ALTERNATIVE TECHNIQUES FOR SACROILIAC JOINT RADIOFREQUENCY DENERVATION

A. THE BIPOLAR RADIOFREQUENCY PALISADE TECHNIQUE
   (COSMAN & GONZALEZ) (*)

This technique creates a continuous, elongated ‘palisade’ lesion to capture all the sacral lateral branch nerves innervating the sacroiliac joint (fig. 41m). It utilises:

- the Cosman™ G4 lesion generator
- 10 cm, 20# straight sharp Cosman™ RF cannula with 10mm exposed tip
- 10 cm temperature monitoring electrodes (Cosman™ disposable TCD-10 or autoclavable CSK-TC10)

The patient is placed prone with a pillow under the pelvis so as to straighten the normal spinal lordosis; a grounding pad is fitted to the patient’s thigh in the normal way for monopolar radiofrequency facet denervations at L4/L5/S1.

Fig. 41m Row of straight RF cannulae are inserted to contact dorsal sacral surface perpendicularly between the S1-S3 foramina and the SI joint line

Lay a needle on the skin and use an AP x-ray view (fig. 41n, centre-right) to establish a cranio-caudal line that falls between the lateral aspect of the dorsal sacral foramina and the SI joint line. Mark the line along the skin.

Using a lateral x-ray view, place six (6) cannulae along the line, lowering the tips onto the sacral surface, starting superior to S1 and stopping inferior to S3 (fig. 41n, left). Note that the cannulae are:

- parallel to each other
- spaced by approximately 10 mm, and at most 12 mm
- roughly perpendicular to the back of the sacrum

Cannulae are inserted under lateral fluoroscopic guidance to ensure that they are parallel and to identify visually if a cannula has erroneously entered a sacral foramen. A ruler can be held perpendicular to the first cannula to ensure that cannulae are 10 mm away from each other (fig. 41n, right). Since the skin is not parallel to the sacrum, each cannula’s hub is tilted cranially so that it is roughly perpendicular to the sacrum, thus improving alignment between adjacent cannula tips. To avoid the ilium, each cannula’s hub may also be tilted slightly medially.

After all cannulae are positioned, a tunnel-vision/needle view can be used to check that adjacent cannulae are substantially parallel; this needle view
is typically AP and angled cranio-caudally (**fig. 41n, centre-left**). A final true AP image confirms cannulae placement lateral to the dorsal sacral foramina (**fig. 41n, centre-right**).

Before any heat lesion is created, perform normal stimulation tests for motor response for each adjacent pair of cannulae by leap-frogging two electrodes along the palisade positions AB, BC, CD, DE, and EF; this is done before lesioning so that administration of pre-lesion anesthetic does not mask a motor response. Sensory stimulation is omitted since lesions are generated between each pair of adjacent cannulae irrespective of sensory response. The ground pad is disconnected throughout stimulation and lesioning since bipolar current should pass directly between paired electrodes.

Four 10-cm temperature-monitoring electrodes are connected to outputs 1, 2, 3, and 4 of a four-output RF generator (Cosman™ G4), and are moved between cannulae in the following sequence in order to create five (5) bipolar RF heat lesions between adjacent pairings of the six (6) cannula. Electrodes 1 and 2 form one bipolar pair. Electrodes 3 and 4 form a second bipolar pair. Each heat lesion uses a Set Temperature of 90 °C and Set Time of 3 minutes.

1. As shown in (**fig. 41o**), place electrodes 1 and 2 in cannulae A and B. Place electrodes 3 and 4 in cannulae D and E. Select two bipolar pairs for energy delivery (Electrode Setup: RF Type=Bipolar, Active Electrodes=4). **Lesion.**
2. As shown in (fig. 41p), leap-frog electrode 1 from cannula A to C. Leap-frog electrode 3 from cannula D to F. Lesion.

3. As shown in (fig. 41q), leap-frog electrode 2 from cannula B to D. Remove and disconnect electrodes 3 and 4. Select only one bipolar pair for energy delivery (Electrode Setup: RF Type=Bipolar, Active Electrodes=2). Lesion.

A scheme of the final procedure is shown in fig. 41r

The total bipolar RF palisade lesion time is 9 minutes. After completing bipolar lesioning of the dorsal sacral
innervations to the sacroiliac joint, carry out a standard monopolar radiofrequency facet denervation at L4/L5/S1. Remember to reconnect the grounding pad and to switch the Electrode Setup to the monopolar setting (RF Type=Standard).

