White Paper

Targets of the continuous-wave and pulsed-wave modes in SYLFIRM X

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With individual clinics targeting different customer groups and thus having different treatment indications on which they focus, the treatment modalities that they primarily use can vary. Radiofrequency (RF) microneedling devices are, nevertheless, common equipment found in most clinics. I first used the SCARLET device (a continuous-wave RF microneedling system) during my clinical research in college. Since then, I have used the SYLFIRM device (pulsed-wave RF microneedling system) and more recently the SYLFIRM X device (dual-wave RF microneedling system). As a user of all of ViOL's RF microneedling devices, I believe SYLFIRM X is the optimum RF microneedling system, allowing clinicians to effectively treat a variety of indications, from skin tightening and lifting to diffuse redness and pigmented lesions. Although, generally speaking, one would doubt the effectiveness of "a single device that can treat multiple indications," SYLFIRM X provides clinical results achieved by not merely seeking to improve the symptoms of an indication, but by addressing the underlying causes and influencing factors thereof.

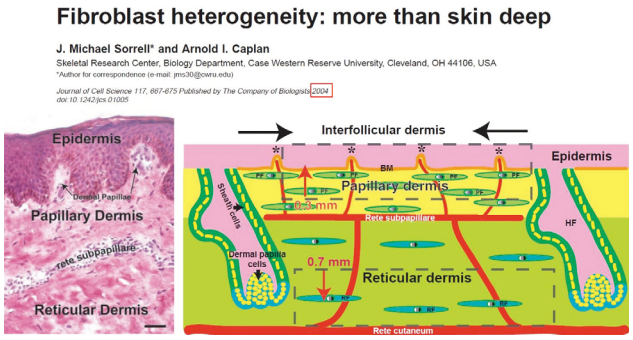


Figure 1. Citation from J Cell Sci, 2004 Feb 15;117(Pt 5): 667-75

This article will cover the applicability of SYLFIRM X's dual-wave system to achieve skin tightening and lifting. To do so, the structure of the dermis should be addressed first. The dermis is composed of two layers: the papillary dermis (superficial layer) and the reticular dermis (deep layer). According to Sorrell and Caplan(2004), the papillary dermis and reticular dermis are separated by the vascular plexus. In addition, as a result of culturing the dermal layer between hair follicles, papillary fibroblasts were present in the papillary dermis at a depth of 0.3mm and reticular fibroblasts were present in the reticular dermis at a depth below 0.7mm. (Figure 1). Moreover, as shown in Figure 2, papillary fibroblasts and reticular fibroblasts have different shapes and properties.

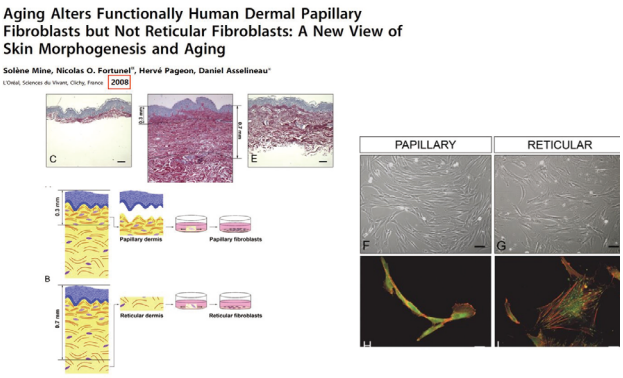
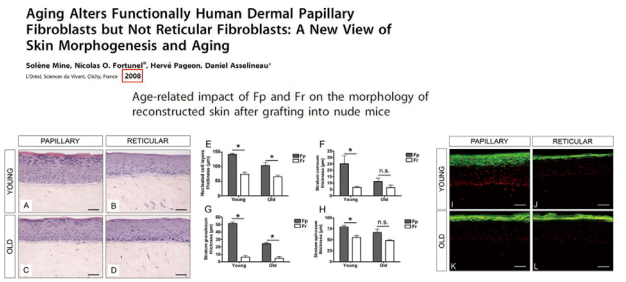


Figure 2. Citation from PLoS One. 2008;3(12):e4066

In a previous study that cultured fibroblasts from the skin of young and older subjects and grafted them onto nude mice, researchers noted that papillary fibroblasts cultivated from the younger subjects underwent cellular differentiation throughout all layers of the epidermis, including rete-ridge structures. Meanwhile, papillary and reticular fibroblasts from older adults and

reticular fibroblasts from the younger subjects underwent cellular differentiation in only the epidermal layer.

