Compression Therapy and Conservative Strategies in Scar Management After Burn Injury

Eric Van den Kerckhove and Mieke Anthonissen

Contents

L. Téot et al. (eds.), *Textbook on Scar Management*, https://doi.org/10.1007/978-3-030-44766-3_27

27

Background

Since a few decades, the focus of treatment of burn patients has shifted from survival to optimizing the rehabilitation outcome of patients with severe scars. This outcome can influence both physical as well as psychological well-being and quality of life of the patient. Therefore, the interest in the field of conservative scar management of these patients has risen drastically. In this regard, the golden standard in all medical or paramedical treatments is aiming for evidence-based interventions. Also in this rather new domain of scar rehabilitation, caregivers strive to use the most efficient therapies. Unfortunately, for most of the daily used interventions, the number of proper scientific clinical trials is still limited and therefore the evidence-based level of many of them is often low. As a consequence, the recommended therapies are often based on recommendations or guidelines written by a group of specialists based on their expertise and available literature. This chapter focuses on the most relevant noninvasive strategies in the aftercare of patients with severe scarring after burn injury with special attention to compression therapy.

The aim of this chapter is to give an overview of the different conservative therapeutic strategies that are mostly used in the rehabilitation of patients with severe scars after burn injury. These strategies include pressure therapy, the use of silicones as a contact medium, massage, the use of moisturizers, splinting and positioning, exercise, and mobilizations. The relevance of the conservative therapeutic strategies will be situated within the field of the available scientific literature or guidelines.

According to the World Health Organization (WHO), annually nearly 11 million people worldwide are burned severely enough to require medical attention. Aesthetic and functional outcomes have become increasingly important, as overall mortality from burn injury has decreased. Hypertrophic scar formation is a common and bothersome complication after a severe burn injury or even after minor burns, due to its functional and aesthetic consequences. These scars, which usually develop after 6–8 weeks of wound closure, are typified by the following characteristics. The red to deep purple color of the scar reflects an enhanced microcirculation. The hypertrophic scar becomes more elevated, firm, warm to touch, hypersensitive, and itchy but the lesion remains within the confines of the original scar. The elevation, firmness, and retraction of the scar is probably due to an overabundant collagen deposition as a cellular response of the fibroblast during the proliferation phase of wound healing. The contraction of the scar has been linked to the presence of fibroblasts with contractile properties, called the "myofibroblasts." Generally, a period of at least 6–18 months is required for maturation of burn scars at which time the redness (erythema) of the scar subsides, the scar no longer appears inflamed, and the scar contraction diminishes.

Many factors can influence the presence or severity of hypertrophic scarring after a burn injury. Genetic predisposition, race, anatomical location of the burn, age, and depth of the burn are some of the factors that are known as "uncontrollable or extrinsic factors," whereas infection, type of wound healing (surgical intervention or not), and tension are factors that can be considered as "extrinsic or controllable" factors. The prevalence of hypertrophic scarring ranges from 32% to 72%. Female gender, young age, race or ethnicity, burn site (on face, neck, and upper limb), multiple surgical procedures, meshed skin grafts, time to heal longer than 2–3 weeks, more than 20% total body surface area (TBSA), and burn severity are some of the identified risk factors.

The scar management treatments in patients with burns have gained a lot of interest recently. This increase in interest is entirely correct, as the quality of life of these patients can be significantly influenced if one can improve the clinical parameters of scars. Burn scar-related symptoms show a proximal impact on health-related quality of life. Therefore, the scar management interventions have high interest in the improvement of quality of life of burn patients, especially those with visible scars and severe burns. Scar management in the treatment of burn patients includes a wide variety of aftercare methods and physio- and occupational therapeutic techniques such as pressure therapy, silicone therapy, massage, moisturizers, splinting and positioning, exercise, and mobilizations.

Of all the noninvasive therapeutic treatments, pressure therapy is one of the most successful, widely used, and evidence-based techniques in the prevention and treatment of hypertrophic (burn-related) scars [1]. In the late 1960s, Dr. Silverstein at Brooke Army Hospital in San Antonio observed that in a patient with burns, vascular support garments for the treatment of a postphlebitic syndrome decreased scarring after a burn injury and Larson noted the same effect with pressure-exerting splints on scar tissue. The use of compression in the prevention of burn scar hypertrophy was then further popularized at Shriners' Burns Institute in Galveston at the beginning of the 1970s.

