Basic Science

The Anatomy of the Lateral Branches of the Sacral Dorsal Rami: Implications for Radiofrequency Ablation

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Background: The sacroiliac joint (SIJ) is a major source of pain in patients with chronic low back pain. Radiofrequency ablation (RFA) of the lateral branches of the dorsal sacral rami that supply the joint is a treatment option gaining considerable attention. However, the position of the lateral branches (commonly targeted with RFA) is variable and the segmental innervation to the SIJ is not well understood.

Objectives: Our objective was to clarify the lateral branches' innervation of the SIJ and their specific locations in relation to the dorsal sacral foramina, which are the standard RFA landmark.

Methods: Dissections and photography of the L5 to S4 sacral dorsal rami were performed on 12 hemipelves from 9 donated cadaveric specimens.

Results: There was a broad range of exit points from the dorsal sacral foramina: ranging from 12:00 – 6:00 position on the right side and 6:00 – 12:00 on the left positions. Nine of 12 of the hemipelves showed anastomosing branches from L5 dorsal rami to the S1 lateral plexus.

Limitations: The limitations of this study include the use of a posterior approach to the pelvic dissection only, thus discounting any possible nerve contribution to the anterior aspect of the SIJ, as well as the possible destruction of some L5 or sacral dorsal rami branches with the removal of the ligaments and muscles of the low back.

Conclusion: Widespread variability of lateral branch exit points from the dorsal sacral foramen and possible contributions from L5 dorsal rami and superior gluteal nerve were disclosed by the current study. Hence, SIJ RFA treatment approaches need to incorporate techniques which address the diverse SIJ innervation.

Key words: Sacroiliac joint pain, radiofrequency ablation, dorsal sacral rami, low back pain

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The sacroiliac joint (SIJ) is the source of pain in approximately 2% – 30% of patients with non-specific chronic low back pain (1-4).There are limited treatment options available for those who suffer with chronic SIJ pain and many treatments do not provide long-term relief. Radiofrequency ablation (RFA) of nerves supplying a symptomatic SIJ is one treatment option attracting growing attention. However, investigations of SIJ innervation have spurred debate concerning the precise spinal levels of dorsal innervation (5-8) and whether any ventral rami contribute to the joint's innervation (9-11). The uncertainty in innervation is evidenced by the wide range of RFA techniques and reported radiofrequency (RF) probe positions – reflecting a given author's understanding of the anatomy. Prima facie, positive outcomes with radiofrequency nerve ablation depend, in part, on a more concrete understanding of the SIJ innervation (12). In this report we sought to provide additional information on the dorsal innervation of this joint; relative to a common RF probe target position – dorsal rami lateral branch exit points from the dorsal sacral foramina. Our focus was particularly directed to the lateral branches as they contribute significantly to the innervation of the joint (10,11) and thus have become a focus for treatment (13-16).

Methods

Dissections of the posterior pelvis region were performed on 12 hemipelves from 9 donated cadavers at the Indiana University School of Medicine, Fort Wayne campus. The cadavers consisted of 5 women and 4 men within the ages of 62 to 86. Three of the cadavers were dissected bilaterally while the remaining 6 cadavers had only a single hemipelvis dissected. The skin and thoracolumbar fascia was first removed. This was followed by the removal of the lower sections of the iliocostalis and longissimus muscles and their aponeuroses. The multifidus muscle was gently shredded and removed piecemeal to expose the sacral dorsal rami. The short sacroiliac ligaments were also removed in small segments to help view the location of the posterior sacral foramen and the nerves. The nerves were then traced laterally. Many of the medial branches of the sacral dorsal rami were removed with the removal of the multifidus muscle. The attachment of the gluteus maximus to the iliac crest and sacrum were severed and the muscle was reflected laterally to better expose the long posterior sacroiliac ligament and the lateral aspect of the SIJ. The most lateral portion of the lateral branch of S1 was traced after it passed through a fibro-osseuos tunnel in the long posterior sacroiliac ligament. Each branch of the sacral dorsal rami was painted blue as well as any joining branches from the L5 nerve. Any branches from the superior gluteal nerve were painted red. A string was painted yellow and used to outline the posterior sacral foramen to highlight their location as shown in Fig. 1.