* Rete-ridge structures are epithelial extensions that increase the surface area of the epidermal-dermal junction, providing mechanical strength to the skin.



Aging Alters Functionally Human Dermal Papillary Fibroblasts but Not Reticular Fibroblasts: A New View of Skin Morphogenesis and Aging

Solène Mine, Nicolas O. Fortunel*, Hervé Pageon, Daniel Asselineau*

L'Oréal, Sciences du Vivant, Clichy, France 2008

Age-related impact of Fp and Fr on the morphology of reconstructed skin after grafting into nude mice

PAPILLARY RETICULAR

YOUNG OLD

A B C D

E F G H

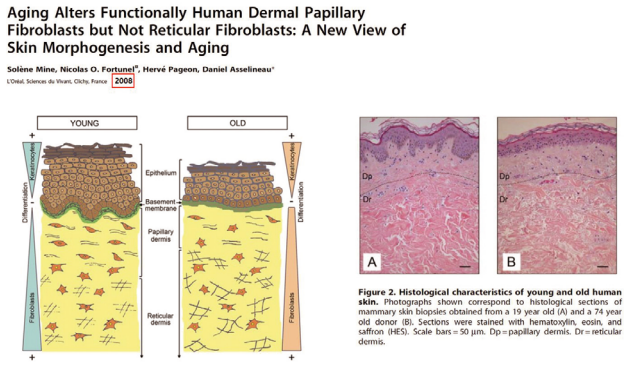
Fp Fr

Young Old

n.s.

I J K L

Figure 3. Citation from PLoS One. 2008;3(12):e4066



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YOUNG OLD

Epithelium

Basement membrane

Papillary dermis

Reticular dermis

Fibroblasts

Differentiation

Dp

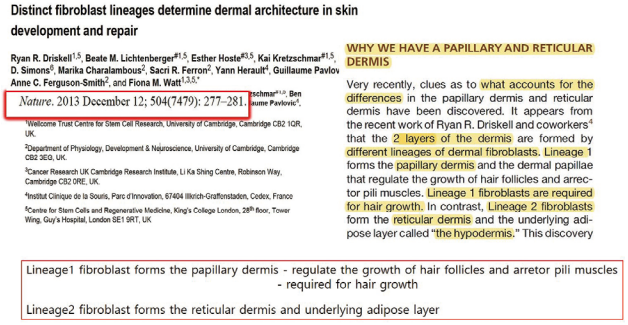
Dr

A B

Figure 2. Histological characteristics of young and old human skin. Photographs shown correspond to histological sections of mammary skin biopsies obtained from a 19 year old (A) and a 74 year old donor (B). Sections were stained with hematoxylin, eosin, and saffron (HES). Scale bars = 50 µm. Dp = papillary dermis. Dr = reticular dermis.

Figure 4. . Citation from PLoS One. 2008;3(12):e4066

Interestingly, when comparing the skin of the younger and older individuals, researchers noted the number of reticular fibroblasts tended to decrease with age, although the difference was not statistically significant. Meanwhile, however, the number of papillary fibroblasts decreased significantly as aging progressed (Figure 4). The results from Figures 3 and 4 indicate that a reduction in papillary fibroblasts is associated with decreases in the thickness of the epidermis and in rete-ridge structures. With fewer healthy papillary fibroblasts, the extracellular matrix in the upper dermis is not properly maintained, limiting the regenerative ability of the epidermis, thereby leading to thinning of the epidermis and the loss of rete-ridge structures. In other words, if the fibroblasts of the papillary dermis are activated, the skin thinning with aging can be improved.



