Treatment of keloid sternotomy scars with 585 nm flashlamp-pumped pulsed-dye laser

Tina S Alster, Carmen M Williams

Summary
Despite increasing knowledge of wound healing and collagen metabolism, hypertrophic scars and keloid scars are difficult to eradicate. Median sternotomy scars are often hypertrophic or keloidal. We treated them with a 585 nm flashlamp-pumped pulsed-dye laser, which selectively injures cutaneous microvessels without inducing scars.

16 adult patients with hypertrophic or keloidal median sternotomy scars after heart surgery received two treatments to one half of their previously untreated scars every 6–8 weeks and were reviewed at 6 months. Symptoms and clinical, histological, photographic, and surface texture assessments were obtained for treated and untreated areas of scar and evaluated independently by two observers blind to the treatment and by digital image analysis of skin surface casts.

There was a significant improvement in erythema, scar height, skin surface texture, and pruritus in laser-treated scar areas; this improvement persisted for at least 6 months.

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Introduction
Hypertrophic scars and keloids are notoriously difficult to treat. A hypertrophic scar is a scar that has become raised, red, and nodular but which remains within the confines of the original skin damage; a keloid grows beyond the confines of the previous wound. Various treatments have been tried in the past, including intralesional steroids, cryosurgery, radiotherapy, pressure therapy, silicone gel sheeting, excisional surgery, and ablative laser surgery. After these treatments, however, hypertrophic scars and keloids often recur or may become worse.

The 585 nm flashlamp-pumped pulsed-dye laser has been shown effectively to remove microvascular lesions, such as telangiectasis and port-wine stains. This laser has also been shown to improve the appearance and surface texture of hypertrophic scars. We studied the effectiveness of the 585 nm laser in improving the appearance, texture, and symptoms arising from hypertrophic and keloidal median sternotomy scars.

Patients and methods
The study protocol was approved by the institutional review board of Georgetown University Medical Center. Between Sept 1, 1993, and Oct 31, 1993, patients at least 18 years of age with keloid or hypertrophic median sternotomy scars of at least 6 months’ duration were enrolled in the study.

16 patients (10 men, 6 women, mean age 49 years, mean scar duration 17 months) were identified through the division of cardiovascular-thoracic surgery at Georgetown University Medical Center as meeting the eligibility criteria: a uniformly hypertrophic scar, no prior treatment, and skin types I, II, or III (melanin in darker skins acts as a competing chromophore for
Our findings confirmed clinical observations that identified use of ACE inhibitors as the major cause of hypoglycaemia. In clinical studies, increases in blood glucose concentrations were observed among hypertensive as well as normotensive diabetic patients during use of ACE inhibitors. Some investigators found increased insulin sensitivity, probably due to enhanced insulin-mediated peripheral glucose disposal from muscular tissue, but others failed to show any effect of ACE inhibitors on glucose metabolism. Most of these studies, however, included fewer than 15 patients and used different techniques to study the effect on glucose metabolism. Oksa et al suggested that the effect of ACE inhibitors on glucose metabolism may be limited to patients who are already predisposed to hypoglycaemia. Tight glycaemic control and the increasing use of ACE inhibitors could result in an increase of admissions for hypoglycaemia caused by the drugs. Our data did not permit further elaboration of this hypothesis. The effect of ACE inhibitors on glucose metabolism requires further investigation.

The association between ACE-inhibitor use and hypoglycaemia could be biased if ACE inhibitors were preferentially prescribed to patients already at an increased risk of hypoglycaemia. We therefore included variables reflecting the type of diabetes treatment, use of glucagon (as a proxy for predisposition to hypoglycaemia), previous admission for diabetes complications, and use of various cardiovascular drugs. None of these potential risk factors, however, substantially affected the observed risk of hypoglycaemia among users of insulin or oral antidiabetic drugs. Former use of ACE inhibitors was not associated with an increased risk of hypoglycaemia.

Another possible limitation of our study was the selection procedure for controls and the assignment of random index dates to controls. We intentionally did not match cases and controls because we were interested in confounding by age or sex. A bias could occur because patients had different exposure times. We recognised this possibility and included only controls and cases that had been treated for at least a year. Furthermore, we included the year of the hypoglycaemia admission in our analyses to control for confounding by time trends. We observed no diminution in odds ratios when controlling for these time trends. We therefore have no reason to believe that the findings were due to selection or other biases as a result of the procedure for selection of controls.

Although it is generally believed that beta-blocking agents should be avoided in patients with insulin-dependent diabetes because they may mask symptoms of hypoglycaemia, these drugs were not significantly associated with an increased risk of admission for hypoglycaemia. The clinical relevance of this contraindication is probably limited and the risk of masking does not outweigh the potential benefits of beta-blockers in the treatment of diabetic patients who have suffered myocardial infarction. We did not observe any increased risk of hypoglycaemia with salicylate use. Fear of hypoglycaemia should not be the primary reason for withholding low-dose aspirin from diabetic patients with a history of recent myocardial infarction.

We calculated that ACE inhibitors could explain 13.8% of all hospital admissions for hypoglycaemia in diabetic patients. A study in France suggested that about 10% of all hypoglycaemic events among patients using oral antidiabetic drugs might be explained by the use of ACE inhibitors. ACE inhibitors have several advantages over other antihypertensive drugs, especially among diabetic patients, because of a renal protective effect in microalbuminuria and because of the improvement in insulin sensitivity. The risk of hypoglycaemia should, however, be considered. Further research to identify risk groups among diabetic patients should be given high priority.
this otherwise haemoglobin-specific laser). Informed consent was obtained from each participant.

