

Factors That Affect Radiofrequency Heat Lesion Size

Eric R Cosman Jr PhD¹, Joseph R Dolensky BS², Ryan A Hoffman BS²

¹ercosman@alum.mit.edu, Cosman Medical, Burlington, MA; ²Georgia Institute of Technology, Atlanta, GA; Funding provided by Cosman Medical

COSMAN
cosmanmedical.com



Introduction

Radiofrequency (RF) heat lesion size was evaluated across cannula diameters, active tip lengths, set temperatures, and lesion times available for interventional pain management. Collected data informs selection of RF cannula size and RF generator settings for RF treatments.

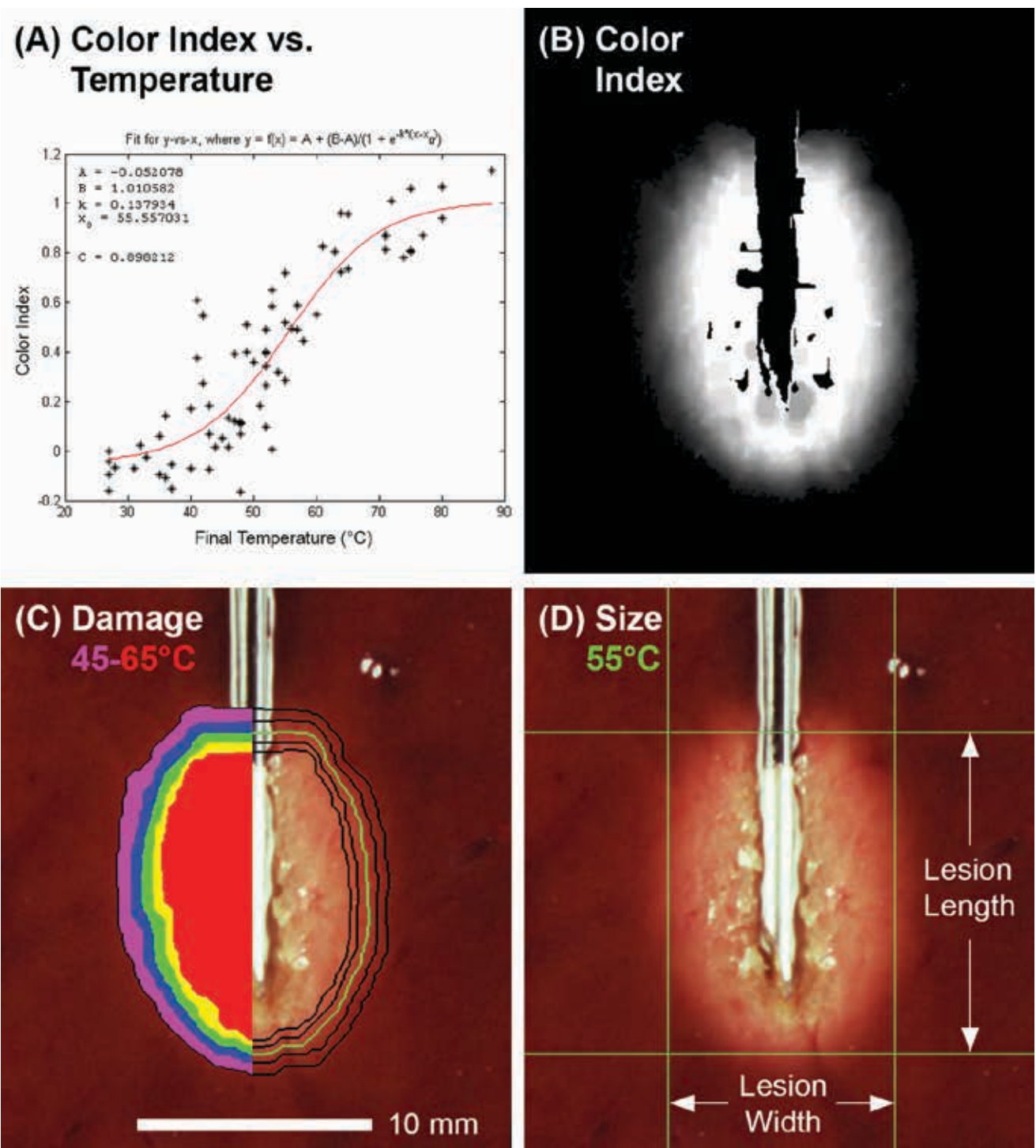


Figure 1 Photographic temperature inference. Liver color indicates 45-50°C (minimal for neurolysis).¹

