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Michael J. Murphy

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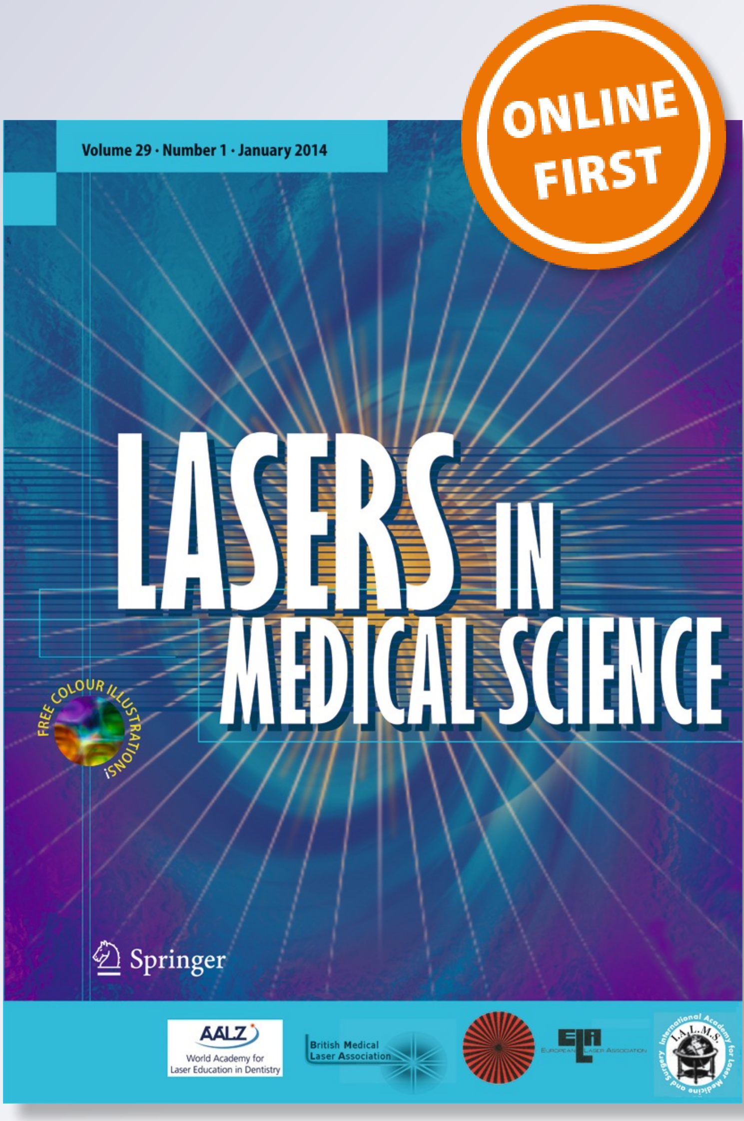

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ORIGINAL ARTICLE

A novel, simple and efficacious technique for tattoo removal resulting in less pain using the Q-switched Nd:YAG laser

Michael J. Murphy

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Abstract A new yet simple technique has been tested on patients seeking tattoo removal by Q-switched Nd:YAG laser based on an observational study. The technique involves application of a glass microscope slide on the treatment area with a firm pressure to compress the skin which results in evacuating the blood from the capillary plexus. Results from a survey of 31 patients revealed that most felt less pain and reported less epidermal damage post-treatment. This new technique is easy to apply and inexpensive, using standard, conventional Q-switched lasers.

Keywords Nd:YAG laser · Tattoo removal · Pain reduction · Q-switched · Glass slide

Introduction

Q-switched lasers have been routinely used for tattoo removal since the mid-1980s when the ruby laser was found to generate excellent scar-free results [1–5]. Since that time, many of these lasers have been used all around the world on many thousands of patients. Three types of QS laser have been found to be useful for this application—the ruby, neodymium yttrium aluminium garnet (Nd:YAG) and alexandrite [6–12]. Each has its advantages and disadvantages [8–10].

Previous attempts to reduce the pain sensation include the application of topical anaesthesia and a vacuum technique [13, 14]. Both of these techniques have yielded limited results.

