

# Insight about Different Physical Therapy Techniques for Management of Hypertrophic Scars

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## Abstract

The most common complication of burn injuries is scar formation, which causes structural and cosmetic impairment. Between 1 and 3 months after an injury, hypertrophic scarring develops. Hypertrophic scarring caused by surgical operations, trauma, and particularly burns is a source of worry for patients and a difficult problem for practitioners. Burn scars can cause aesthetic and functional problems, resulting in limitations in activities of daily living. They can substantially impact one's quality of life, both functionally and cosmetically. Despite using many therapeutic techniques, scar control remains a significant concern. Pharmacological and physical therapy, as well as surgical procedures, are used with varying degrees of success and efficacy. New treatments for scar prevention are currently making their way into normal practice, due to the implementation of novel procedures for treating hypertrophic scars and keloids, as are new insights into the pathophysiology of excessive scarring. The purpose of this study was to review different physical therapy modalities that might be effective for the management of hypertrophic scars. (**International Journal of Biomedicine. 2022;12(2):188-192.**)

**Key Words:** hypertrophic scar • pressure garment therapy • shock wave • laser

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## Abbreviations

ECM, extracellular matrix; ESWT, extracorporeal shock wave therapy; HTS, hypertrophic scars; ROM, range of motion

## Introduction

Scar formation is a result of the wound healing process that occurs when body tissues are damaged by a physical injury. Hypertrophic scars (HTS) and keloids are pathological scars caused by abnormal responses to trauma and can be itchy, raised, painful, rigid, and cause severe functional and cosmetic disability.<sup>(1)</sup>

HTS is a dermal form of the fibroproliferative disorder that often develops following thermal or traumatic injury to the deep regions of the skin (deep dermis) and is characterized by excessive deposition and alterations in the morphology of the collagen and other ECM proteins. Unlike keloids, which

progress beyond the original area of injury, HTSs remain within the boundary of the initial injury. HTSs occur at the site of injury resulting in cosmetic disfigurement, and can cause functional problems that often recur despite surgical attempts to remove or improve the scars. When HTSs are present in mobile skin regions, they can cause contractions that limit joint mobility. These difficulties can lead to psychological and social issues for burn survivors.<sup>(1-3)</sup>

Wound healing can be divided into 4 stages: hemostasis phase, inflammation phase, proliferation phase, and tissue remodeling phase. In these 4 stages, there are complicated interactions within a complex network of profibrotic and antifibrotic molecules, such as growth factors, proteolytic

enzymes, and extracellular matrix (ECM) proteins. Each molecule plays its part in the different phases of the wound healing process. As soon as the injury occurs, the hemostasis process begins, and the bleeding is controlled by the aggregation of platelets at the injury site. The subsequent formation of the fibrin clot helps stop the bleeding and provides a scaffold for the attachment and proliferation of the cells. Growth factors and cytokines are secreted by the inflammatory cells, and they share in initiating the proliferative phase of wound healing; after that, angiogenesis and collagen synthesis, followed by tissue remodeling, complete the stages of the wound healing process.<sup>(1)</sup> The delicate balance of deposition and degradation of ECM protein will be disrupted if either excessive production of the collagen, proteoglycans, and fibronectin by fibroblasts or deficient degradation and remodeling of ECM occurs. HTSs occur when the inflammatory response to injury is prolonged, leading to the pathological characteristics of HTS, including increased vascularization, hypercellularity, and excessive collagen deposition.<sup>(1,2)</sup>

#### **Risk factors of HTS**

Burn injuries, especially large and/or deep burn wounds, elevate the risk of pathological scar development because of the prolonged duration of the inflammatory phase. Indeed, it has been shown that a burn wound that heals in less than 10 days has a 4% risk of developing into HTS, whereas a burn wound that takes 21 days or more to heal has a 70% or greater risk. Infection like that in ear-pierce holes is prone to repeated infections, which lead to prolonged inflammation in the reticular dermis, increasing the risk of developing a scar. Local mechanical tension in location on the body increases formation of scarring such as (anterior chest-scapular region–sternum), whereas they seldom occur in areas where the tension of the skin is rare. Some hypertrophic scar patients have a familial history of pathological scarring, which suggests that these scars can be driven by genetic factors. Patients with black skin are 15 times more likely than patients with white skin to develop pathological scars.<sup>(4)</sup>