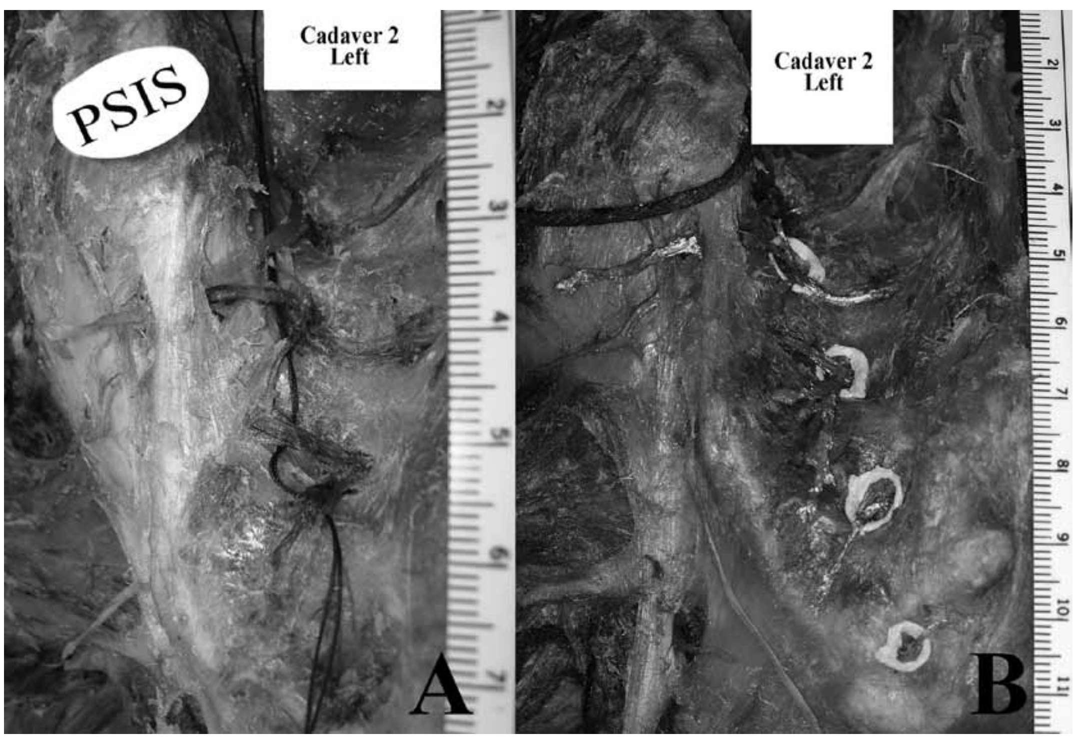

Fig. 1. *Example shown is cadaver 2 left hemipelvis. (A) After dissection and prior to painting of the nerves. (B) After dissection and painting of the nerves. Sacral dorsal rami are blue, ventral rami contribution are red, and the dorsal sacral foramen are outlined in yellow. The approximate location of the SIJ is outlined in black string.*

Table 1. *Number and locations of lateral branches of sacral dorsal rami.*

Specimen	L5		S1		S2		S3		S4		Superior Gluteal	
	L	R	L	R	L	R	L	R	L	R	L	R
1	+	+	3* (6:00-9:30)**	4 (1:00-5:30)	4 (8:00-10:00)	2 (2:00-4:00)	3 (7:00-10:00)	1 (5:00)	2 (6:00, 12:00)	2 (1:00, 6:00)	+	+
2	+	+	3 (7:00-12:00)	3 (12:00-5:00)	3 (7:00-10:00)	3 (1:00-5:30)	1 (8:00)	2 (3:00, 4:00)	-	-	+	-
3	+	-	3 (7:00-11:00)	3 (2:00-6:00)	1 (9:00)	2 (2:00, 5:00)	2 (8:00, 10:00)	3 (1:00-5:00)	2 (7:00, 10:00)	3 (1:00-4:00)	-	-
4		+		2 (3:00, 5:00)		1 (2:00)		2 (1:00, 4:00)		2 (2:00, 5:00)		-
5		-		4 (2:00-6:00)		1 (1:00)		2 (2:00, 5:00)		2 (1:00, 4:00)		-
6		+		3 (2:00-4:00)		2 (2:00, 4:00)		2 (1:30, 3:00)		2 (3:00, 5:00)		-
7	-		3 (6:00-10:00)		2 (7:00, 12:00)		2 (8:00, 10:00)		2 (7:00, 11:00)		+	
8	+		3 (7:00-10:00)		1 (9:00)		3 (7:30-11:00)		-		+	
9	+		4 (6:00-10:00)		1 (8:00-9:00)		4 (8:00-11:00)		3 (6:00-12:00)		-	