Furthermore, silicone therapy is also a popular and evidence-supported conservative treatment to prevent or treat hypertrophic scars [2]. The first silicone applications were individually made as a pressure device or pad to solve concavity problems under pressure garments. The pressure pads are individually made using elastomer (medical grade with catalyst), putty, or foam, and

fitted directly on the patient. They are usually worn in combination with classical pressure garments, masks, and splints. Silicone applications can also be applied directly to the scar without any intention to augment or establish pressure on the scar. In the 1980s, silicone gel sheets were effectively used for the first time in the treatment of burn-related scars, however without clear standardized treatment protocols. Since the beginning of the 1990s, publications and protocols about the use of silicone sheets and gels as contact media in the prevention of hypertrophic scarring and contractures started to appear. They remain very popular as a conservative strategy ever since.

Concerning the other noninvasive treatment modalities, such as massage, the use of moisturizers, positioning and splinting, exercise, and mobilizations, the number of published controlled trials (randomized controlled trials [RCTs] of controlled clinical trial [CCTs]) for each category is rather low and within each category, different techniques or types of applications and products are used. In the field of rehabilitation, especially in burn rehabilitation, controlled randomized double-blind trials are practically and ethically extremely difficult to perform. Due to this shortcoming, except for the effect of pressure on the thickness of a scar, there is no real scientific consensus on the actual effect of the various treatment modalities. Therefore, most recommendations are mostly made based on guidelines and consensus meetings of experts [3–8].

Pressure therapy is indicated to prevent and treat skin grafts and wounds that take longer than 14–21 days to heal, because of the higher risk of hypertrophic scar formation. As soon as the healing skin tolerates compression and shear forces, pressure therapy is recommended for 23 hours per day until scar maturation. Continuous pressure on scars can be exerted by means of custom-fitted pressure garments, orthoses or transparent face masks, casts, or splints, measured by trained technicians or therapists. The optimal amount of pressure required remains controversial. Theoretically, pressures that exceed 24 mmHg pressure to overcome capillary pressure are required. However, good clinical results have been reported with levels as low as 5–15 mmHg pressure. Many authors however state or show that 15 mmHg or even higher, 20 mmHg to 30 mmHg, is necessary to accelerate the maturation process and that the effects of pressures below 10 mmHg pressure are minimal [1, 9]. Higher pressure increases the effect, but can also induce complications such as paresthesia, blistering, abnormal bone growth, limb necrosis, etc. The generated pressure plays a crucial role and needs to be monitored regularly (e.g., by using a simple pneumatic pressure sensor, such as for instance the Kikuhime pressure sensor). The Kikuhime pressure sensor has been tested in clinical circumstances and was found to be reliable and valid in the assessment of the efficiency of pressure garment therapy. The pressure of pressure garments needs to be checked every 2–3 months and, if necessary, they need to be replaced or modified to achieve optimal results [1]. Frequent washing and proper hygiene with a minimal use of ointments, lotions, or moisturizers that contain unsaturated lipid acids can help in reducing the aging and wearing of the garments.

There are mainly two different types of pressure garments that are used in the treatment and prevention of hypertrophic burn scars: elastic tricot and powernet structures. The first type of elastic tricot garments are mostly woven knit structures with a biaxial stretch and a multidimensional structure. These elastic tricot garments usually tend to be delivered with less tension (or pressure values on the scar) but maintain the pressure longer than powernet garments. The powernet structure garments have mostly one-axial stretch and a plenary open structure. The second type, the powernet garments are a bit more comfortable pertaining to water vapor permeability in summer or warm climates, but are more fragile due to their open structure. Also therefore elastic tricot garments offer a far better protection against UV rays, a property that cannot be underestimated since pigment changes are one of the most important sequelae after a severe burn injury with a higher risk for UV-induced malignant changes as result. Although the exact value for this protecting factor of the garments (UPF) is not defined, for textiles of common daily worn clothing this factor is set on a value of 50.

Pressure is strongly recommended to decrease scar height and scar erythema [1]. The working mechanism of pressure therapy is not completely understood. First, pressure can control collagen synthesis [9]. The realignment of collagen fibers and the reduction of development of whorled-typed collagen nodules might induce thinning of scars. Secondly, pressure might reduce the vascular flow to scar tissue, which leads to a decrease of nutrient and oxygen supply for cellular activities. It might diminish fibrotic activity (TGF-β reduction), accelerate cell apoptosis of fibroblasts, and reduce scar redness [9]. In addition, application of pressure commonly reduces pain and itching and alleviates edema associated with active hypertrophic scars [4, 9]. Based on the evidence framework of Sharp et al., pressure therapy is strongly recommended and found to be evidence based to decrease scar height and recommended to diminish scar erythema [1].