This report will detail a simple and effective technique which has a number of significant benefits for patients. This technique involves the use of standard microscope glass slides placed over the tattooed area with a moderate pressure applied to the skin. The laser energy is then fired through the glass slide to the ink beneath. Note that no difference in the efficacy of the treatment was observed using this new technique.

M. J. Murphy (✉)
Clinical Lasers plc, 145-157 St John Street, London EC1V 4PW, UK
e-mail: m.murphy@clinicallasers.com

Materials and methods

Before each treatment, the tattooed area and the glass slide were cleaned with alcohol swabs to remove any surface dirt and hence improve optical coupling.

Immediately prior to the treatment, a thin layer of a water-based gel (ECG Gel from Camcare Gels, Ely, Cambridgeshire, UK) was applied to the skin surface. This was applied to minimise reflection losses between the glass and the skin surface (due to index mismatching). In addition, the water gel fills some of the air gaps found in the stratum corneum, making it more optically conductive.

A fresh microscope glass slide (IMED Microscope Slides; clear glass, 1–1.2-mm thick) was then placed on the surface above the tattoo and firmly pressed against the skin to compress it during the treatment. A DermaLase DLY600 Q-switched Nd:YAG laser was used to treat the tattooed sites using the 1,064-nm wavelength with a fluence range of 3.5–5.1 J/cm^2 in a 5-mm spot diameter and a pulse width of 8 ns, with a repetition rate of 6 Hz.

Patient survey results

A short survey was carried out on 31 patients who had been subjected to the treatment with and without the glass slide in the same treatment session. All patients were from the West of Scotland and presented skin type 2 or 3 (according to the Fitzpatrick scale) with 12 males and 19 females in an age range from 18 to 53 (mean age of 35.5). Of the tattoos, 94 %

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were professionally applied, and the majority, 62 %, were blue/black with a smaller number presenting colours such as red, green, light blue and purple. Patients were typically treated at 4 to 6-week intervals (note, no anaesthesia was used in any of these treatments).

Each patient was asked to rate their opinion on the pain sensation on a scale of 1 to 10 (1 being minimal, 10 being maximal) with both the conventional technique and the newer glass slide method, during the same treatment session.

Results

As with any optical transition, there will be a loss of energy due to refractive index mismatching when the laser energy traverses the two sides of the glass slide. Fresnel reflections typically account for around a 4 % loss at each optical surface. Measurements of the energy through the glass slide, with a thin film of gel on one side, revealed an energy loss of 7.8±0.3 %. These measurements were carried out using an Ophir DGHH meter with a detector head designed for nanosecond laser pulses.

In tattoos which have not previously been treated by lasers, there is an immediate whitening of the treated areas. This is presumed to be due to the formation of many minute steam 'bubbles' on the surface of the ink particles [2–5]. Tattoos which have been treated previously may also exhibit whitening immediately after irradiation, but this effect diminishes with an increasing number of treatments.

The most immediate difference between this technique and the previously used conventional technique is a reduction in the sensation felt by the patient. Virtually every patient reported a reduction in the sensation (or pain) felt during the laser application (see Table 1).

Table 1 Results of patient survey with 31 patients

	Pain sensation, mean (SD)
Without slide	6.97 (1.9)
With slide	3.84 (1.8)

Patients were asked to comment on each category on a scale of 1 to 10. In both cases, $p<0.005$ (statistics calculated using Minitab 16 software)

A common occurrence with the older conventional technique is the appearance of punctate bleeding immediately post-treatment, particularly with tattoos with no previous treatment history. This has been almost completely eliminated with the glass slide technique, suggesting less mechanical damage to the capillary plexus and epidermis. This can be explained by the evacuation of blood from the capillaries during the compression by the glass slide.

It is interesting to note that the impact of shattered fragments of ink can be felt during the treatment, through the glass slide. This may be verified by firing at non-tattooed skin where no such impacts can be felt.

In addition, the vast majority of patients (>93.5 %) also reported less epidermal damage and oedema in the weeks following treatment.

