Original Article ISSN (O):2395-2822; ISSN (P):2395-2814

Surface and Bony Landmarks for Sacral Neuromodulation: An In-Vivo Study

Saurabh Bhargava[1], Deepak Tiwari[1]

[1]Associate Professor, Department of Emergency Medicine, National Institute of Medical Science & Research, Jaipur, Rajasthan

Received: August 2019
Accepted: September 2019

ABSTRACT

Background: About a century ago, the anatomic variation in the relationship between the lumbar spines was first described in the literature and it still plays a vital role in spine deformity, pelvic trauma and low back pain. Sacral neuromodulation (SNM) also known as sacral nerve stimulation. Various refractory voiding disorders like urinary retention, frequency urgency syndrome, urge incontinence and faecal incontinence can be treated by sacral neuromodulation. Sacral neuromodulation exact mechanism is not well understood yet. So that a number of proposed theories explains various effects of electrical neuromodulation which are: a) urinary tract dysfunction involves storage or emptying abnormalities. b) Pudendal afferent signalling in the neurological wiring system. c) Somatic afferent inhibition of sensory processing in the spinal cord. This article focus on the determination of standard external bony landmarks for neuromodulation thus these efforts evaluated the success rate of 2cm and 9 cm bony landmarks. **Methods:** The sample (simple random sampling) size of 55subjects (34 males and 21 females) was selected according to criteria described in previous studies. It was a clinical routine for all the patients to undergo abdominal MR imaging, with the osseous pelvis, in a supine position with extended to hip and knee joints. Additional radiation were not exposed to the patient for the purpose of this study. **Results:** The mean distance between coccyx to S3 for male was found to be ranging between 8.94cm – 9.13cm with an average value of 9.04cm and 0.61 relative standard deviation whereas and for female was found to be ranging between 7.99cm – 8.87cm with an average value of 8.63cm and 0.57 relative standard deviation. This value was however 8.31cm, 8.36cm and 9.07cm for subjects of age groups ≤30, ≤40, and ≤50 respectively. Similar mean distance between midline to S3 for males was found to be ranging between 1.79 – 2.23cm with an average value of 1.98cm and 0.67 relative standard deviation for female was found to be ranging between 1.80 – 1.96cm with an average value of 1.92cm and 0.71 relative standard deviation. This value was however 1.93cm, 1.96cm and 1.98cm for subjects of age groups ≤30, ≤40, and ≤50 respectively. **Conclusion:** Variations in sacral anatomy and lead placement did not predict SNM success. A distance 2 cm and 9 cm of the S3 from midline and coccyx is a reasonable starting landmark for in-office blind PNE. There were a slight difference was observed from these values and variations were also seen with age and sex.

Keywords: Bony landmarks; Lead wire; Sacral S3 foramen; sacral anatomy; sacral neuromodulation.

INTRODUCTION

The lower five fused vertebrae forms a large bone called Sacrum, the sacrum contributes in the weight transmission of the body to the pelvic girdle, stability and strength to the pelvis.[1] Location of sacrum is the lower extremities and pelvis crossroads, neuroradiologists and body imagers are interested in the anatomy and pathology of sacrum.[2] Because of the relatively complex anatomy of the sacrum, the adjacent pelvic bones and overlying bowel, plain films are not diagnosed.[3] Hence a variety of cross sectional imaging techniques are significant for sacral imaging depending on the specific clinical situations.[4]

Name & Address of Corresponding Author
Dr. Deepak Tiwari
Associate Professor
Department of Emergency Medicine,
National Institute of Medical Science & Research, Jaipur
Rajasthan

The radiologist must be familiar with a wide variety of congenital conditions, infections, tumours and inflammations which affects the sacrum.[4-7] A procedure in paraplegic patients was attempted by Tanagho and Schmidt in California which was similar to Brindley's protocol. To induce detrusor contraction extradural stimulation of the sacral root which was followed by posterior rhizotomy to eliminate bladder sphincter hyperactivity. Then the work was limited to the use of percutaneous puncture to stimulate the root of S3 without lessoning because they obtained inhibition of contraction which was an adverse effect. After that, for the modification of pathologic behaviour of hyperactive bladder, an electrical stimulation of the sacral root was found. In this way the term sacral neuromodulation was coined.[8] Sacral neuromodulation (SNM) also known as sacral nerve stimulation. Various refractory voiding disorders like urinary retention, frequency urgency syndrome, urge incontinence and faecal incontinence can be treated by sacral neuromodulation.[9-11] Sacral neuromodulation exact mechanism is not well understood yet. So that a number of proposed theories explains various effects of electrical neuromodulation which are: a) urinary tract dysfunction involves storage or emptying abnormalities. b) Pudendal afferent signalling in the neurological wiring system. c) Somatic afferent inhibition of sensory processing in the spinal cord.

