Lasers in Medical Science (2023) 38:144
https://doi.org/10.1007/s10103-023-03814-1

BRIEF REPORT

An audit of the use of fractional CO2 laser for hypertrophic burn scars: a real-life perspective

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Received: 29 August 2022 / Accepted: 14 June 2023
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Introduction

Hypertrophic scars can occur in up to 90% of thermal injuries [1]. They are caused by the proliferation of myofibroblasts and the subsequent excess deposition of extracellular collagen [2, 3]. Patients with hypertrophic scars often complain that they are raised, itchy, painful and rigid, as well as having a significant impact on patient's thoughts on their appearance and quality of life [4, 5]. Although severe scars may be treated with surgery, non-surgical methods are preferred and tend to include the use of compression bandaging, silicone dressings, 5-fluorouracil and steroids (topical and intralesional). However, these non-surgical techniques often require multiple applications and may not be effective in the long term, so further treatment options for these scars is important [6].

Since they were first described in 2004 by Manstein et al., there has been a significant increase in the use of fractional carbon dioxide (CO2) lasers to treat hypertrophic burn scars [7]. Fractional CO2 lasers are ablative and work by vaporising water in the scar tissue, leading to micro perforations and thus remodelling of the excess collagen in the hypertrophic scar [8, 9]. This process ultimately causes a reduction in volume, and skin to become more flexible, allowing for improved range of movement. Bohan et al. demonstrated significant reduction in ultrasound measured scar thickness after just two treatments [10], and Hantash et al. found that the remodelling triggered by CO2 laser therapy can continue for up to 3 months following the initial therapy [11]. A meta-analysis by Peng et al. found that alongside these positive scar improvements, the side effects of CO2 lasers were minimal [12].

The objective improvement in burn scars with the use of CO2 lasers has been shown [10, 13]. However, there is currently no standardised objective measure of this severity, and it is thought that there is limited correlation between objective measures and patient satisfaction with scar treatment [14]. The POSAS score was first described in 2004 as a tool to evaluate burn severity [15]. It is now viewed as one of the superior measures of burn scar evaluation given its incorporation of patient-reported outcome measures, alongside consistent and reliable results when compared to other burn scar tools [16].

There are few papers that look at both patient- and observer-related measures of scar severity pre- and post-CO2 laser treatment and in particular, the effectiveness of this in real practice. Our audit aimed to evaluate the use of CO2 lasers in real practice in a regional laser centre, noting both patient- and observer-related outcomes.

Methods

As an audit benchmarking outcomes in patients receiving standard care, ethics committee approval was not required.

Data was collected prospectively. All patients attended a UK regional skin laser centre in a large public teaching hospital between November 2020 and March 2022. They received treatment for hypertrophic scars secondary to burn injury as per the normal protocol for the department. Included in this audit were any patients receiving ablative fractional carbon dioxide (CO2) laser as part of their management for burns scars.

Treatments were carried out by specialist doctors and nurses trained and experienced in lasers and light therapies. The CO2 laser (10,600 nm, SmartXide Touch, DEKA, Florence, Italy) was used in its fractional mode using the following settings: Power 10W, Emission Mode HP,

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Published online: 22 June 2023

2 Stacks, Spacing 500 µm for all patients. A single pass was carried out under topical anaesthetic for all but one patient who required a general anaesthetic. Treatments were repeated at 3–6-month intervals.

Their scars were assessed at every visit and graded according to the validated scoring system POSAS (Patient and Observer Scar Assessment Scale) v2.0 by the patient and the same two clinicians independently [17]. Averages were taken of the observer scores and the overall change in scores over time was calculated. Reductions were expressed as positive differences and increases as negative (Table 1).

Normality of the data was confirmed by the Shapiro–Wilk test. Statistical difference between scores was determined by Student's *t*-test of the sample means (a dependent test). Correlation was tested using Pearson's product moment correlation. Statistical analysis was conducted using R (v4.1.2; The R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 47 treatments were carried out on 23 patients. Patients with only one treatment or having only one usable complete POSAS score were not included in analysis as there was no change to measure. Seventeen patients had usable observer scores and 16 had usable patient scores. Of these, each patient received 2–5 treatments. Mean follow-up was 226 days (range 84–580). Patients included received 2–5 treatments (mean 2.47). The average age of our patients was 47 years. The male to female ratio was 1.43. The average time between injury and first CO2 laser treatment was 88 months (range 4–550).