Methods

Over 500 lesions were generated in ex vivo animal tissue. Average lesion size was assessed at the 55°C thermal damage level using computer-aided photographic temperature inference of 5-20 lesions per configuration (Fig 1). Parameter sampling centered on generator settings 80°C and 2 minutes, and on common cannula tip sizes 23ga/5mm, 22ga/5mm, 20ga/10mm, 18ga/10mm, 16ga/10mm (diameter/length):

Tip Size Combinations of tip diameters (23, 22, 20, 18, 16ga) and lengths (5, 6, 10, 15mm) at 80°C for 2min, and RRE 16ga/6mm trocar.

Temperature Common cannulae at 60, 70, 80, 90°C for 2 minutes.

Time Common cannulae at 80°C for 1, 1.5, 2, 3, 5, 10 minutes.

Large Lesions Monopolar and parallel bipolar RF for 3:15min (0:15 ramp + 3:00 hold)¹, and SInergy cooled RF system (Baylis Medical, 18ga/4mm tip, 16.5ga introducer) using recommended settings, ie 60°C for 3:15min (0:45 pre-treatment cooling + 2:30 RF with 80°C/min ramp).^{2,3}

Sharp cannula (Cosman CC/RFK) and nitinol electrode (Cosman TCN) placed between 2.5cm-thick slabs of bovine liver equilibrated to 19-27°C, atop a stainless steel ground plate. The RF generator (Cosman G4) raised tip temperature to set value $\pm 2^\circ\text{C}$ in ≈ 15 seconds. Tissue color was mapped to temperature measurements in preliminary bipolar RF lesions (Fig 2). Before inference of thermal damage, each lesion photo's color was normalized by K-means RGB color clustering, manual selection of lesion and raw clusters, and rescaling based on the measured tip temperature.

Results

Tip Size, Temperature, Time (Fig 3) Increasing cannula diameter from 22ga to 16ga increased average lateral lesion width by 58-65% (3-4mm) at 80°C and 2 minutes. Increasing set temperature from 60°C to 90°C increased lesion width 108-152% at 2 minutes; for example, width increased from 5.1mm to 10.3mm for the average 16g/10mm tip cannula. While lesions grew most rapidly over the first minute, average lesion width was 11-20% larger at 2 minutes, and 23-32% larger at 3 minutes, compared to 1 minute. Lesion length extended distal and proximal to the tip, exceeded tip length by 1-5mm at 80°C and 2 minutes, and was larger for increased tip size, temperature, and lesion time.

Large Lesions (Fig 4) The SInergy cooled RF system produced 10mm average lesion width using recommended settings. Standard monopolar RF produced 10mm average lesion width for 18ga/10mm tips at 90°C, 16ga/6mm tips at 80-85°C, and 16ga/10mm tips at 80°C. On average, standard bipolar RF produced rounded brick-shaped lesions of 18.1mm width for 20ga/10mm tips at 90°C with 12mm spacing; 18.7mm width for 18ga/10mm tips at 90°C with 12mm spacing; 22.5mm width for 16ga/10mm tips at 80°C with 15mm spacing.

