

TITLE: Wound Healing – Scar Minimization

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## INTRODUCTION

Scar minimization is not often discussed among Otolaryngologists. However, after surgery in the head and neck, patients often ask what they can do to improve the appearance of their new scar. Here we will discuss the physiology of normal wound healing, as well as techniques and over-the-counter topical therapies that can aid in scar minimization. Included in this discussion are sunscreen, scar massage, hydration ointments and dressings, adhesive microporous hypoallergenic paper tape, silicone gel, silicone sheeting, moist exposed burn ointment, pressure dressings, vitamin E, vitamin D, and Mederma®.

## WOUND HEALING

Wound healing is generally thought to occur in 3 phases, which are usually labeled inflammatory, proliferative, and maturation. The first phase of wound healing, or the inflammatory phase, is characterized by 2 portions, the hemostatic portion and the cellular portion. The second phase of wound healing, or the proliferative phase, is characterized by 3 portions, the re-epithelialization portion, the neovascularization portion, and the collagen deposition portion. The third phase of wound healing, or the maturation phase, deals with remodeling of the scar, and it is sometimes labeled the remodeling phase.

The hemostatic portion of the inflammatory phase involves a convergence of the coagulation cascade, complement cascade, and platelet activation. It involves an initial period of vasoconstriction, followed by vasodilation. Simultaneously, degranulation of platelets occurs, which results in the release of numerous biologically active mediators. Among these mediators, TGF- $\beta$  serves a prominent role in scar development. Finally, a

platelet plug is formed as a result of activated platelets joining with fibrin and exposed collagen.

The cellular portion of the inflammatory phase involves an initial influx of neutrophils, which are the dominant cell type at 1-2 days. These neutrophils are responsible for the phagocytosis of debris and bacteria. Next, an influx of macrophages occurs, and these cells become the dominant cell type at 2-4 days. They secrete a number of biologically active mediators and also serve a regulatory role. For this latter function, they are considered essential for wound healing, as opposed to the neutrophil. Finally, an influx of fibroblasts occurs, and these cells become the dominant cell type at 15 days. They differentiate into myofibroblasts, which secrete collagen and aid in wound contraction.

The re-epithelialization portion of the proliferative phase involves enzymatic remodeling of the wound bed. Additionally, fibroblasts begin migration from the wound edge into the wound bed at a rate of 12-21  $\mu\text{m/hr}$ . This rate is significantly impacted by a moisture-rich local environment, such that more moisture speeds migration. The neovascularization portion of the proliferative phase involves granulation tissue formation and angiogenesis. The collagen deposition portion of the proliferative phase involves early deposition of type III collagen. A predominance of type III collagen is characteristic of an immature scar. Later, type I collagen is formed, and this molecule predominates in mature scars.

The maturation, or remodeling, phase involves an increase in type I collagen deposition, which ultimately results in decreased scar dimensions and increased tensile strength of the scar. At 3 weeks after wounding, the scar obtains 15% of the tensile strength of unwounded skin. At 6 weeks after wounding, the scar obtains 60% of the tensile strength of unwounded skin. At 6 months after wounding, the scar obtains 80% of the tensile strength of unwounded skin, and it remains at this strength indefinitely. A scar never regains the full tensile strength of unwounded skin.

## **SCAR MANAGEMENT**

Before considering the nuances of scar minimization, it is imperative that the surgical wound heals under optimal conditions. This is accomplished via attention to detail. First, proper surgical principles should be applied intraoperatively. Specifically, the incision should be planned properly, tissue should be handled appropriately, and the incision should be closed under the least amount of tension possible. Postoperatively, factors that affect wound healing should be promptly addressed and corrected. These include local factors, such as wound desiccation and infection, as well as systemic factors, such as medical comorbidities, hypovolemia, and malnutrition.

After a wound heals appropriately in the acute setting, attention can be paid to scar management and minimization. Loosely defined, the goals of scar management are to minimize tension, maintain moisture, avoid inflammation, and optimize the molecular

environment of the scar. These goals should be emphasized during the transition from immature scar to mature scar, which takes approximately 6 months to 1 year after wounding. Several techniques and over-the-counter products are available for use during this time period to aid in scar minimization.

Sunscreen is reasoned to aid in scar minimization by preventing post-inflammatory hyperpigmentation. Specifically, sunscreen helps prevent ultraviolet light stimulation of melanogenesis in the scar, thereby preventing hyperpigmentation of the scar. The evidence supporting the use of sunscreen application to immature scars is predominately anecdotal, but some organizations recommend using a sunscreen with  $\text{SPF} \geq 35$  for at least 1 year after wounding. However, sunscreen will not affect “rubor perseverans”, which is the physiologic, non-inflammatory redness of a normal scar. This redness is due to vascular elements in the immature scar, and it typically fades in 7-12 months after incisional wounding. However, it can persist beyond this time frame, and the rate of fading is affected by scar location.

Scar massage is reasoned to aid in scar minimization by optimizing the molecular environment of the scar. Specifically, mechanical forces induce changes in enzymatic expression, and these enzymes degrade fibrotic tissue, which results in increased pliability of the scar. Additionally, these mechanical forces result in the release of beta-endorphins, which aids in pain relief. Weak evidence supports the use of scar massage in treatment of routine postoperative scars. It is advised to begin scar massage after removal of non-absorbable sutures, or approximately postoperative day 10-14. It is advised to avoid scar massage before postoperative day 10-14, to allow the wound adequate time to re-epithelialize. Additionally, it is advised to use enough pressure to blanch the scar, use a non-irritating emollient, and massage for 10 minutes twice per day. Scar massage has been described using rotary hand movements, and duration of therapy has been described as 1-2 months.

