ulthera® WHITE PAPER:

The Effect of Heat on Collagen and Neocollagenesis

VARIOUS ENERGY-BASED DEVICES ARE USED TO TIGHTEN/TONE/LIFT THE SKIN •••

Various energy based technologies are available that trigger neocollagenesis and help firm, tighten, tone or lift the skin, namely those utilizing radiofrequency, and deep-tissue ultrasound modes of energy delivery. Radiofrequency approaches produce a range of temperatures. The ThermaCool System (Thermage, Inc., Hayward, CA) *(1/Abraham/169/A)*, for example, reaches temperatures of approximately 55°C in the dermis *(1/Abraham/171/A)*.[1] The Accent RF system (Alma Lasers, Inc., Ft. Lauderdale, FL) generates temperatures of between 40°C and 44°C *(2/Sadick/183/A)*.[2]

The Ulthera® System (Ulthera, Inc., Mesa, AZ) deep-tissue ultrasound heats the target tissue to >60°C *(3/Laubach/729/A)(4/White/69/A)*.[3,4] This modality is the only device that has received FDA clearance for a "lift" indication. Of note, the temperature to which these devices heat the skin correlates with the level of collagen denaturation – and subsequent neocollagenesis – achieved.

THE THRESHOLD FOR COLLAGEN DENATURATION IS APPROXIMATELY 60-65°C •••

Drs Hayashi and colleagues assessed the effect of a wide range of temperatures (37°C, 55°C, 60°C, 65°C, 70°C, 75°C, and 80°C) on collagen contraction utilizing samples from the glenohumeral joint capsule *(5/Hayashi/107/A)*.[5] At 65°C, collagen contracted *(5/Hayashi/109/A)* and architectural changes indicative of denaturation could be observed *(5/Hayashi/109/B/C)*. These changes intensified at slightly higher temperatures—70°C and 80°C *(5/Hayashi/109/C)*. Among the higher temperatures tested (70°C, 75°C, 80°C), histological analysis showed no significant differences *(5/Hayashi/109/B)*, suggesting that additional heat does not have additional effects on collagen. Similarly, Drs Vangsness and colleagues applied a range of temperatures to human tendons *(6/Vangsness/268/A/269/B)* and observed collagen contraction and shortening just below 70°C *(6/Vangsness/269/A)* and denaturation at higher temperatures *(6/Vangsness/269/A)*.[6]

Further validating these results, Drs Lin and colleagues used a second-harmonic generation microscope to directly observe the effects of heat (between 25°C and 60°C) on collagen fibers *(7/Lin/622/A/B)* from rodent tail tendons *(7/Lin/623/A)*.[7] They observed that collagen fibers begin to curve at 52°C and 55°C *(7/Lin/623/B)*, and collagen denaturation occurred at 60°C *(7/Lin/624/A)*.

More recent research by Drs Paul and colleagues assessing the effect of heat on collagen in samples of adipose tissue (with septal and reticular connective tissue), dermis, and fascia *(8/Paul/88/A/B)* further supports a collagen denaturation threshold of ~60-65°C *(8/Paul/94/A)*.[8] In this study, the collagen contraction threshold fell between 60-70°C *(8/Paul/94/A)*; specific collagen contraction temperatures were 81.9°C for the dermis, 61.5°C for the fascia, and 69.4°C for the septa/adipose tissue *(8/Paul/92/A)*.

COLLAGEN DENATURATION IS FOLLOWED BY NEOCOLLAGENESIS •••

Collagen rejuvenates over the month or so after treatment *(9/Hayashi/170/A/B)*.[9] Increased small collagen fiber formation—evidence of neocollagenesis—has been noted at 30 days post heat treatment *(9/Hayashi/170/B)*. A second study tracking tissue changes after heating to the denaturation range *(10/Hantash/1/A)* found neocollagenesis, neoelastogenesis, and deposition of new hyaluronic acid at 10 weeks post treatment *(10/Hantash/3/A/4/A/B)*.[10]

Temperatures below 60°C have minimal effects on collagen structure and thus are unlikely to have significant effects on collagenesis

Drs Lin and colleagues note that while collagen fibers begin to curve at 52°C-55°C *(7/Lin/623/B)*, structural changes were not seen at lower temperatures (25°C and 40°C)*(7/Lin/623/B)*.[7]

Similarly, Drs Hayashi and colleagues found that temperatures of 37°C, 55°C, and 60°C had no significant effect on collagen length *(5/Hayashi/109/A)* and resulted in significantly fewer histological changes than did higher temperatures *(5/Hayashi/109/B)*.[5]

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