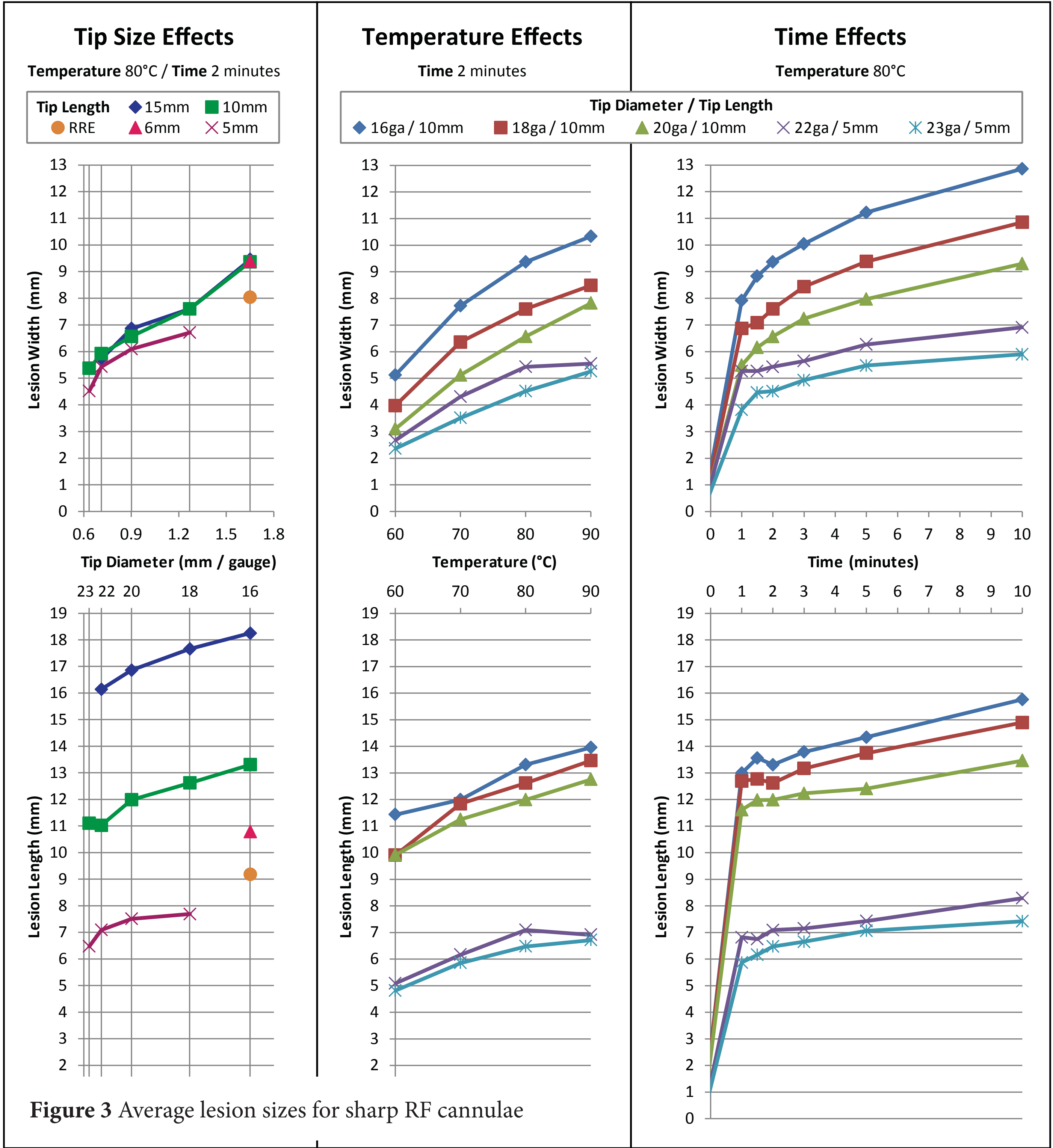


Figure 3 Average lesion sizes for sharp RF cannulae

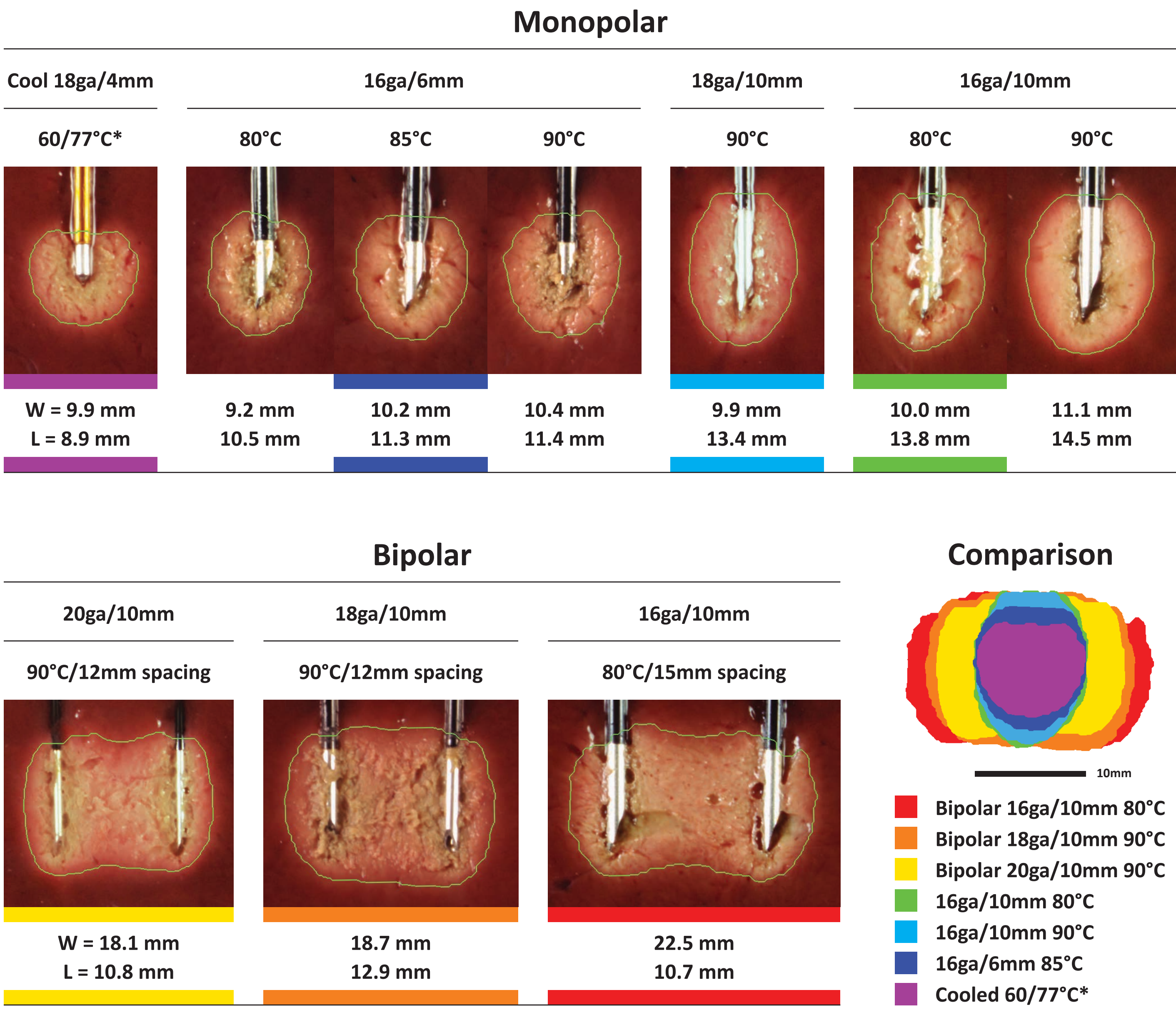


Figure 4 Average midline width W and length L of large lesions for 3:15 minute total time. From left to right, the average maximal bipolar lesion lengths are 12.9mm, 14.1mm, and 14.0mm, respectively. *Remote thermometry indicated 77°C tissue temperature when the cooled RF electrode measured 60°C.

Discussion

Cannula gauge, tip length, set temperature, and lesion time affect RF heat lesion width and length.⁴ Monopolar RF with standard 18-16ga cannulae can produce heat lesions of average width comparable to that of heat lesions produced by SInergy cooled RF electrodes. Bipolar RF with standard cannulae can produce heat lesions of over 20mm width by proper selection of tip spacing and generator settings. Bipolar lesions form even if tips are not exactly parallel.¹ Muscle and bovine liver have similar RF temperature profiles (Fig 2), but liver discriminates temperatures over a wider range (Fig 1A) including minimal neurolytic values $\geq 45-50^\circ\text{C}$. Clinical lesions may differ from ex vivo and cadaveric models due to differing electrothermal properties, blood flow, tissue uniformity, initial temperature, injected fluids, post-mortem changes.¹

References

1. Cosman ER Jr, Gonzalez CD. Bipolar Radiofrequency Lesion Geometry: Implications for Palisade Treatment of Sacroiliac Joint Pain. Pain Practice 2011;11:3-22.
2. Cohen SP, Hurley RW, Buckenmaier III CC, Kurihara C, Morlando B, Dragovich A. Randomized placebocontrolled study evaluating lateral branch radiofrequency denervation for sacroiliac joint pain. Anesthesiology. 2008; 109:279-288.
3. SInergy System User Guide PM1013 rev 09/08. Montreal, Canada: Baylis Medical Company, Inc.; 2008.
4. Cosman Sr ER, Nashold BS, Ovelman-Levitt J. Theoretical aspects of radiofrequency lesions in the dorsal root entry zone. Neurosurgery 1984; 15:945-950.