Distinct fibroblast lineages determine dermal architecture in skin development and repair

Ryan R. Driskell[1,5], Beate M. Lichtenberger[#1,5], Esther Hoste[#3,5], Kai Kretzschmar[#1,5], D. Simons[6], Marika Charalambous[2], Sacri R. Ferron[2], Yann Herault[4], Guillaume Pavlov Anne C. Ferguson-Smith[2], and Fiona M. Watt[1,3,5,*]

Nature. 2013 December 12; 504(7479): 277–281.

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WHY WE HAVE A PAPILLARY AND RETICULAR DERMIS

Very recently, clues as to what accounts for the differences in the papillary dermis and reticular dermis have been discovered. It appears from the recent work of Ryan R. Driskell and coworkers[4] that the 2 layers of the dermis are formed by different lineages of dermal fibroblasts. Lineage 1 forms the papillary dermis and the dermal papillae that regulate the growth of hair follicles and arrector pili muscles. Lineage 1 fibroblasts are required for hair growth. In contrast, Lineage 2 fibroblasts form the reticular dermis and the underlying adipose layer called "the hypodermis." This discovery

Lineage1 fibroblast forms the papillary dermis - regulate the growth of hair follicles and arretor pili muscles - required for hair growth

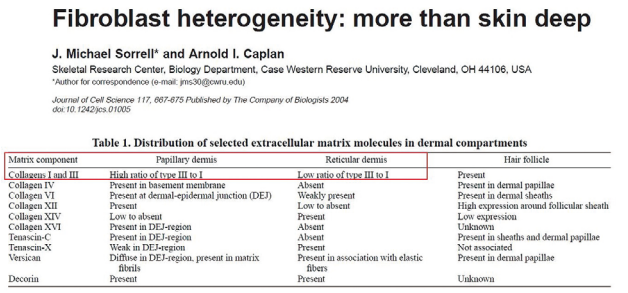
Lineage2 fibroblast forms the reticular dermis and underlying adipose layer

Figure 5. Citation from Nature. 2013 Dec 12;504(7479):277-281

According to a clinical paper published in 2013 (Figure 5), in the process of skin development and repair, the composition of the dermis varies according to different fibroblast lineages. That is, papillary dermis and reticular dermis have different roles beyond the difference in depth. Papillary fibroblasts in the upper dermis have been found to regulate hair growth and the arrector pili muscle, whereas reticular fibroblasts in the lower dermis have been shown to regulate the reticular dermis and subcutaneous fat layer and to be involved in the differentiation of adipocytes. One other way that the papillary dermis differs from the reticular dermis is in the ratio of type III to type I collagen present: the papillary dermis shows higher amounts of type III collagen than other layers of the skin (Figure 6). Compared to adult skin, infant skin has higher amounts of

type III collagen, and as such, infant skin is less prone to scarring and tends to regenerate well (Figure 7).

* The arrector pill muscle is a tiny muscle that connects a hair follicle to the dermis.



Fibroblast heterogeneity: more than skin deep

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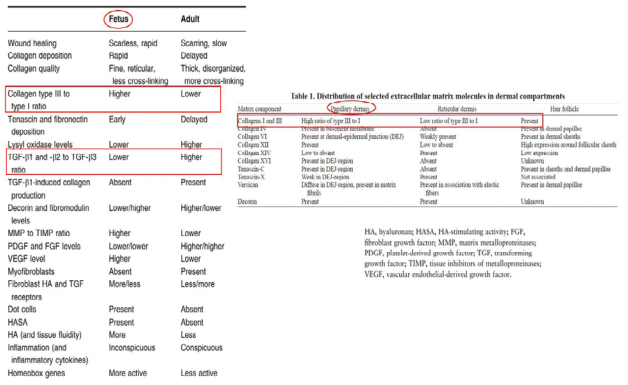
Table 1. Distribution of selected extracellular matrix molecules in dermal compartments