*Number of lateral branches found for given sacral foramen; **Range of exit locations of those lateral branches; + = present; - = not present

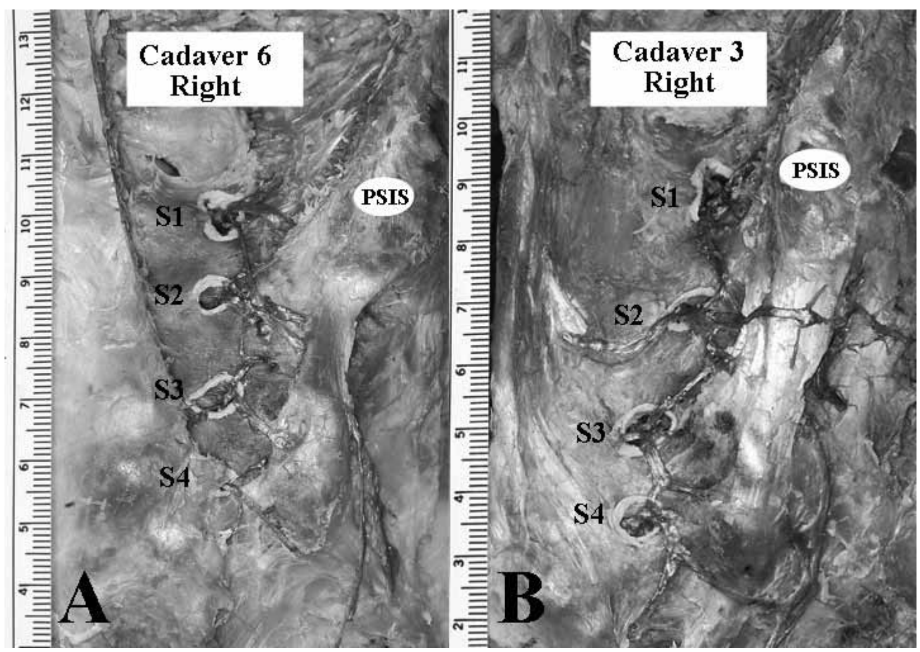

Fig. 2. *These contrasting cadavers illustrate the wide variability of lateral branch networks from the sacral dorsal rami. PSIS = posterior superior iliac spine. (A) S1 2:00 – 4:00, S2 2:00 – 4:00, S3 1:30 – 3:00, S4 3:00 – 5:00 (B) S1 2:00 – 6:00, S2 2:00 – 5:00, S3 1:00 – 5:00, S4 1:00 – 4:00.*

Results

Table 1 demonstrates the number and location found of the lateral branches for each sacral dorsal ramus. Seventy-nine percent (38 of 48) of the foramina demonstrated more than one exiting lateral branch as seen in Fig. 1. Some of the lateral branches from S1 or S2 exited as high as the 12:00 – 2:00 position on the right and 10:00 – 12:00 on the left. These branches tended to anastomose with the branches that exited the sacral foramen directly superior to it or from branches of the L5 dorsal rami as seen in Fig. 2. The more inferior lateral branches had a tendency to exit between 4:00 – 5:00 on the right and 7:00 – 8:00 on the left (Fig. 3). Two of the cadavers had no branches exiting from the S4 foramen. Nine of the 12 hemipelves had a distinguishable L5 dorsal ramus contribution to the lateral plexus of the sacral dorsal rami. Of the 12 hemipelves, 5 demonstrated branches from the superior gluteal nerve that entered the lateral side of the long posterior sacroiliac ligament. These nerves appeared to terminate in the SIJ.

