

XD Microlens™ Compression Optic for Deep-Dermis Non-Ablative Fractional Treatment

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Objective:

We describe a fractional non-ablative device for remodeling the deep dermis of the skin. A discussion of the principles of the mechanism of action, technical characteristics and early clinical findings are included.

Conclusions:

The device provides a range of microbeam energies to target deep portions of the dermis and dermal/hypodermal (D/H) junction delivering coagulation columns over 1 mm in depth in a single pulse. Clinical experiences with this device demonstrate promising results for striae and scars.

Introduction

Fractional non-ablative technologies have been developed for skin resurfacing without the side effects, downtime and patient discomfort associated with fractional ablative and full-surface ablative treatments. Because of its dramatically improved profile, minimal to no downtime and ease of treatment, extending the range and clinical outcomes of applications for non-ablative fractional treatment will significantly expand its utility. The optimum treatment parameters will most likely depend on the pathology of the indication to be treated. While some textural pathologies such as photodamaged skin may be corrected with superficial remodeling, conditions with deeper dermal involvement such as scars and striae which may require deeper dermal remodeling.

The laser requirements for generating deep coagulation columns include appropriate choice of wavelength, microbeam geometry and energy. Wavelength absorption by the target chromophore (water) should be low enough to enable sufficient penetration of the tissue, yet high enough to permit selective photothermal coagulation at the device's available powers. The attempt to increase depth of treatment by increasing microbeam energy has two problems: first, most devices produce cylindrical

coagulation columns that are approximately as wide at the dermal/epidermal (D/E) junction as they are within the reticular dermis. Increasing microbeam energy will also increase the diameters of the micro-columns causing greater epidermal injury and increased side effects. Second, the coagulation column depth versus energy ratio is constant only within a limited range of energies. Beyond a maximum energy, saturation occurs that is due to tissue optical and thermal effects which ultimately limits the maximum achievable depth.

For deeper treatments, it is desirable to minimize epidermal involvement and to increase penetration of the available energy. This is possible if one takes advantage of a contact mode of non-ablative treatment that combines cooling with tissue compression.

Device Description

The XD Microlens on the 1540 and/or 1440 fractional non-ablative laser handpieces of the Palomar StarLux® system is a new addition to the family of optics for non-ablative handpieces that provides a means to limit epidermal injury while producing coagulation columns deep into the reticular dermis and D/H junction. The sapphire contact window consists of 49 micro-pins each co-aligned with a microbeam and separated by 2 mm from each other in a square pattern (Figure 1).



1540 nm XD Microlens Technical Specifications	
Spot Size	12 mm x 12 mm
Microbeam Energy	40 – 70 mJ
Pulse Duration	15 ms
Microbeam Density	25 $\mu\text{B}/\text{cm}^2$
Cooling	Chilled Sapphire Tip (to 5 °C)

Figure 1. Palomar 1540 XD Microlens fractional handpiece and specifications.

The handpiece is applied to the skin with firm pressure and the laser is fired to deliver a short pulse of energy after a brief compression time. The compressive forces on the skin directly beneath the pins create conditions in the skin that enhance both beam penetration and epidermal cooling as explained in the following section. **Figure 2** is a photograph of the skin immediately following application of the optic to the skin.

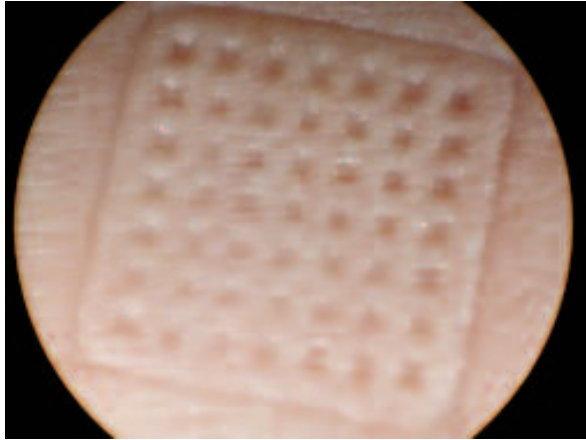


Figure 2. Photograph of human forearm skin immediately following application of the XD Microlens.