Matrix component	Papillary dermis	Reticular dermis	Hair follicle
Collagens I and III	High ratio of type III to I	Low ratio of type III to I	Present
Collagen IV	Present in basement membrane	Absent	Present in dermal papillae
Collagen VI	Present at dermal-epidermal junction (DEJ)	Weakly present	Present in dermal sheaths
Collagen XII	Present	Low to absent	High expression around follicular sheath
Collagen XIV	Low to absent	Present	Low expression
Collagen XVI	Present in DEJ-region	Absent	Unknown
Tenascin-C	Present in DEJ-region	Absent	Present in sheaths and dermal papillae
Tenascin-X	Weak in DEJ-region	Present	Not associated
Versican	Diffuse in DEJ-region, present in matrix fibrils	Present in association with elastic fibers	Present in dermal papillae
Decorin	Present	Present	Unknown

Figure 6. Citation from J Cell Sci, 2004 Feb 15;117(pt 5): 667-75



	Fetus	Adult
Wound healing	Scarless, rapid	Scarring, slow
Collagen deposition	Rapid	Delayed
Collagen quality	Fine, reticular, less cross-linking	Thick, disorganized, more cross-linking
Collagen type III to type I ratio	Higher	Lower
Tenascin and fibronectin deposition	Early	Delayed
Lysyl oxidase levels	Lower	Higher
TGF-β1 and -β2 to TGF-β3 ratio	Lower	Higher
TGF-β1-induced collagen production	Absent	Present
Decorin and fibromodulin levels	Lower/higher	Higher/lower
MMP to TIMP ratio	Higher	Lower
PDGF and FGF levels	Lower/lower	Higher/higher
VEGF level	Higher	Lower
Myofibroblasts	Absent	Present
Fibroblast HA and TGF receptors	More/less	Less/more
Dot cells	Present	Absent
HASA	Present	Absent
HA (and tissue fluidity)	More	Less
Inflammation (and inflammatory cytokines)	Inconspicuous	Conspicuous
Homeobox genes	More active	Less active

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Decorin	Present	Present	Unknown

HA, hyaluronan; HASA, HA-stimulating activity; FGF, fibroblast growth factor; MMP, matrix metalloproteinases; PDGF, platelet-derived growth factor; TGF, transforming growth factor; TIMP, tissue inhibitors of metalloproteinases; VEGF, vascular endothelial-derived growth factor.

Figure 7. Comparison of collagen distribution in infants and adults, and in the papillary dermis and reticular dermis

Wound healing processes can broadly be divided into “reparative“ and “regenerative” processes. One typical example of reparative healing is the formation of a shiny, dry, hairless scar after a deep second degree burn injury. A representative example of regenerative healing is the restoration of a lizard tail after being cut off. Reticular fibroblasts are unable to form hair follicles when a wound occurs. Instead, they create a collagen-rich extracellular matrix to heal the skin, although the skin becomes fibrotic and rigid. The human body is primarily programmed to activate reticular fibroblasts when a wound occurs. Due to the nature of reticular fibroblasts, which are unable to produce hair follicles and other appendages, scarring occurs. The extracellular matrix created by papillary fibroblasts, however, is relatively smooth and less dense, unlike the extracellular matrix formed by reticular fibroblasts, and papillary fibroblasts are able to form hair follicles and skin appendages. Consequently, if the papillary fibroblasts are stimulated at the early stage of the wound healing process, it can lead to a fascinating healing process that does not create scars.

* Skin appendages are skin-associated structures that serve a particular function, such as sebaceous glands, apocrine and eccrine sweat glands, hair, etc.