Discussion

Anatomy of Sacral Dorsal Rami Lateral Branches

Anatomy of the Human Body (17) had an anatomical drawing of the dorsal sacral plexus that showed the lateral branches exiting the foramen at approximately 4:00 to 5:00 on the right side and 7:00 to 8:00 on the left side. Another atlas of anatomy demonstrated the lateral branches exiting each of the dorsal sacral foramen at approximately 5:00 on the right side and 7:00 on the left side (5, Fig. 4). Yin et al (8) reported that the lateral branches of the sacral dorsal rami exit the dorsal foramen in a variable pattern ranging from 2:00 to 6:00 on the right and 6:00 to 10:00 on the left side. Another study described an optimal sensory stimulation pattern prior to radiofrequency lesioning at 3:00 to 5:00 on the right and 7:00 to 8:30 on the left (7).

Willard et al (6) described the dorsal sacral plexus where each lateral branch of the dorsal rami of S1-S3 anastomosed with each other forming interconnecting loops of the dorsal sacral plexus before traveling laterally to pass through or over the long posterior sacroiliac ligament. This study did not mention an angle or location of the lateral branches as they exit the dorsal sacral foramen.

Our investigation revealed wide variability in lateral branch exit points, in contrast to earlier reports (Fig. 3). We found that the exits of the lateral branches had a maximum range of 12:00 – 6:00 on the right side and 6:00 – 12:00 on the left side. The average exits of the lateral branches were from 1:30 to 5:00 on the right side and 7:00 to 10:30 on the left side.

Blocks of the lateral branches have been shown to provide relief from pain produced by the SIJ dysfunction (7,8,18). Thus patients typically are screened with lateral branch blocks prior to RFA treatment. In spite of this, Cohen et al (19) showed that positive outcomes with lateral branch blocks are not a statistically signifi-

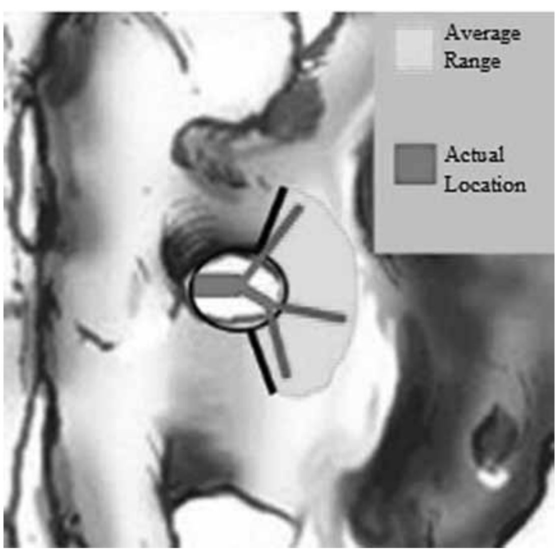

Fig. 3. *Average range of the lateral branches of the dorsal sacral foramen was 1:00 to 5:00 on the right. A typical location pattern of lateral branches of S2 shown in dark gray.*

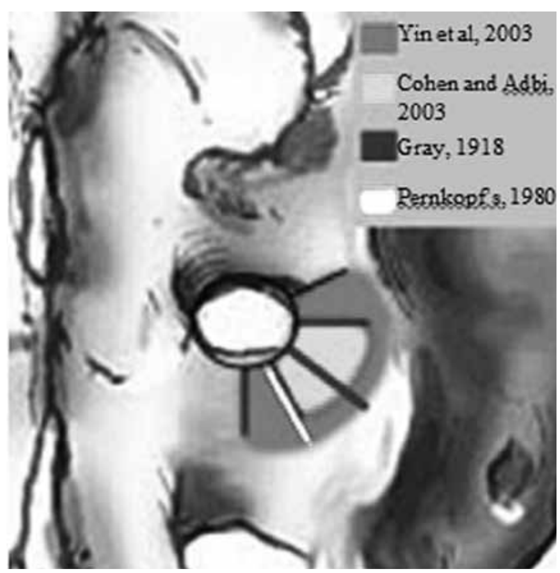

Fig. 4. *Location of lateral branch sacral dorsal rami with respect to the foramen as found in current literature (S2 shown).*