Silicone gel sheets or gels are also used in the prevention of scars after wound healing of more than 21 days and in the treatment of hypertrophic scars. Silicone gel sheets or gels can be used as soon as wounds are re-epithelialized and until complete maturation of scars [2]. The silicone gel sheets are typically worn 12–16 hours per day. The topical silicone gels are applied twice a day

[2]. Skin reactions such as allergy, dermatitis, itch, or skin breakdown may occur, but fewer when using silicone gels compared to gel sheets. Progressive building-up of wearing the silicone and hygienic precautions of both the product and the skin are important actions to reduce the risks of adverse effects, especially in warm weather or climates. Besides there are no clear benefits to using gels versus gel sheets or non-silicone versus silicone products with respect to the treatment effect [2]; the silicone-containing occlusive sheets have the most substantial amount of publications and references [3].

Silicones are recommended to improve scar erythema, thickness, and pliability [2, 3]. The universally accepted mechanism of action of silicone is hydration and occlusion of the stratum corneum [6, 10, 11]. Based on the guidelines of Meaume et al., silicone is the current gold standard and the first-line, noninvasive option for the prevention and treatment of hypertrophic scars [6].

In daily practice, silicone applications are worn in combination with pressure garments, masks, or splints to achieve the best outcomes. Silicone applications can be prefabricated sheets or individually made by specialized manufacturers as a pressure device or pad to solve concavity problems (chin, breast, clavicle, neck, and face) or in soft tissue parts of the face and neck.

Therapists routinely use *massage* in the treatment of (hypertrophic) scars, which can be applied manually or with the use of a vacuum device. Different manual massage techniques, such as the GAF techniques by Jaudoin D. and the "massage dermo-épidermique" by Godeau J., are described to limit fibrosis of scar tissue and to free adhesions. Depending on scar age and/or inflammatory status of scar tissue, the applied technique can vary between applying a mild pressure combined with a "translation" of the epidermis and a moderate pressure to create a skinfold combined with small rotations in different directions. Also a mechanical suction device can be used for mature scars. This therapy is called "vacuum therapy" or "depressomassage." Using this mechanical massage, a skinfold is created in a treatment head with negative pressure after which the skinfold can be manipulated.

Massage therapy is used in the treatment of hypertrophic scars and skin grafts to improve pliability and to reduce pain and itching [3]. The mechanical disruption of fibrotic scar tissue explains the improvements in pliability. The gate theory of Melzack and Wall support the reduction of pain and pruritus. Following the literature, the applied massage therapies differ in the type of manual techniques and mechanical settings, with or without moisturizer, duration, and frequency. However, to our knowledge, massage therapy is applied daily using progressive techniques to obtain the best outcomes. The manual or mechanical technique depends on the inflammation status of the scar (immature scar versus mature scar).

Moisturizers and lotions are used in the treatment of hypertrophic scars, which are typically dry skin and often itchy. Hypertrophic scars show increased transepidermal water loss compared to healthy skin [12, 13]. Hydration can restore the skin barrier function. Little is known about the ideal composition of moisturizers and frequency of application for burn scar treatment [13], but we believe in an application of a water-based, neutral lotion or cream at least thrice a day.

Positioning and splinting are indicated in each burn rehabilitation phase. In the acute phase, positioning and splints aim to control edema and to bring pressure relief. In the intermediate phase, positioning and splinting are indicated for soft tissue or skin graft protection and tissue elongation, whereof the last indication is also important in the long-term phase. Positioning after a burn injury corresponds with an anti-comfort position. There is no universal position, but burn depth and location must be considered when determining optimal anti-contracture positioning. Positioning may be active, which is ideal for cooperative patients, or passive, which requires the use of splints. Three different types of splints are commonly used, a static, a static progressive, and a dynamic splint. Indication for one or the other type can be to protect a skin graft after surgery, to prevent or to treat contractures, or to improve joint mobility. However there is no consensus on the ideal splint-wearing schedule. The longer a splint is worn, the greater the benefit for tissue lengthening. Some suggest a regime of 2-hours-on, 2-hours-off; others advocate active exercises during the day and splinting only at night. Schedules should be established and adjusted according to the changes in joint mobility and activity level of the patient [14].

Positioning and splinting protocols must be supervised regularly for effectiveness and require cooperation of both the patient and the burn team.

Exercising and mobilizations are important components of the daily treatment of patients after a burn injury. After a severe burn injury, patients have an increased catabolism that leads to loss of lean body mass and causes muscle weakness and decreased functional capacity. The prolonged bed rest and the lack of physical activity have an important impact on recovery after burn injuries in the rehabilitation process. Further, the hypertrophic scar formation leads to scar contractures and decreased range of motion. Therefore, the rehabilitation program starts with passive and active movements, strength training of upper and/or lower limb and progressively includes more challenging exercises such as bed cycling, sit-to-stand-transfers, and walking with or without assistance. Depending on the patient's cooperation, general condition, and cardiovascular and neurological status, mobilizations start already after 24–48 hours after admission to the burn unit or

surgical procedure, but always in dialogue with the attending physician.