#### **Signs and symptoms of HTS**

There is hard and thickened raised tissue over the wound site. Skin color over the wound site from pink to red to purple appears most commonly on the upper trunk of one's body – back, chest, shoulders, upper arms, and the skin that covers joints. The scar usually develops from 1 to 2 months after injury and may cause irritation, itching, tenderness and/or pain sensation. The scar on the skin over a joint may limit your joint's normal movement.<sup>(5)</sup>

#### **HTS types**

Even a normal scar passes through a period when it is immature, and that means it is pink and often with a healing ridge (edema plus collagen synthesis). HTS during the immature stage will be pink and slightly raised, firm but not hard, and can be itchy sometimes. It begins soon after injury and takes months to resolve, typically peaking a few weeks after injury. A mature scar is a transition from an immature scar to a mature scar, and the visual marker is the resolution of erythema at this point; the inflammatory cells, endothelial cells and most of the fibroblasts have undergone apoptosis, and the epithelium looks completely normal. Mature scars are

flat without erythema, the scar is stable without symptoms, and scar pigmentation is similar to surrounding skin, although they can be paler or slightly darker.<sup>(6)</sup>

#### **HTS prevention**

Following surgery or accidental trauma, the priority should always be to prevent the abnormal formation of the scar. In the case of surgical procedures, scar prevention measures should be initiated through or before the operation. In surgery, the position and the length of the incision line should be carefully considered and, if possible, should always be along the skin tension lines. Excessive scar formation can be prevented by reducing inflammation and providing rapid wound closure, for example, early debridement of dead tissue to help wound healing, reducing the risk of infection through rinsing and cleansing, and best dressings to provide moist wound healing and/or early surgical wound coverage. During surgery, the surgeon should ensure that excessive tension on the wound edges is avoided.<sup>(6,7)</sup>

The 3 major components of scar prevention immediately after wound closure are: decreased tension, hydration/taping/occlusion, and pressure garments. Wounds that have high tension on edges, like those perpendicular to skin tension lines and those in sternal regions, have a higher risk of developing excessive scar formation, which can be decreased using post-surgical taping for a period of 3 months.<sup>(6)</sup>

Moisturizing creams and moisture-retentive dressings have been shown to be beneficial for itching scars and can decrease their size and the pain or discomfort connected with scars. Studies have shown that in the time following wound healing, water still evaporates more rapidly during the formation of scar tissue. Dehydration encourages the production of cytokines, leading to much collagen deposition by fibroblasts, which results in scar formation. So, these products may help to prevent excessive scar formation by restoring the water barrier through occlusion and hydration of the skin and need to be used as soon as the wound is healed.<sup>(6,8)</sup>

For patients with scars that spread, e.g., after burns, pressure garments may be used prophylactically in wounds that take >2–3 weeks to heal spontaneously, with the device being applied as soon as the wound is closed, and the patient can tolerate the pressure.<sup>(6,7)</sup>

General preventive measures for all types of scars include avoiding exposure to sunlight and the continued use of sunscreens with a high to maximum sun protection factor (>50) until the scar has matured. Randomized studies in animals and humans have shown that ultraviolet radiation increases scar pigmentation and worsens the clinical appearance of scars. The general rule: scars should always be re-evaluated (4–8 weeks) after surgery to determine whether additional scar management interventions are required or whether preventive therapy can be terminated.<sup>(7)</sup>

#### **Assessment of scar**

Japan Scar Workshop (JSW), a scar assessment scale, consists of 2 tables. One table is used to determine whether the scar is a typical mature scar, a hypertrophic scar, or a keloid. This grading system helps the user to select the most appropriate treatment method for the scar. Another table is used to judge the response to treatment and for follow-up. The 2 tables contain