Mechanism of Action

Figure 3 illustrates the actions of a single pin when compressed upon the skin. As the dermis is compressed, the pin is brought closer to deeper targets and the (incompressible) interstitial water is displaced from beneath the pin into surrounding spaces. With less water to absorb, scattering of the laser light is reduced enabling increased absorption of the light by deeper targets. In addition, better contact improves heat transfer from the skin to the cooled sapphire pins decreasing epidermal temperature and injury.

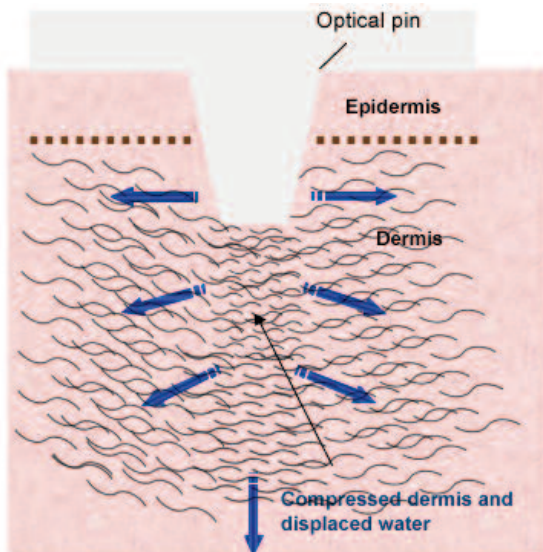


Figure 3. Illustration of skin compression.

Ex Vivo Histology

Material & Methods

Porcine skin was warmed to physiologic temperatures and treated with the XD Microlens at 70 mJ/microbeam (mb). Treatment consisted of applying the device to the skin with firm pressure and firing the laser after a predetermined compression time. The treated tissue was biopsied and sectioned with a cryotome. The 200 micron sections were stained with Nitroblue tetrazolium chloride (NBTC) and photographed to determine regions of cell viability loss. These regions are colocalized with regions of collagen coagulation.

Results

Figure 4 depicts cross-sections of the tissue following three seconds of compression using the 1440 nm handpiece with the XD Microlens. The unstained (white) region is the zone of coagulation. The same handpiece with compression results in a nearly 50% increase in column depth while the diameter of the micro-column damage at the dermal/epidermal (D/E) junction is decreased. Also note that there is less D/E junction separation indicating less epidermal damage. **Figure 5** depicts a coagulation profile with a column depth greater than 1 mm following application with firm compression of the 1540 nm handpiece with the XD Microlens. While treatment with a standard optic typically produces columns of coagulation in which the diameter at the D/E junction (DA) is the same as the width in the dermis (DB), the width of the damage column at the D/E junction for the XD Microlens is half the width as that in the dermis.

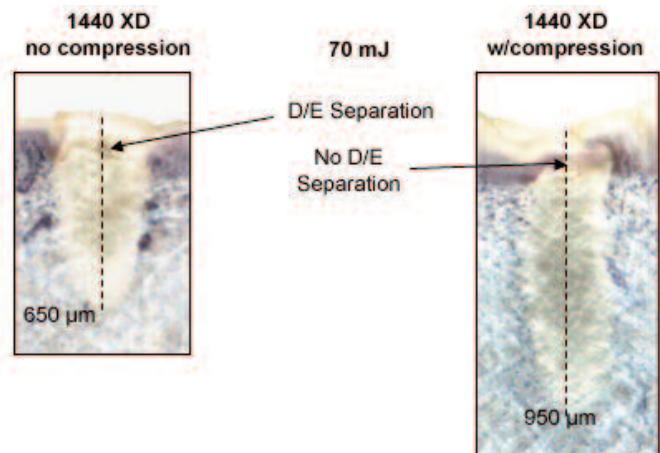
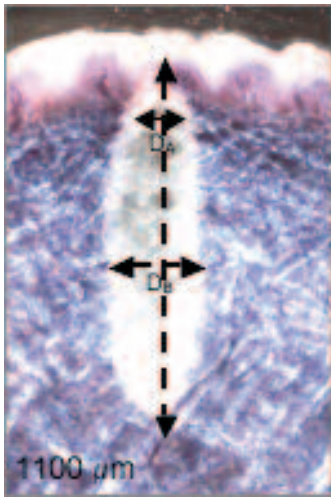


Figure 4. Comparative histology showing damage profiles following treatment with the 1440 nm handpiece with the XD Microlens using either no compression or 2 seconds of compression.