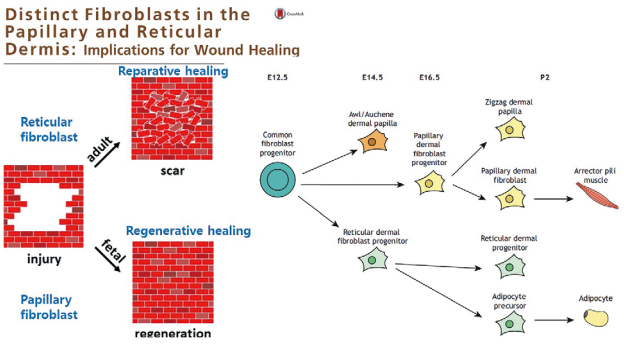

Figure 8. Citation from Dermatol Clin. 2017 Jan;35(1):95-100

In relation to the context above, the use of RF microneedling with proper needle depths and waveforms can be applied to stimulate reticular

fibroblasts to induce type I collagen synthesis and papillary fibroblasts to induce type III collagen for skin tightening and lifting effects. SYLFIRM X emits RF energy in eight different modes, which are principally composed of continuous-wave (CW) and pulsed-wave (PW) modes. Using the CW mode that continuously irradiates RF for a set time and a deep needle depth targeting the reticular dermis or below, it affects the reticular fibroblasts to form a collagen-rich extracellular matrix. In the CW3 mode (Figure 10), the temperature of the skin tissue reaches 60-70 degrees Celsius, with coagulation appearing at around 150-200 ms out of the total RF irradiation time of 300 ms, and this temperature is retained for a certain period of time even after the RF conduction time has elapsed.

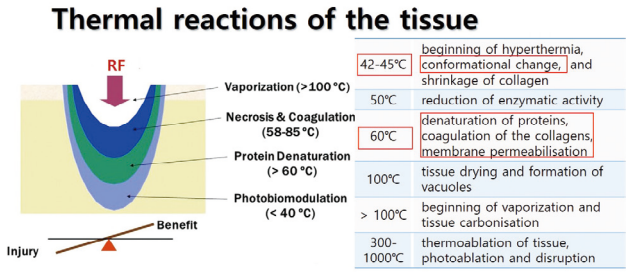

Figure 9. Thermal reactions of the tissue

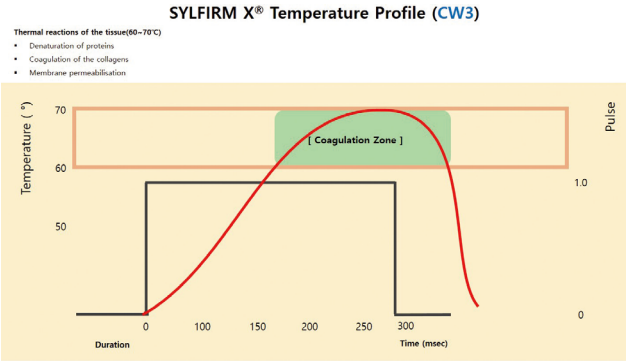

Figure 10. Temperature profile of SYLFIRM X's CW3 mode

While almost all RF microneedling devices employ a CW mode that can be used to lift sagging skin by creating areas of coagulation in the reticular dermis or below it, SYLFIRM X is the only device that emits both CW and PW RF and can target the papillary dermis as well as the reticular dermis. Using the PW mode that irradiates RF in the form of multiple pulses and a depth of 0.3mm targeting the papillary dermis, it affects the papillary fibroblasts. SYLFIRM X's PW2 mode delivers 40 ms of RF energy to the skin in the form of four pulses at 10-ms intervals, as shown in Figure 11.

