used empirical data. Valuable reports with statistical analysis and using control groups were by Atkinson et al,\(^7\) Maher et al,\(^10\) Rosengren et al,\(^37\) Bianchi et al,\(^38\) and De Giorgi.\(^39\) Three principles for the postoperative wound management are fundamental. The first is the prevention of wound infection. This situation inevitably would bear the risk to interrupt the physiology of normal wound healing with an increased risk for bad scarring. To prevent infection, daily cleaning of the fresh scar is needed, either in the form of simple washing with water and soap or in risk patients with some kind of disinfectant, at least until the first wound healing has been completed. We prefer to use octenisept solution (ingredients: 100 g solution contains 0.1 g octenindihydrochlorid and 2.0 g phenoxyethanol) (Schülke & Mayr AG, Zurich, Switzerland, also available in the US). It is useful for both skin and mucous membrane disinfection and is well tolerated.\(^35\) It has a rapid effect and a broad antiseptic spectrum, for MRSA,
chlamydia trachomatis, pseudomonas aeruginosa, neisseria gonorrhoeae, gardenerella vaginalis, candida albicans, and trichomonas.

Furthermore, we recommend the following procedure for every patient during the first 2–3 days: local application of terracortril ointment (Intrapharm Laboratories Limited, United Kingdom, also available in the US) with the initial dressing for a maximal 2–3 days. Based on liquid paraffin, each gram of terracortril ointment contains 30-mg oxytetracycline as oxytetracycline hydrochloride and 10-mg hydrocortisone. It helps the initial wound healing against early bacterial contamination. Particularly, it is efficient against Staphylococcus aureus, the main causative organism for skin infections. It also reduces swelling and serves moisture with the liquid paraffin.

The second principle is based on the necessity for immobilization of the fresh scar as much as possible and parallel, providing the wound surface with moisture for better scar hydration. Akinson et al. and Rosengren et al examined the benefit of using paper taping and found significant reductions in scar volume and scar width. Bianchi et al. and De Giorgi et al. examined the effect of silicone gel and revealed significant improvements of the scar quality in color, stiffness, irregularities, pliability, and pigmentation.

To point out again, these methods make sense as long as collagen maturation is completed, which means about 6 weeks. If, after this time, the scars present themselves still discolored, it is advisable to continue this treatment until the scar has faded. Two regimens have gained broad acceptance: the use of plaster tapering and silicon gel or silicon plates. The advantage of plastering is that it is simultaneously a kind of immobilization and a moisturizing effect. If plastering is impossible, just moisturizing with fatty ointment is useful.

For the plastering, we recommend 3M Micropore tan surgical tape 0.5-inch wide (3M GmbH, Germany, also available in the US). It is a sufficiently sticky plaster.

About 1 week after wound closure and removal of cutaneous stitches, we ask the patient to start with plastering of the fresh scar for 6 weeks, or alternatively, if a plaster cannot be tolerated, with silicone gel. The plaster stays in place as long as it remains stable on the surface of the scar, normally for a week. After showering or getting into contact with water, it should be dried with a hair dryer. Before the exchange of the plaster, the patient should use Bepanthen ointment (dexapanthenol) (Bayer, Switzerland) during the night until the next morning and then apply the plaster again. Dexapanthenol used once weekly helps to enhance the skin barrier, prevents skin irritation, and stimulates skin regeneration.

For all patients who do not tolerate any kind of plaster but with a known risk for bad scarring, the application of silicon gel or silicon plates is useful to achieve more moisturizing of the scar by the occlusion effect.