There was a significant improvement in mean change of observer rated scores for scar thickness with a reduction of 1.21 (*95% CI* 0.62–1.80; $P<0.001$); relief with an improvement of 1.56 (*95% CI* 0.88–2.24; $P<0.001$); pliability with an improvement of 1.32 (*95% CI* 0.62–2.03; $P<0.01$); surface area affected with an improvement of 1.56 (*95% CI* 0.72–2.40; $P<0.01$); and overall observer impression of the scar with a reduction of 1.24 (*95% CI* 0.84–1.63; $P<0.00001$).

No significant change was seen in observer-rated vascularity with a mean change of 0.80 (*95% CI* −0.04–1.64; $P=0.06$) or pigmentation with a mean change of 0.71 (*95% CI* −0.06–1.47; $P=0.07$).

In the mean change of patient-assessed scores, we saw significant improvements in stiffness with a reduction of 1.63 (*95% CI* 0.67–2.58; $P<0.01$); thickness with a reduction of 1.44 (*95% CI* 0.48–2.39; $P<0.01$) and itch with a mean improvement of 1.81 (*95% CI* 0.69–2.93; $P<0.01$).

No significant change was seen in patient-rated pain with a mean reduction of 1.13 (*95% CI* −0.04–2.29; $P=0.06$); colour with a mean change of 0.38 (*95% CI* −0.77–1.52; $P=0.50$); irregularity with a mean change of 1.19 (*95% CI* −0.30–2.67; $P=0.11$); and overall impression of the scar with mean improvement of 0.81 (*95% CI* −0.04–1.67; $P=0.06$).

No significant correlation was found between age of scar at first treatment and observer-rated thickness, $r = 0.07$ (*95% CI* −0.42–0.55; $P=0.78$); relief, $r = 0.02$ (*95% CI* −0.46–0.50; $P=0.93$); pliability, $r = 0.12$ (*95% CI* −0.38–0.57; $P=0.65$); surface area, $r = -0.26$ (*95% CI* −0.66–0.25; $P=0.32$); or overall improvement, $r = -0.07$ (*95% CI* −0.53–0.43; $P=0.80$). There was no significant correlation between age of patient- and observer-rated overall improvement: $r = -0.08$ (*95% CI* −0.54–0.41; $P=0.75$) (Fig. 1, Fig. 2a, b).

Table 1 POSAS score parameters [17]

Observer-related parameters	Patient-related parameters
Pliability	Stiffness
Thickness	Thickness
Relief	Irregularity
Pigmentation	Colour
Vascularity	Pain
Surface Area	Itching

Discussion

A meta-analysis in 2021 found several studies demonstrating significant improvements in hypertrophic burn scars treated with fractional carbon dioxide laser using similar assessment tools [18]. Our results found good improvement in observer-related outcomes and some improvement in patient-related outcomes, and there are limited studies that looked at both these outcomes. Patel et al. looked at hypertrophic burn scars in children, finding significant improvements in all observer-related outcomes other than vascularity and all patient-related outcomes other than itch and pain [19]. Cox et al. looked at treatment of hypertrophic burn scars with CO2 lasers in the upper extremities and found significance in all observer-related outcomes and all patient-related outcomes except itching [20]. Finally, Ge looked at using multiple modalities on the CO2 laser depending on the hypertrophic burn scar, and they found significance in all patient- and observer-related outcomes [21]. Interestingly, Meynköhn et al. found similar results when treating facial scars [22]. All these papers found more significant improvements in POSAS scoring compared to our results, so it is important to explore why this is.