Table 2. *Studies of sacroiliac joint innervation.*

Author	Dorsal Rami Contribution	Ventral Rami Contribution	L5 contribution
Solonen, 1957	S1 and S2	Yes (L4, L5 and S1)	Yes
Ikeda, 1991	L5, S1-S4	Yes (L5 and S2)	Yes
Grob et al, 1995	S1-S4	No	No
Yin et al, 2003	L5, S1-S3	Not studied	Yes
McGrath and Zhang, 2004*	S2-S4	Not studied	Not studied
Szadek et al, 2008†	Not studied	Yes(L4 and L5)	Yes
Willard et al, 2010	L5, S1-S4	Not studied	Yes

*McGrath and Zhang studied the innervation to the long posterior sacroiliac ligament only.
†Szadek et al studied the innervation to the anterior sacroiliac ligaments.

cant predictor of positive outcomes with RFA of lateral branches. The study demonstrated that the use of the cooled RFA technique, which can produce a larger lesion, was the only positive predictor of successful patient outcomes. The larger lesion produced with cooled RFA may encompass the variations we found in the anatomy of the lateral branches of the dorsal sacral rami; however, responses potentially could vary with anatomy, probe position, and operator.

Innervation of the Sacroiliac Joint

In 1957, Solonen (9) suggested the innervation is derived from neighboring nerves such as the lumbosacral trunk (ventral rami of L4 and L5) and superior gluteal nerve (ventral rami of L4, L5, and S1) as well as the dorsal rami of S1 and S2 nerves. Ikeda (10) described the anterior portion of the joint to be innervated by the ventral rami of the L5 and S2 nerves from the sacral plexus and the posterior portion of the SIJ to be innervated by the dorsal rami of L5 and the lateral branches of the sacral nerves. In 2008, Szadek and coworkers (20) showed that the anterior sacroiliac ligaments receive innervation from small branches of the ventral rami of L4 and L5 as the lumbosacral trunk.

However, a cadaver study by Grob and colleagues (11) described the innervation to the SIJ as solely from the dorsal rami of the sacral nerves, S1-S4. This study included histological and immunocytochemical preparation that demonstrated neurofiliments only within the dorsal portion of the SIJ of fetuses (save 2 possible neurofilament positive ventral capsule axons where the origin could not be determined). Studies of SIJ innervation are summarized in Table 2.

In the current study, we found that 9 of 12 (75%) of the cadavers demonstrated an L5 contribution to the dorsal sacral plexus. We also found a branch of the superior gluteal nerve that entered the long posterior sacroiliac ligament in 42% of the cadavers. These variations in the innervation of the SIJ present possible pain pathways that would remain with treatment that included only the lateral branches of the dorsal sacral rami.

Limitations

The limitations of this study are that we only dissected from a posterior aspect of the pelvic region. Given the lack of neuronal receptors in the fetal ventral capsule (11), we were not compelled to search for any possible innervation of the anterior portion of the SIJ. Thus ventral innervation is still a remote consideration. Moreover it is intriguing from a pain referral standpoint to realize that the ventral rami do contribute to at least some of the SIJ's innervation via the superior gluteal nerve. Destruction of some L5 or sacral dorsal rami branches with the removal of the short sacroiliac ligaments and muscles of the low back may have occurred. This would cause an underestimation of the L5 contribution to the innervation to the joint. However, with the dissection of the more lateral aspect of the joint, minimal damage was inflicted to the superior gluteal nerve and vessels; thus the contribution from this nerve is most likely not underestimated in this report.

Conclusion

The exit points of the lateral branches of the sacral dorsal rami have been shown to be even more varied than previously demonstrated with a range of 12:00 – 6:00 on the right and 6:00 – 12:00 on the left. Nearly all the foramina have more than one branch exiting from it. Because many of the current cadavers demonstrated a L5 contribution to the plexus, formed by the lateral branches of the sacral dorsal rami, it can be concluded that at least some patients may have pain transmitted by branches from the L5 nerve. Thus, the L5 dorsal rami should be included with treatment with RFA. The possible contribution from small branches from the superior gluteal nerve also provides a pathway for continued pain transmission after RFA of the lateral branches of the sacral dorsal rami. The current study suggests the necessity for future investigations to assess the reliability of SIJ RFA treatment approaches that address the considerable variability of lateral branch exit points from the dorsal sacral foramen. Further study with a greater number of cadaver specimens is needed to complete proper statistical analysis of the actual locations and variability of the innervation to the SIJ.

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