sample images of each hypertrophic scar subjective item; this allows the user to evaluate each item without hesitation. The classification table consists of 2 parts risk factors and present symptoms, and the risk factors consist of 6 items (each of which has 2-3 categories): human race, familial tendency, number of scars, region of the scar, age at onset and causes. The present symptoms consist of 6 items (each of which has 2-3 categories): the size of the scar (cm<sup>2</sup>), vertical growth, horizontal growth, the shape of the scar, erythema around the scars and subjective symptoms. Thus, the total number of items is 12. The categories in each item are weighted (0-1-2). The minimum and the maximum number of points in the classification table are 0 and 25, respectively. The classification of the scar score is as the following: The scar score ranging between 0-5 will have mature characteristics. From 6-15 or 16-25, the scar is a hypertrophic scar or keloid scar, respectively. The evaluation table consists of 6 items: induration, elevation, redness of the scar, erythema around the scar, spontaneous and pressing pain, and itch. Each item has 4 categories: namely, none, weak, mild, and strong; these categories are weighted (0-1-2-3). The lower and upper limits of the number of points in the evaluation table are thus 0 and 18, respectively. When the symptoms improve, the total score decreases.<sup>(8,9)</sup>

#### **Physiotherapy techniques for management of post-burn HTS**

Physical therapy treatment aims to influence the scar maturation process and therefore enhance the physical and mechanical properties of the scar. Also, it prevents adhesions, thus improving tissue strength and gliding.<sup>(10)</sup>

##### **Pressure garment therapy (PGT)**

Pressure garments are considered the favored therapeutic strategy for both the prevention and treatment of HTS. Currently, PGT is the general conservative management for preventing HTS formation.<sup>(11)</sup>

The precise mechanisms of the PGT action are not precisely understood. However, the most acceptable mechanisms are those that apply mechanical pressure by pressure garments, which leads to limiting the supply of blood, oxygen, and nutrients to the scar area, therefore, reducing fibroblast activity and the levels of collagen production more rapidly than the process of scar maturation. Consequently, mechanical pressure facilitates scar maturation, thinning and softening of scar tissues, reducing erythema of the scar, and minimizing itch and pain associated with HTS.<sup>(12,13)</sup>

Pressure garments should be used immediately when the healing tissue can tolerate the pressure and worn for at least 23 hours and/or 1 day for a period of 6 to 12 months or until the scar matures.<sup>(12)</sup>

Commonly, the amount of pressure between 15–40 mmHg is the recommended pressure level as being more effective and safer. Thus, pressure higher than 40mmHg is more likely to produce many side effects such as blistering, paraesthesia, abnormal bone growth, and limb necrosis. Alternatively, the pressure >15 mmHg is more likely to have no effect on scar tissue.<sup>(12)</sup>

However, PGT has some disadvantages that limit its effectiveness, such as the occurrence of complications, including overheating, pruritus, blistering, swelling, wound

maceration, abnormal bone growth, poor compliance due to severe patient discomfort, the difficulty of applying a pressure garment evenly on the scar area, particularly in concave areas and flexor joints.<sup>(13-15)</sup>

##### **Silicone therapy**

Silicone sheets and silicone gels are considered non-invasive, first-line therapeutic strategies for both prophylaxis and treatment of hypertrophic scars. They are soft and semi-occlusive gel sheets that are durable and easy to handle. Silicone sheets should be worn for 12–24 hours each day for 3 to 6 months, commencing 2 weeks after wound healing. To avoid side effects such as rashes and infections, they should be washed daily with mild soap and water. Silicone gel is applied in fluid form to the skin, and when it dries forms a silicone sheet that is transparent, soft, and impermeable to fluids. Silicone gel should be applied twice a day.<sup>(7)</sup>

Silicone gels are easy to apply and suitable for use on visible areas such as the face and hands. On the contrary, silicone sheets are not suitable for use on visible areas, large areas of skin, and mobile body parts such as the joints. This justifies increased patient preference for and compliance with silicone gels.<sup>(17,16)</sup>

The major mechanisms of action of silicone therapy are occlusion and hydration of the stratum corneum. An increase of transepidermal water evaporation after wound healing results in dehydration of keratinocytes; after that, the keratinocytes release cytokines to fibroblast activation and increase the level of collagen production. Silicone products decrease water loss from the skin; therefore, hydration of the keratinocytes will be increased, resulting in reducing the stimulation of keratinocytes and producing cytokines; thus, fibroblasts will not be activated.<sup>(7,17,18)</sup>