Hydration ointments and dressings are reasoned to aid in scar minimization by maintaining moisture and optimizing the molecular environment of the scar. Occlusive dressings, such as Tegaderm™, or semi-occlusive dressings, such as Steri-Strip™, have been shown to speed re-epithelialization of fresh surgical wounds. Petrolatum-based ointments, when applied 3 times daily for 1 month after surgery, have been shown to reduce erythema in postsurgical scars.

Adhesive microporous hypoallergenic paper tape is reasoned to aid in scar minimization by maintaining moisture and minimizing tension on the scar. Micropore™ tape, when worn continuously for 12 weeks after surgery, has been shown to decrease scar volume and risk of hypertrophic scar formation when compared to untreated scars.

Silicone gel and silicone sheeting are reasoned to aid in scar minimization by maintaining moisture. Silicone gel, when applied 2 times daily for 3 months after surgery, has been shown to improve the appearance of surgical scars when compared to scars treated with a water-based gel. Silicone sheeting, when worn at least 12 hours per

day for six months after surgery, has been shown to decrease the risk of abnormal scar formation when compared to untreated scars. Some studies demonstrate that Micropore™ tape performs equivalently to silicone gel and silicone sheeting in regard to improving the appearance of postsurgical scars. These results emphasize the importance of utilizing some form of moisture-retentive therapy in postsurgical scars.

Moist exposed burn ointment (MEBO) is composed of 6 herbal extracts in a base of beeswax and sesame oil, and its active ingredient is  $\beta$ -sitosterol. It is reasoned to aid in scar minimization by maintaining moisture in addition to the therapeutic effect of plant extracts. When applied daily until re-epithelialization, MEBO has been shown to outperform occlusive dressings with regard to speed of re-epithelialization of split-thickness skin graft donor sites. When applied 3-4 times daily for 6 weeks after surgery, MEBO has been shown to outperform antibiotic ointment with regard to the cosmetic appearance of postsurgical scars.

Pressure dressings are reasoned to aid in scar minimization by optimizing the molecular environment of the scar; specifically, that compression would induce apoptosis of fibroblasts, which would modulate cytokine expression to prevent scar hypertrophy. Pressure dressings are anecdotally effective in management of hypertrophic scars and burn scars. However, there is no evidence to support the use of pressure dressings to improve the appearance of normal postsurgical scars.

The antioxidant properties of vitamin E have been well documented in vitro. Therefore, topical vitamin E, or  $\alpha$ -tocopherol in an oil base, is reasoned to aid in scar minimization by reducing the amount of reactive oxygen species during the inflammatory phase of wound healing. Studies have shown no benefit in the cosmetic appearance of postsurgical scars treated with topical vitamin E, relative to treatment with a petrolatum-based ointment. Furthermore, some studies have demonstrated an increased incidence of contact dermatitis in patients using topical vitamin E therapy for postsurgical scars, relative to treatment with a petrolatum-based ointment.

Vitamin D has been implicated as an anti-inflammatory molecule with the ability to decrease keratinocyte proliferation. For these reasons, topical vitamin D therapy is thought to aid in scar minimization. However, studies have shown that calcipotriol, a synthetic vitamin D derivative, did not impact the incidence of hypertrophic scar formation when applied to fresh postsurgical scars, relative to treatment with a placebo ointment.

Mederma® is a very popular over-the-counter product aimed at scar minimization. Its active ingredient, allium cepa, an onion extract, contains the molecule Quercetin. Quercetin has been implicated as an anti-inflammatory molecule. Therefore, Mederma® is reasoned to aid in scar minimization by reducing inflammation in the scar. When applied 3 times daily for one month after surgery, Mederma® showed no benefit in improving the erythema of postsurgical scars.

## PEDIATRIC CONSIDERATIONS

When applying any of these techniques or products in the pediatric population, it is important to remember that infants have an immature epidermal-dermal bond. Therefore physicians should seek to protect the epidermis and prevent skin trauma in pediatric patients. To do this, opt for ointment rather than adhesive dressings. If an adhesive dressing is necessary, opt for an adhesive microporous hypoallergenic paper tape to help minimize skin trauma. Also, it is important to remember that some foam dressings, such as Mepilex®, are more absorptive than plain gauze, allowing for decreased frequency of dressing changes. Finally, in pediatric patients, it is important to minimize the pain associated with dressing changes. For this reason, physicians should pretreat with analgesics prior to dressing changes in pediatric patients.

## CONCLUSION

While Otolaryngologists do not commonly discuss scar minimization, it is necessary to be able to counsel patients regarding how they can improve the appearance of their postsurgical scars. There are numerous over-the-counter products aimed at scar minimization, and several of them have demonstrated measurable benefits in scientific studies. While no specific product emerges as the clear victor, it is reasonable to recommend some form of moisture-retentive topical therapy to patients, with the aim of improving the appearance of their postsurgical scars.

PRODUCT	FREQUENCY	DURATION	BENEFIT
Sunscreen (SPF $\geq$ 35)	Any time sun exposure is anticipated	$\geq$ 1 year	Reduced scar pigmentation
Scar massage	10 minutes BID	1-2 months	Increased scar pliability
Petrolatum-based ointment	TID	1 month	Reduced scar erythema
Adhesive microporous hypoallergenic paper tape	Use continuously; change 2x per week	3 months	Reduced scar volume
Silicone gel	BID	3-4 months	Improved scar appearance
Silicone sheeting	Use $\geq$ 12 hours per day	3-6 months	Decreased risk of abnormal scar formation
Moist exposed burn ointment (MEBO)	TID - QID	6 weeks	Improved scar appearance

Pressure dressing			Not significant
Vitamin E			Not significant
Vitamin D			Not significant
Mederma®			Not significant

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