Biological effects of silicone gel sheeting

LORENZO BORGOGNONI, MD

Since silicone gels were first used in the treatment of hypertrophic scars (HS) and keloids (K) they have proved useful and safe. Depending on the specific investigation, the application of silicone gels showed improvements in redness, itching, texture and thickness of HS and K in 60% to 100% of cases. Generally, texture was the first scar characteristic to change, followed by color and height.

Despite silicone gels wide use in the treatment of HS and K, and the many studies that have been performed in the past 2 decades, the mode of action of these materials remains poorly understood. This knowledge is even more difficult to obtain because the pathogenesis of HS and K is still unclear. Moreover, terms are sometimes used interchangeably, making it difficult to compare results on the effect of treatments among different studies. However, criteria to differentiate HS and K have recently been reported, and it has been hypothesized that immunologic mechanisms could be involved in the development of HS and K. Furthermore, we demonstrated the presence of an immune cell infiltrate in HS and K and characterized the immunophenotypic features of this infiltrate, which are indicative of a delayed type immune reaction. HS and K show distinct immunophenotypic profiles, and the amount of the immune cell infiltrate is related to the age and the clinical behavior of HS.

It has been reported that silicone gel softens and reduces HS in a shorter period of time than pressure therapy and that the results obtained are not due to pressure, temperature, or oxygen tension. However, it has also been reported that temperature differences of less than 1°C, as found under silicone gel sheeting (SGS), can have a significant effect on collagenase kinetics and may alter scarring. Elasticity, measured by elastometry, is significantly increased in SGS treated HS compared with control lesions.

In a recent study, we performed an investigation to evaluate the efficacy of SGS in the treatment of HS and K using objective measurements to confirm subjective evaluations by taking biopsies for histologic and immunohistochemical analysis. Quantitative measures used were thickness using ultrasound and perfusion using laser doppler perfusion imaging. Preliminary results showed a significant reduction of total scar thickness both in HS and in K with SGS treatment. The mean percentage change from the initial assessment of total scar thickness also showed a highly significant reduction. There was a reduction in scar perfusion, although not statistically significant, especially in HS. Biopsies were also taken from patients who at baseline and at 12 weeks had given their consent. We observed a reduction of spindle-shaped cells and an increased number of lymphocytes that strongly expressed CD11a/CD18 (LFA-1) adhesion molecules, which suggests that the SGS application induced modifications of the cell infiltrate in HS and K.

It appears there is no release of silicone into the skin after silicone gel application, but this is still not definite. Silicones are synthetic polymers containing a repeating silicone-oxygen backbone and organic groups attached directly to the silicon atom. Elemental silicon is used as a starting material in the manufacture of many silicone products. The most common synthetic polymer is polydimethylsiloxane (PDMS). Depending on the length of the polymer chain and the degree of cross linking, silicone may be differentiated into different classes of commercial products. SGS is composed of gel and a

From the Division of Plastic and Reconstructive Surgery, St. M. Annunziata Hospital, Florence, Italy.
Reprint requests: Dr. Lorenzo Borgognoni, U.O. Chirurgia Plastica, Ospedale S.M. Annunziata, Via Antella 58, 50011 Firenze-ITALIA. Fax: +39 055 2496535; Email: lorenzo.borgognoni@asf.toscana.it.
Copyright © 2002 by The Wound Healing Society.
ISSN: 1067-1927 $15.00 + 0
supporting elastomer membrane. Gels are lightly cross-linked PDMS, where the cross-link is achieved with vinyl and hydrogen groups on separate silicone atoms in the presence of a catalyst. This polymer network is swollen with PDMS fluid to yield a sticky, cohesive mass without form, depending on the extent of cross-linking and on how much fluid is added. Elastomers are composed of PDMS fluid, cross-linked like gel but to a much greater extent, containing very little free fluid polymer. In addition, special forms of amorphous silica compose up to about 30% of its weight.

No evidence of inflammation or foreign body reaction in the scars treated with SGS has been reported, suggesting that silicone does not enter the treated tissue, and no silica from the dressing was found at the wound site. However, the release of silicone-related compounds from a SGS and their distribution into the skin were shown in vitro. In this case, the silicone-related compounds distributed in the skin might have some pharmacological effects on the tissue.

A possible mechanism of action of SGS could be to bring about occlusion and hydration, which in turn are able to induce modifications in the scar tissue. In fact, it has been shown that SGS induces hydration of the skin surface and occlusion and hydration have a therapeutic action on HS and K. Moreover, these effects are obtained with silicone creams/dressings with or without silicone. Furthermore, it has been shown in vitro that hydration, not silicone, inhibits the proliferation of fibroblasts and their collagen production. After occlusion, an increased number of mononuclear cells were found in the epidermis. It has also been reported that there was an activation of the Langerhans cell system—i.e., Langerhans cells extended their dendrites into the granular layer and made contact with mononuclear cells—and an appearance of Langerhans cells in the dermis after occlusion.

Cytokine mRNA changes have been shown after the treatment of HS with both silicone and hydrogel occlusive dressings. Increased mean levels of interleukin-8 (IL-8),

**FIGURE 1.** A low number of CD68+ macrophages is present in the dermis of the scar three months after keloid excision (APAAP method, original magnification x100).

**FIGURE 2.** A high number of CD68+ macrophages is present in the dermis of the scar after keloid excision and silicone gel sheeting application for three months (APAAP method, original magnification x100).
basic fibroblast growth factor, granulocyte-macrophage colony-stimulating factor and decreased levels of transforming growth factor beta and fibronectin were found after treatment with both dressings. However, only the hydrogel dressing revealed significant changes in IL-8 and basic fibroblast growth factor levels relative to untreated scars. Significant changes in IL-8 and fibronectin were found after treatment with the hydrogel dressing, whereas only fibronectin changes were significant after the treatment with silicone gel sheeting relative to normal skin.

Therefore, it seems that occlusion and hydration could have some biological effects on HS and K with or without the use of silicone. However, it is still unclear whether the effects induced by SGS are exactly the same as those induced by hydration obtained by other methods. Silicone could act not only by causing hydration, but also through other mechanisms.

In fact, it has also been reported that static electricity, generated by friction-activated silicone sheeting, helps to cause involution of HS and K. Moreover, a silicone cushion, which induces an increased and continuous negatively charged static-electric field, obtained similar effects to SGS and shortened the treatment period in HS and K. It has been hypothesized that the interaction between the negative static-electric field of silicone cushions and the charged components of the tissue fluids could induce the involution process in HS and K.

SGS has been shown efficacious not only in the treatment but also in the prevention of HS and K. The application of SGS after surgical resection prevented the development of HS and K in 75% to 85% of the cases. In a previous report, we studied a selected group of individuals with K that recurred after a previous surgical excision. One group of patients with these K underwent a further surgical excision and the second group with K were treated with surgical excision followed by the application of SGS for 3 months. In the scars where SGS was applied, we observed a significantly higher rate of complete remission. Moreover, we found a higher number of CD36+ dendritic cells and CD68+ macrophages in the scars treated with SGS when compared with the pre-treated lesion and with the scars in which the SGS was not applied (Figures 1, 2), suggesting that SGS application could induce the remodeling processes in the scar tissue.

In conclusion, despite some biological effects of SGS that were reported in previous investigations, further studies are certainly needed to better clarify the mechanism of action of this therapy which, due to its noninvasive, effective, and safe nature, is largely used for the prevention and treatment of HS and K.

**REFERENCES**