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).1

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).1,2 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/109/A).3 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/A)) and observed collagen contraction and shortening just below 70°C (6/Vangsness/269/A) and denaturation at higher temperatures (6/Vangsness/269/A).3

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/623/A) 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).7

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 between 60-65°C (8/Paul/94/A).9 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 collagenogenesis.

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).7

REFERENCES