In the literature, little is known about the best rehabilitation schemes to follow for adult burn patients. However, the aim of exercising is to maintain and restore the physical capacity, muscle strength, and autonomy of patients [15]. Mobilizations are required for realignment and lengthening of scar tissue, preventing joint and ligament stiffening.

Among experts, compression therapy is considered a first-line intervention in the aftercare of patients with severe scars related to burn injury while the use of all the other mentioned techniques are considered to be at least "best practice."

27.1 Conclusion

Although strong evidence is lacking for many of the different noninvasive therapeutic approaches that are used in the rehabilitation of patients with severe scars, all the interventions discussed in this chapter, that is, pressure and silicone therapy, massage, hydration, positioning and splinting, exercise, and mobilizations, are recommended and considered useful by the authors in the aftercare of these patients.

Take-Home Messages

- Pressure and silicone therapy have the best evidence in topical scar management.
- Massage is useful to treat pruritus and stiffness of scars.
- Combination strategies are mandatory and need to be individualized to optimize results.
- Hydration of scars is useful, but cost-effectiveness of the product that is used is also important.
- Positioning and splinting protocols must be individualized and supervised regularly for effectiveness.
- Physical activity and exercise are crucial to maintain and restore the physical capacity and muscle strength of burn patients.
- Mobilizations are required for realignment and lengthening of scar tissue as well as preventing joint and ligament stiffening.

References

1. Sharp PA, Pan B, Yakuboff KP, Rothchild D. Development of a best evidence statement for the use of pressure therapy for management of hypertrophic scarring. J Burn Care Res. 2016;37(4):255–64.
2. Nedelec B, Carter A, Forbes L, Hsu SC, McMahon M, Parry I, Ryan CM, Serghiou MA, Schneider JC, Sharp PA, de Oliveira A, Boruff J. Practice guidelines for the application of nonsilicone or silicone gels and gel sheets after burn injury. J Burn Care Res. 2015;36(3):345–74.
3. Anthonissen M, Daly D, Janssens T, Van Den Kerckhove E. The effects of conservative treatments on burn scars: a systematic review. Burns. 2016;42:508–18.
4. Monstrey S, Middelkoop E, Vranckx JJ, Bassetto F, Ziegler UE, Meaume S, Téot L. Updated scar management practical guidelines: non-invasive and invasive measures. J Plast Reconstr Aesthet Surg. 2014;67(8):1017–25.
5. Del Toro D, Dedhia R, Tollefson TT. Advances in scar management. Curr Opin Otolaryngol Head Neck Surg. 2016;24(4):322–9.
6. Meaume S, Le Pillouer-Prost A, Richert B, Roseeuw D, Vadoud J. Management of scars: updated practical guidelines and use of silicones. Eur J Dermatol. 2014;24(4):435–43.
7. Gold MH, Berman B, Clementoni MT, Gauglitz GG, Nahai F, Murcia C. Updated international clinical recommendations on scar management: part 1 - evaluating the evidence. Dermatol Surg. 2014;40(8):817–24.
8. Gold MH, McGuire M, Mustoe TA, et al. Updated international clinical recommendations on scar management: part 2 – algorithms for scar prevention and treatment. Dermatol Surg. 2014;40(8):825–31.
9. Ai JW, Liu J, Pei SD, Liu Y, Li DS, Lin HM, Pei B. The effectiveness of pressure therapy (15–25 mmHg) for hypertrophic burn scars: a systematic review and meta-analysis. Sci Rep. 2017;7:40185.
10. Friedstat J, Hultman C. Hypertrophic burn scar management: what does the evidence show? A systematic review of randomized controlled trials. Ann Plast Surg. 2014;72:S198–201.
11. Li-Tsang CW, Lau JCM, Choi J, Chan CC, Jianan L. A prospective randomized clinical trial to investigate the effect of silicone gel sheeting (Cica-Care) on post-traumatic hypertrophic scar among the Chinese population. Burns. 2006;32:678–83.
12. Suetake T, Sasai S, Zhen Y, Tagami H. Effects of silicone gel sheet on the stratum corneum hydration. Br J Plast Surg. 2000;53(6):503–7.
13. Klotz T, Kurmis R, Munn Z, Heath K, Greenwood JE. The effectiveness of moisturizers for the management of burn scars following severe burn injury: a systematic review protocol. JBI Database Syst Rev Implement Rep. 2014;12(11):212–20.
14. Dewey WS, Richard RL, Parry IS. Positioning, splinting, and contracture management. Phys Med Rehabil. 2011;22:229–47.
15. Porter C, Hardee J, Herndon DN, Suman OE. The role of exercise in the rehabilitation of patients with severe burns. Exerc Sport Sci Rev. 2015;43(1):34–40.