If a single-output generator is used, bipolar lesions can be produced one at a time by leap-frogging electrodes down the row of cannula positions, requiring a total palisade lesion time of 15 minutes for five bipolar lesions. Some physicians prefer to use 18-gauge cannulae (Cosman CC101018) since doing so produces somewhat larger lesions. Furthermore, some physicians prefer to angle cannulae in the true AP direction, having marked a 10-mm insertion spacing along the skin; although this reduces the offset alignment between cannula tips, it somewhat simplifies placement, typically reduces the number of cannula positions to five, and thus typically reduces the number of bipolar lesions to four (requiring only 6 minutes of palisade lesion time in total).
BIPOLAR THERMAL RF

Whereas a monopolar configuration drives RF current between an electrode’s exposed tip and a distant ground pad, a bipolar configuration drives RF current between two nearby electrode tips. As bipolar electrode tips are brought closer together, the resulting thermal lesion shape transitions from that of two volumes surrounding each tip separately, to that of a single volume connecting the tips (fig. 6a). The connected geometry and larger total lesion volume are strongly influenced by a focusing of the electric and current density fields between closely-spaced electrode tips. Bipolar electrodes can be arranged collinearly or in parallel, but parallel arrangements produce the largest lesion size increases (Cosman, Nashold, Ovelman-Levitt, 1984). Important features of parallel bipolar heat lesions include:

• **Large**: Bipolar RF lesions are larger than cooled RF lesions as used in pain management (fig. 6b; fig. 6c, left). The size of one bipolar RF lesion is roughly that of three conventional monopolar RF lesions placed side by side (fig. 6c, right).

• **Conformal**: Bipolar RF applied to closely-spaced electrode tips produces heat lesions shaped like a rounded brick, also known as a “strip lesion”. To conform to anatomical constraints, the width and length of the strip can be adjusted nearly independently of each other and the lesion depth (fig. 6a). As such, a large lesion can be produced without unnecessary damage to healthy tissue and with reduced risk to sensitive structures. This is not
possible for monopolar lesions around a cylindrical electrode since the lesion width and depth are the same.

- **Connected strip lesions:** By leap-frogging electrodes (Ferrante et al., 2001), brick-like strip lesions can be placed side-by-side without gaps to produce an elongated lesion zone that has consistent height and thickness (**fig 6c, middle; fig 6d**). This is not possible for cooled and conventional monopolar RF without positioning electrodes very close together.

- **Robust:** Strip lesions can be generated reliably for parallel tip spacings of 10 mm, tip temperature 90 °C, and lesion time 3 minutes. Perturbations of these geometric and RF parameters do not substantially affect lesion size (Cosman and Gonzalez, 2011; **fig. 6a**). The tip temperature and lesion time used for bipolar RF are greater than those used for monopolar RF since it is desired that larger heat lesions are formed.

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**Fig. 6b** Bipolar Heat Lesion Size is 15x 22 x 8 mm³ for 18 gauge, 15 mm tip length, 15 mm spacing, 90 °C, 3 minutes

**Fig. 6c** Comparison of bipolar RF lesion size with that of cooled and conventional monopolar RF
As an example, all these features are illustrated by the RF palisade approach to sacroiliac joint (SIJ) denervation (fig. 6d). In this approach, 4 to 5 large bipolar RF lesions are placed side-by-side like bricks in wall to traverse the region between the dorsal sacral foramina and SIJ line in which sacral lateral branch nerves form the SIJ’s dorsal innervation. While each lesion is large in the inferior-superior direction, its depth is constrained in the left-right direction, thus reducing the risk of damage to the sacral nerve roots. Because lesion size is robust to variations in tip spacing, and because adjacent lesions overlap, the total lesion zone has a consistent thickness and height from the sacral surface.

Bipolar RF lesions of the sizes shown in (fig. 6a) have been used successfully in pain management (Ferrante et al., 2001; Burnham et al., 2007; Cosman and Gonzalez, 2011). Ex vivo experiments by Cosman and Gonzalez (2011) document further flexibility in the size and shape of bipolar lesions. Indeed, bipolar lesions with dimensions exceeding 2 cm can be readily created with standard RF equipment (fig. 6b). As for all RF lesioning, before the clinical use of novel bipolar configurations, a physician must consult lesion-size studies to determine whether that configuration is appropriate for the target anatomy. The proximity of target nerves to non-target nerves, blood vessels, skin surface, and other sensitive structures imposes an upper bound on the safe size of any heat lesion, especially in the spine.