Firstly, many of the above papers saw an improvement in vascularity and pigmentation. These are not features that are expected to improve with CO2 lasers as the lasers are targeting thickness and laxity and they may in fact worsen

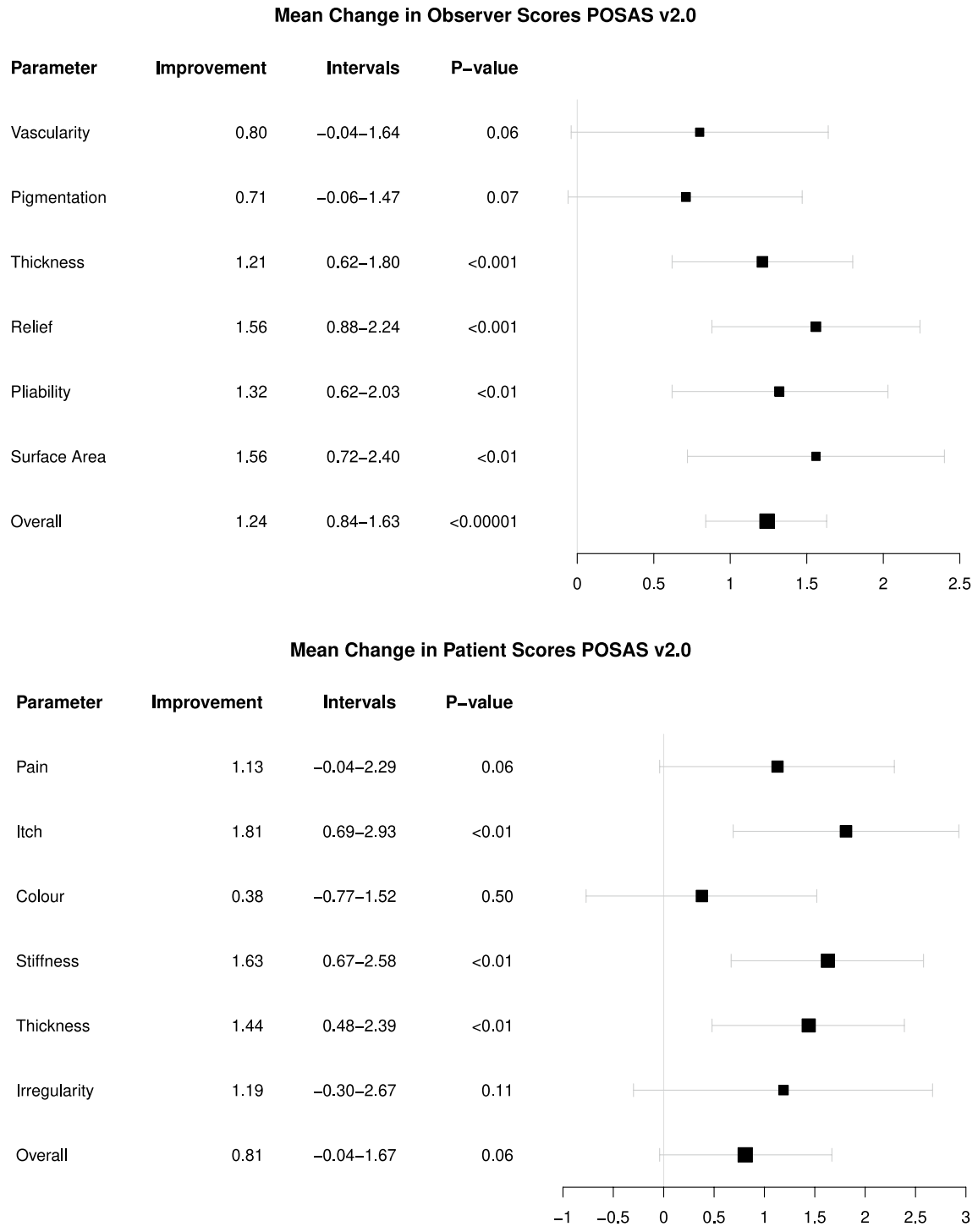


Fig. 1 Forest plots displaying the mean change in patient POSAS scores

these features [23]. To treat features such as vascularity, other modalities such as a pulsed dye laser are often used [24]. However, unlike our data, all the papers noted some improvement in vascularity/pigmentation. When looking at the papers, they all treated patients that were an average of 5.5–12.6 months since their original scar formation. Meanwhile our patients were treated at an average of 88 months following their original injury (although it must be noted that the range was broad: 4–550 months). Therefore, it is feasible that these papers captured some element of early scar healing. Our patients had more mature scars, which will have already faded naturally or been treated with