One half of each scar was treated every 6–8 weeks with an SPTL-1 flashlamp-pumped pulsed dye laser (Candela Laser Corp, Wayland, MA, USA) at a wavelength of 585 nm, a pulse duration of 450 μs, a spot size of 5 mm, and with fluence per pulse of between 6·5 and 7·25 J/cm² (mean 7·0 J/cm²). Scars were examined by two observers, who were unaware which half of the scar had received treatment, before and 6 months after treatment.

A hand-held instrument (DermaSpectrometer, Cortex Technology, Hadsund, Denmark) was used to measure erythema. The mean of three measurements were obtained from each area under study. Scar thickness was measured with calipers by determining the maximum vertical elevation of the scar above normal skin. Scar pliability was rated along a scale commonly used to assess functional mobility of burn scars: normal skin 0, supple skin that yields with negligible resistance 1, yielding scars that give away to pressure while offering a moderate resistance 2, a firm scar that moves as a solid, inflexible unit 3, and banding that produces a rope of scar tissue with blanching 4.

3 mm-diameter punch biopsy samples were obtained from treated and untreated parts of each scar, processed, and stained with haematoxylin and eosin, and Giemsa, and evaluated for epidermal changes, dermal sclerosis, fibroblasts, and mast cells. Silicone-rubber skin impressions (Syringe Elasticon, Healthco International, Westborough, MA, USA) were obtained of the scars and the adjacent normal skin and analysed with a Magiscan Digital Image Processing system, which provides an objective measurement of skin lines and wrinkles. The skin surface topography (Ra value) of each impression was determined as the deviation measured above and below an average line running through the scar profile (low Ra reflects less deviation from the mean, higher, more normal skin ridges and indentations).

Study participants were asked about pain, pruritis, or burning of their scars, and whether medications were necessary to alleviate symptoms.

Mean values were calculated for erythema, scar height, pliability, and skin texture. Standard two-tailed, paired t-test analyses were done between baseline, non-laser-irradiated scars, and laser-irradiated scars. Scar pliability was also compared by Wilcoxon signed rank test.

**Results**

All patients had an improvement in the clinical appearance of the laser-irradiated parts of their scars (figure 1) after 6 months. 12 (75%) reported pruritis of their scars before laser treatment, 1 of whom occasionally took an antihistamine. All but 1 of these patients reported cessation of pruritis within the treated portions of their scars after one laser session. Of the 8 who had tenderness and burning within their scars before treatment, only 1 reported continued, albeit improved, symptoms after treatment.

**Erythema index**

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<th>SP laser Treatment 2</th>
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**Scar height (mm)**

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<td>2·56 (1·55)</td>
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**Pliability rating**

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**Ra values**

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Figure 1: Hypertrophic median sternotomy scar before (left) and 6 months after two laser treatments to the upper half (right)

Figure 2: Mean (SD) measurements or scores before and after treatment
Erythema measurements of laser-irradiated scars showed statistically significant differences compared with baseline and untreated scars after one and two laser treatments (figure 2), although erythema was still significantly different from normal skin (p=0.0006). Mean scar height was reduced after one and two laser treatments; and scar pliability improved. There was also a significant difference (p<0.0001) in skin surface texture (Ra) between laser-irradiated scar tissue, baseline, and non-laser-irradiated scar tissue.

Little or no epidermal changes were seen in the biopsy samples of laser-irradiated and non-laser-irradiated scars. Dense coarse sclerosis with thick hyalinised collagen in the papillary and reticular dermis was noted in all baseline scar biopsy samples and in the majority of non-laser-treated scars. In addition, numerous fibroblasts were seen embedded within the unidirectional-oriented sclerotic collagen fibres. By contrast, the laser-irradiated scars had a normal number of dermal fibroblasts within looser, less coarse collagen fibres. The number of mast cells in the laser-irradiated scars were increased compared with baseline and untreated control scars.

**Discussion**

Hypertrophic scars and keloids affect 4.5–16% of the general population. The incidence of post-median sternotomy hypertrophic scars and keloids is estimated to be between 10–20%. Reports on the efficacy of most scar treatments have been limited by a lack of controls. Because of the size of median sternotomy scars, they provide a good model for controlled studies. Previous studies have not routinely included objective assessments of response to treatment. Our study incorporated quantifiable outcome measures which were evaluated blindly.

Ra measurements through optical profilometry on scars were low when compared with those of normal surrounding skin because scars have fewer skin-surface markings. After laser treatments, however, the treated parts showed significantly higher Ra values than untreated portions. Laser treatment also significantly reduced scar erythema, scar height, and increased pliability. Microscopy of scar biopsy samples showed the response of sclerotic collagen bundles to laser irradiation. The increased number of mast cells seen after laser treatment of these scars accords with a previous report showing mast-cell proliferation in port-wine stains treated with the same laser.

The mechanism whereby hypertrophic and keloid scars are altered by this vascular-specific laser system is unknown. Similar results have not been obtained with lasers that vapourise or coagulate scar tissue. The laser we used affects skin by selective photothermolysis: selective absorption of light by haemoglobin leads to local heating of cutaneous blood vessels, which is confined by use of a short pulse duration. Thermal injury to vessels leads to thrombosis, vasculitis, and gradual local repair, including neovascularisation. Little is known, however, about the influence of this process on the dermal extracellular matrix. Microvascular destruction presumably leads to ischaemia, which may affect collagen or release of collagenase. It is also possible that sufficient heat is conducted from the blood vessels to the surrounding dermis directly to alter the collagen composition of the scar. Perhaps the most likely explanation for this laser's effectiveness is related to the increase in mast cells; normal and keloid fibroblast growth is stimulated by histamine.

We thank our colleagues in the division of cardiovascular-thoracic surgery at Georgetown University Hospital who referred patients for this study, to Mary Jo Grove, for technical assistance, and to Thomas Varriacchione, for assistance in data analysis.

**References**