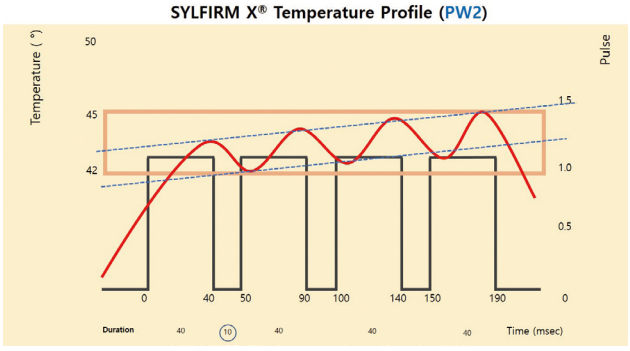

Figure 11. Temperature profile of SYLFIRM X's PW2 mode

When RF is delivered in this way, the temperature in the skin reaches 42-45 degrees Celsius, and this moderate heat stimulates papillary fibroblast activity without unwanted discoloration or coagulation in the skin, which can occur at temperatures rising above 50 degrees Celsius. At a needle depth of 0.3 mm in the PW mode, papillary fibroblasts can be stimulated to increase type I and type III collagen production, especially type III collagen, as confirmed through biopsy results of a patient treated with SYLFIRM X (Figures 12 and 13).

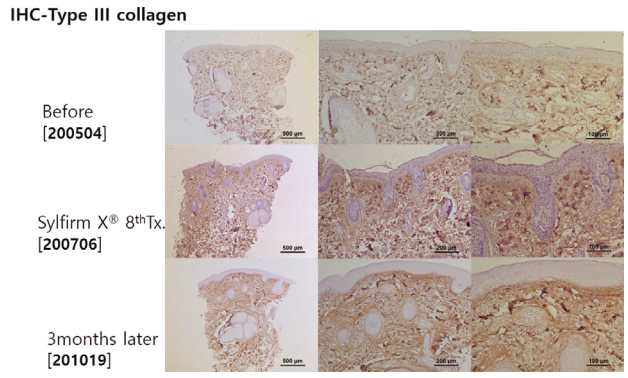

Figure 13. Immunohistochemistry of type III collagen before and after SYLFIRM X treatment

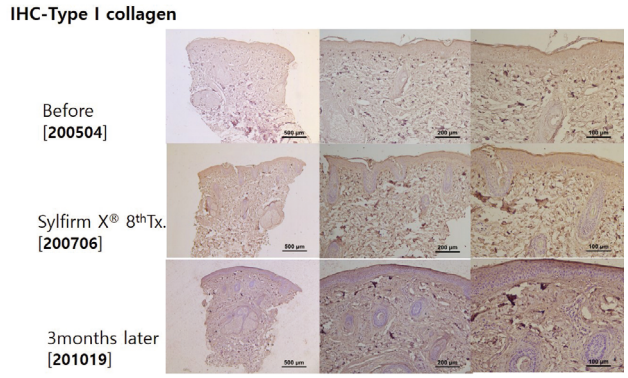

Figure 12. Immunohistochemistry of type I collagen before and after SYLFIRM X treatment

In conclusion, SYLFIRM X can be used to target and stimulate reticular fibroblasts in the reticular dermis in the CW mode and papillary fibroblasts in the papillary dermis in the PW mode to achieve skin tightening and lifting effects through increased collagen production throughout the entire dermal layer.

REFERENCES

1. Fibroblast heterogeneity: more than skin deep. Sorrell JM, Caplan AI.J Cell Sci. 2004 Feb 15;117(Pt 5):667-75.
2. Aging alters functionally human dermal papillary fibroblasts but not reticular fibroblasts: a new view of skin morphogenesis and aging. Mine S, Fortunel NO, Pageon H, Asselineau D. PLoS One. 2008;3(12):e4066.
3. Distinct fibroblast lineages determine dermal architecture in skin development and repair. Driskell RR, Lichtenberger BM, Hoste E, Kretzschmar K, Simons BD, Charalambous M, Ferron SR, Herault Y, Pavlovic G, Ferguson-Smith AC, Watt FM. Nature. 2013 Dec 12;504(7479):277-281.
4. Fibroblast heterogeneity: more than skin deep. Sorrell JM, Caplan AI. J Cell Sci. 2004 Feb 15;117(Pt 5):667-75.
5. Distinct Fibroblasts in the Papillary and Reticular Dermis: Implications for Wound Healing. Woodley DT. Dermatol Clin. 2017 Jan;35(1):95-100.

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