Fig. 2 **a** Hypertrophic burn scar on the neck of patient G before CO2 laser therapy. **b** Scar at 3 months following CO2 laser therapy. Smoothing of the irregular texture/relief of scar and improved pliability with greater range of movement

pulsed dye laser prior, making no further improvement possible. What's more, the average age of our participants was 47 years; however, in these papers the average age of patients was 6, 28, and 31 years, respectively. Scar healing may be improved in younger patients; therefore, this could also contribute to the remodelling ability with slower fibroblast proliferation associated with increased ageing [25, 26]. In future studies with higher numbers of data points, it would be beneficial to analyse the correlation between age of scars and posttreatment improvement.

Secondly, it is worth noting the model of laser used in each study. Whilst our data was taken from patients treated with DEKA SmartXide, the patients in these other papers were treated with Lumenis UltraPulse. When treating hypertrophic burn scars, the aim is to break up the scarred collagen whilst minimising the thermal zone to reduce the further contraction of the scar [25]. The Lumenis UltraPulse allows higher peak powers to be used to break up the collagen with minimal contraction compared to other CO2 lasers. However, this is usually done under general anaesthetic [27]. One of the key benefits demonstrated by our data is that these scars can be treated under topical anaesthetic at lower powers and still get good results. By being able to treat with topical anaesthetic, this becomes a treatment option for many more patients, and the recovery time can be reduced. Cost may also be a factor to be considered, and smaller centres that may have been put off by the expense of ablative laser systems may be reassured they may still be able to achieve good results with less expensive machines [27, 28]. We believe this study has demonstrated that you can still get good results with the lower power treatments under topical anaesthetic.

Whilst we were keen to capture patient- and observer-related outcomes, we need to evaluate why the patient-related outcomes were markedly worse improvements than the observer-related outcomes. Also, anecdotally patients often reported that they were very happy with the improvement in their scars; however, this did not appear to be captured. Perhaps as the scores of severities were objective and patients had to score their scars at two independent timings, they may not have remembered previous scores so although they felt a difference this could not be captured. Furthermore, the POSAS score was capturing the patient's opinion on the physical nature of their scar. Although patients may have been happy with the improvement in their scar, they may still believe that it appears severe. For this reason, perhaps a quality-of-life scoring system such as the DLQI may capture the impact that matters to patients with treated hypertrophic scars. A beneficial impact on quality of life using CO2 lasers for hypertrophic burn scars has been demonstrated in other studies [29, 30].

It is important to acknowledge a major limitation is that this was an audit. For this reason, the patient population was not controlled for confounders and the treatment they received (such as previous treatment with pulsed dye lasers or varied topical steroid administration) was not controlled for. Furthermore, our data collection sometimes commenced part-way through a patients' treatment or did not capture their complete course if these sessions fell outside the research time period. However, we do think that the use of audits in this way is critical to monitor the real-life outcomes and can produce some useful data to present to patients. Whilst an aim of this audit is to measure the improvement in patient scars having our treatment as a baseline measurement, we would hope to reaudit with a view to ensuring outcomes remain the same in the future.

Conclusion

Our audit found that patients with hypertrophic burn scars receiving fractional CO_2 laser treatment as part of their standard care demonstrated good cosmetic and symptomatic improvement with minimal complications. It also showed that these results can be effectively gained in real practice and with lower powers under topical anaesthetic in an outpatient setting.

Author contribution Conceptualisation: Daniel Keith. Data curation: Emma Hitchens, Kay Thomas and Daniel Keith. Formal analysis: Daniel Keith. Project administration: Elizabeth Wasson, Daniel Keith. Writing — original draft: Elizabeth Wasson. Writing — review and editing: Charankumal Thandi, Daniel Keith. Supervision: Daniel Keith.

Data availability Data available on request from the author.

Declarations

Ethics approval This was an audit therefore no ethical approval was required.

Consent to participate Patients signed informed consent regarding publishing their data and photographs.

Competing interests The authors declare no competing interests.

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