##### **Massage therapy**

Massage therapy is a conventional therapeutic strategy for the treatment of HTSs. Manual or mechanical scar massage should be used in combination with silicone and pressure therapy when possible.<sup>(18)</sup> Scar massage is used to improve scar pliability, ROM, and soften scar tissue by mechanical disruption of adhering fibrotic scar tissue and also to reduce pain and itching associated with scarring, according to the gate control theory of Melzack and Wall. To be effective, massage therapy should be applied daily.<sup>(15)</sup>

##### **Extracorporeal shock wave therapy (ESWT)**

ESWT is a novel, non-invasive type of physical therapy for HTS treatment.<sup>(19)</sup> The exact mechanism underlying the positive effect of ESWT is still unclear. However, it is believed that suppressed epithelial-mesenchymal transition might be responsible for the anti-scarring effects of ESWT. On a histological level, after ESWT exposure, the levels of collagen type I, TGF- $\beta$ 1,  $\alpha$ -SMA, fibronectin, and TWIST1 were considerably reduced in the HTS. However, E-cadherin was increased. Also, mechanical disruption of tissue by cavitation shock waves induces microtrauma in scar tissue, which results in scar remodeling. Furthermore, shock waves affect pain receptor physiology. Consequently, ESWT (1) enhances the HTS appearance and symptoms, and (2) ameliorates ROM, demonstrated by an increase in passive ROM. ESWT is considered safe, easy to apply, and tolerable by patients; it has

a low incidence of associated side effects, is cost-efficient, and can be used in an outpatient setting.<sup>(20,21)</sup>

### **Laser therapy**

Many different laser types are effective for the HTS treatment.<sup>(14)</sup> The most prominent is the 585-nm pulsed dye laser (PDL). Another prominent laser type for the HTS treatment is the 1064-nm Nd:YAG laser. The recommended energies are 6.0J/cm<sup>2</sup> to 7.5J/cm<sup>2</sup> (7-mm spot) or 4.5 J/cm<sup>2</sup> to 5.5J/cm<sup>2</sup> (10-mm spot) and 14J/cm<sup>2</sup> (5-mm spot). To obtain the best outcomes, 2 to 6 sessions of treatment are recommended, and one every 3 to 4 weeks.

The mechanism underlying the therapeutic effect of laser therapy is that the laser vaporizes the blockage inside the vessel and decreases the vascularity of scar tissues. Thus, a reduction in vascularity decreases inflammatory cytokine or growth factor levels in the tissue, suppressing the formation of scars.<sup>(22)</sup> The most common side effects of laser therapy include hyperpigmentation, hypopigmentation, blistering and postoperative purpura.<sup>(11)</sup>

### **Kinesio Taping**

Kinesio Tape is a therapeutic, highly elastic tape made from cotton. It is self-adhesive, thus it adheres to the skin. The mechanisms underlying the positive effect of Kinesio Taping on scars include that it eliminates multidirectional forces and tension of the scar, helps to avoid exacerbation of the inflammatory response during wound healing, aids in the softening of scar tissue and decreasing formation of adhesions, and yields low load for a prolonged period of stress on scar tissue, all of which in turn improve scar tissue remodeling.<sup>(23)</sup> Therefore, using Kinesio Tape improves the pliability, vascularity, height, thickness, cosmetic appearance, pigmentation, and pain relief.<sup>(24)</sup> Kinesio Tape should be worn 24 hours/day and reapplied every 3-5 days. And the period between applications should be increased once the scar responds and matures. Kinesio Taping is considered a low-cost and comfortable technique for treating widespread hypertrophic scars, and it is easy to use for health care providers and patients. Also, it can be applied to regular and irregular body parts like the neck and face.<sup>(25)</sup>

## **Conclusion**

Hypertrophic scarring is a significant issue with long-term functional, cosmetic, and psychological consequences for the patient. HTS has a complex etiology. The depth of the wound is one component that has a significant influence. Burns that are only on the surface heal faster and leave fewer scars. Additional components of healing come into play when the depth of the wound increases and affects structures deeper than the epidermis. Pressure, silicone, massage, extracorporeal shock wave, laser therapy, and Kinesio Taping are all useful and approved non-invasive physiotherapeutic treatments for individuals with HTS.

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## **Competing Interests**

The authors declare that they have no competing interests.

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