Figure 1 shows the raw data from each condition, with and without the glass slide. It is clear that the shift in the data points, when applying the glass slide, to the lower end of the pain scale shows how effective this technique is.

Discussion

The reduction in pain felt by patients during the treatment is statistically significant. Pain is typically caused when the ink

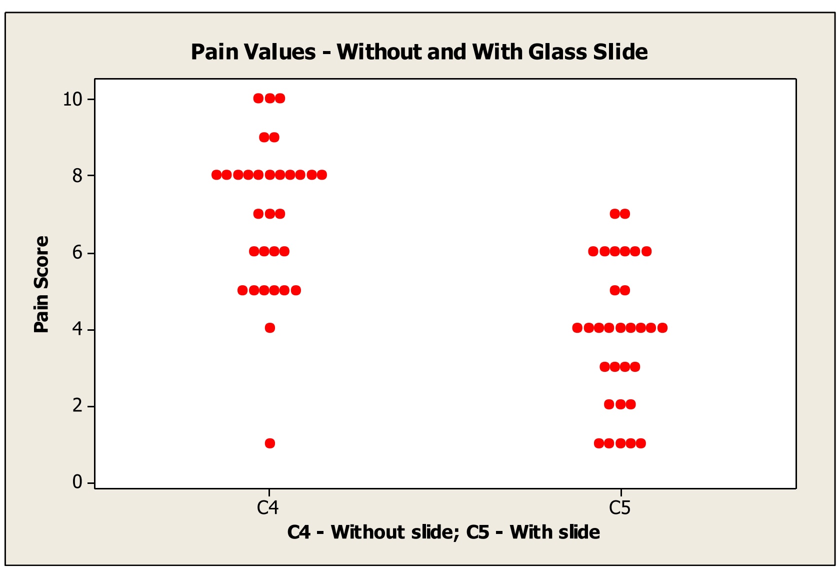

Fig. 1 Distribution of the raw data—the left hand column (*C4*) shows the pain data when the glass slide is not applied, while the right hand column (*C5*) shows the pain data when the slide is applied

particles shatter during the photomechanical reaction induced by the nanosecond pulse. This is easily verified when laser energy is exposed to non-pigmented skin and virtually no sensation is felt (author's observations). In fact, quite often the ink-shattering process can be felt by the operator through the glass slide as a slight 'thud' sensation. By compressing the skin, the pain sensation is reduced as a consequence of "afferent inhibition of pain transmission due to the dermal A-beta fibres being stimulated by the compression force" (Melzack's gate theory [15]).

A technique had been previously developed using a vacuum chamber to minimise pain during treatments [13, 14]. However, this technique involves considerably more expense and technology than the simple glass slide method presented here.

A note of caution must be included—since the laser energy is being fired through a glass slide, there is a potential for around 8 % of the incident fluence to be reflected towards the eyes of the laser operator or patient. While this may initially appear to be insignificant, the reflected power density potentially may be up to 80 MW/cm^2—more than enough to inflict serious damage on the retina. Extreme care must be taken when choosing the appropriate safety glasses to prevent any unwanted ocular exposure.

An interesting, although not clinically significant, observation was the lack of the burning smell usually associated with the vapourisation of surface hair during laser treatments. Clearly, the gel and glass slide 'trap' vapourised particles thereby preventing them from engaging the nostrils of the treatment room's occupants. While this does not add to the efficaciousness of the treatment, it does improve the general atmosphere.

Using the same arguments as above, the glass slide technique may also yield improved results with the Q-switched ruby and alexandrite lasers. It may also help to improve other light-based treatment applications such as the laser/IPL removal of hair, blood vessels and other unwanted tissues/targets plus other applications such as skin rejuvenation and resurfacing, and similar.

Conclusion

Patient feedback was immediate, in particular, with the pain sensation during laser application dropping from a mean of 6.97 to 3.84. This result is very important since many patients find the treatment uncomfortable and can often lead to unfinished treatment programmes.

The reduction in punctate bleeding and epidermal damage was also significant. Not only does this make the whole process more comfortable for the patients but it also ensures a better outcome with less chance of post-treatment infection.

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