Mustoe et al. examined the advantage of this modality and explained that due to the occlusion of the scar, the consecutive hydration of the stratum corneum leads to cytokine-mediated signaling of keratinocytes to dermal fibroblasts, which finally reduces scarring. Furthermore, Zhong et al. proved that reduced hydration increased the expression of S100 protein family members, S100A8/S100A9, in stratified keratinocyte culture and human ex vivo skin culture. S100A8/A9 has been found to be highly expressed in the epidermis of human hypertrophic scar and keloid tissues. Diminished hydration led to the activation of fibroblasts in the keratinocyte-fibroblast coculture. In contrast, knockdown of S100A8 or S100A9 by ribonucleic acid (RNA) interference in keratinocytes failed to activate fibroblasts. Interestingly, application of pharmacological blockers of S100A8/A9 receptors, toll-like receptor 4, and receptor for advanced glycation end products inhibited fibroblast activation induced by recombinant S100A8/A9 proteins. It could be further shown that local delivery of S100A8 protein resulted in considerably more hypertrophic scarring in the in vivo rabbit ear scar model.

The third principle of postoperative scar management is sun protection for at least 6 months, either by continuously covering with clothes or applying a sun blocker.

Furthermore, early postoperative compression therapy with special garments and intralesional corticosteroid injections has been proven to be very effective in risk patients.

CONCLUSIONS

To prevent unsightly facial scars after aesthetic or reconstructive surgery, an algorithm based on important perioperative scientific evidence-based guidelines must be followed. This includes patient preparation, choosing of the best incision location, the right incision technique, the best wound closure with appropriate suture technique and material, and finally, the adequate postoperative wound and scar management.

With our systematic literature search, we present current scientific proofs of three well-established empirical measures. These are (1) the FIT, (2) the importance of maximal tension reduction along the dermal layers during wound closure as well as postoperatively, and (3) the importance of maximal hydration of the scar by covering it with plaster or any kind of silicone.

REFERENCES

1. Kim YS, Na YC, Park JH. Hair transplantation in patients with hair loss or scar deformity in the side hairline after midfacelift surgery. Arch Plast Surg. 2019;46:147–151.
2. Wang J, Wu J, Xu M, et al. A comprehensive reconstruction strategy for moderate to severe faciocervical scar contractures. Lasers Med Sci. 2021;36:1275–1282.
3. Thomas DW, Hopkinson I, Harding KG, et al. The pathogenesis of hypertrophic/keloid scarring. Int J Oral Maxillofac Surg. 1994;23:232–236.
4. Tsai CH, Ogawa R. Keloid research: current status and future directions. Scars Burn Heal. 2019;5:2059513119868659.

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5. Kim S, Choi TH, Liu W, et al. Update on scar management: guidelines for treating Asian patients. Plast Reconstr Surg. 2013;132:1580–1589.

6. Ogawa R. The most current algorithms for the treatment and prevention of hypertrophic scars and keloids. Plast Reconstr Surg. 2010;125:557–568.

7. Atkinson JM, 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;116:1648–1656.

8. Feinendegen DL, Constantinescu MA, Knutti DA, et al. Brow reduction, reshaping and suspension by a 20-degree beveled brow incision technique. J Craniofac Surg. 2016;44:958–963.

9. Monstrey S, Middelkoop E, Vranckx JJ, et al. Updated scar management: prevention and management of hypertrophic scars and keloids. J Wound Care. 2014;67:1017–1025.

10. Maher SF, et al. Linear scar reduction using silicone gel sheets in individuals with normal healing. J Wound Care. 2012;21:602–609.

11. Mecanne S, Le Filiouer-Prost A, Richert B, et al. Management of scars: updated practical guidelines and use of silicones. Eur J Dermatol. 2012;22:435–443.

12. Mustoe TA, Cooter RD, Gold MH, et al; International Advisory Panel on Scar Management. International clinical recommendations on scar management. Plast Reconstr Surg. 2002;110:560–571.

13. Del Toro D, Dedhia R, Tollefson TT. Advances in scar management: prevention and management of hypertrophic scars and keloids. Curr Opin Otolaryngol Head Neck Surg. 2016;24:322–329.

14. Johnson J, Greenspan B, Gorga D, et al. Compliance with pressure garment use in burn rehabilitation. J Burn Care Rehabil. 1994;15:180–188.

15. Snowden C, Lynch E, Avery L, et al. The most current algorithms for the treatment and prevention of hypertrophic scars and keloids. Plast Reconstr Surg Glob Open. 2019;7:e2286.