Increase in dermal treatment volume for same coverage at D/E junction

DA/DB ~ 0.5

Figure 5. Typical damage profiles.

Clinical Evaluation

A subject with Fitzpatrick Skin Type III skin was treated on the volar forearm with a single pulse from the 1540 XD Microlens at 70 mJ/mb using either 0, 2 or 5 seconds of firm compression. Two days after treatment, the treated sites were photographed to measure the size of the epidermal micro-injury zones which coincided with the micro-columns in the papillary dermis (Figure 6). These hyper-pigmented epidermal zones were also seen in histology at this time point and are defined by a contiguous basal cell layer above which is contained necrotic cellular debris and pigment presumed to be melanin or oxidized by-products. The epidermal micro-injury zones were coaligned with the underlying coagulated micro-columns in the papillary dermis. The results comparing the effects of compression time on diameter of the hyper-pigmented epidermal zones are shown in Figure 7. With an increase in compression from no compression time to 2 and 5 seconds, there is a 15% and 20% reduction, respectively, in the epidermal area involvement.

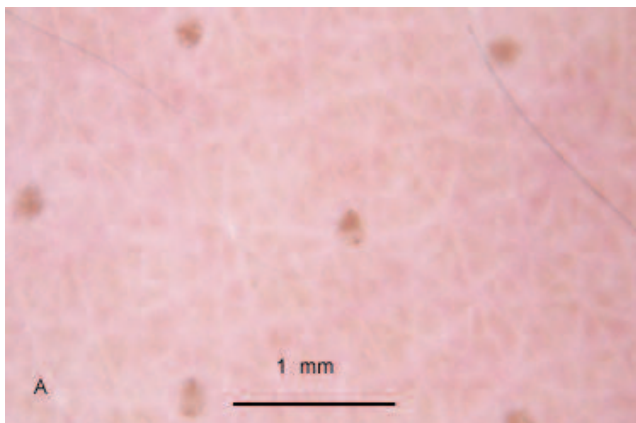


Figure 6. Epidermal micro-zones following treatment with the 1540 XD Microlens.

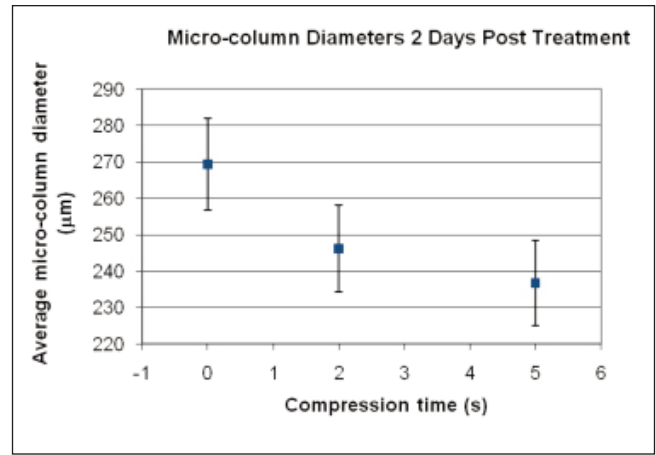


Figure 7. Differences in the diameters of the epidermal injury zone following various compression times. Error bars indicate \pm standard deviation.

Conclusion

For fractional non-ablative treatments, the deeper penetration with reduced involvement at the dermal/epidermal junction with the XD Microlens has many potential advantages particularly for conditions that may require deeper remodeling. Initial results from the treatment of erythematous scars with the 1540 XD indicate that the theoretical benefits of the XD Microlens also translate into clinically relevant benefits for the patient.