MATERIALS AND METHODS

The present study entitled, "Surface and boney landmarks for sacral neuromodulation: An In-Vivo Study" was be a cross sectional study conducted in the Department of Emergency Medicine, National Institute of Medical Science & Research, Jaipur, Rajasthan. The study was conducted after getting the Human ethical committee permission and the necessary permissions from the clinical director and the vice dean of the University from July 2019 to December 2019. The sample (simple random sampling) size of 55subjects (34 males and 21 females) was selected according to criteria described in previous studies. The data was collected after the consent from the patient in a prescribed format (data collection and consent forms are attached with the proposal).

It was a clinical routine for all the patients to undergo abdominal MR imaging, with the osseous pelvis, in a supine position with extended to hip and knee joints. Additional radiation were not exposed to the patient for the purpose of this study. All the normal subjects' bony landmarks, sacral surface and coccyx measurement were performed wxated with formaldehyde in MR images. Anatomical study of S1 Spinous process length, height, and size of the L5-S1 segment were performed.

Correlations among measured variables were assessed using descriptive statistics. The radiological measurements were performed digitally in work-station of 1.5-T MR system. The coronal and sagittal (TSE) T2-weighted images were taken into consideration.[10, 12]

Statistical Methods

All measurements were done under strict calibration and standardization protocol. The measurements were compiled and entered in Microsoft Excel, and then exported to SPSS. Mean, standard deviation, and P values were done for all 55 participants with level of significance at 5% (0.05) and power of the study at 95%. The statistical analysis was subjected to unpaired Students t-test. Pearson's correlation were used to know the mean distance between coccyx and S3 and mean distance between midline and S3 by linear correlation analysis. Consents were obtained from the patients for the study and publication.

RESULTS

The present study entitled, "Surface and bony landmarks for sacral neuromodulation: An In-Vivo Study", was an effort to study the measurements of bony landmarks and their relationship between each other. The study included 55 samples with 34 males and 21 females. The mean age, of the female subjects was 27.3 years and it ranges from 18 – 49 years and male subjects, was 25.7 years and it ranges from 21 – 35 years.

Table 1: Average age and sex ratio

Subjects	Sample		Age	
	Size	Percentage	Average	Range
Male	34	61.81	25.7	21 – 35
Female	21	38.19	27.3	18 – 49
Total	55	100	26.5	18 – 49

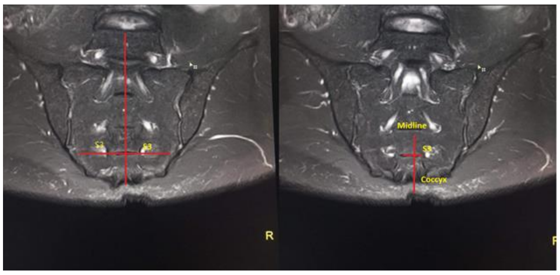

Figure 1: MR Images of sacrum and Coccyx for the evaluation of surface and bony landmarks

Table 2: The mean distance from Coccyx to S3 and midline to S3 classified by age and sex

Subjects	Coccyx to S3 Distance			Midline to S3 Distance		
	Average Distance (cm)	S.D.	Range (cm)	Average Distance (mm)	S.D.	Range (cm)
Male	9.04	0.61	8.94 – 9.13	1.98	0.67	1.79 – 2.23
Female	8.63	0.57	7.99 – 8.87	1.92	0.71	1.80 – 1.96
Total	8.835	-	7.99 – 9.13	1.95	-	1.79 – 2.23

Table 3: The mean distance from Coccyx to S3 and midline to S3 classified by age

Subjects	Coccyx to S3 Distance			Midline to S3 Distance		
	Average Distance (cm)	S.D.	Range (cm)	Average Distance (mm)	S.D.	Range (cm)
≤30	8.31	0.13	7.99 – 8.63	1.93	0.27	1.79 – 1.91
≤40	8.36	0.21	8.24 – 8.77	1.96	0.17	1.84 – 1.96
≤50	9.07	0.14	8.94 – 9.13	1.98	0.21	1.88 – 2.23
Total	8.835	-	7.99 – 9.13	1.95	-	1.79 – 2.23

The mean distance between coccyxes to S3 for male was found to be ranging between 8.94cm – 9.13cm with an average value of 9.04cm and 0.61 relative standard deviation.

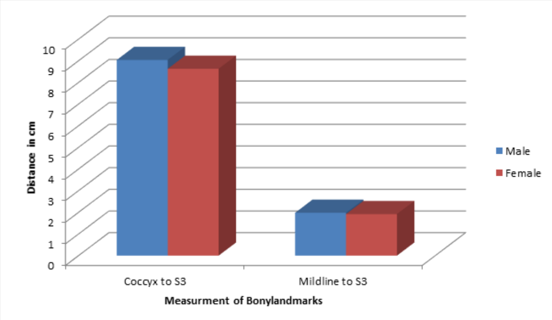

Figure 2: The graphical representation and genderwise determination of bony landmarks on sacrum

On the other hand the mean distance between coccyxes to S3 for female was found to be ranging between 7.99cm – 8.87cm with an average value of 8.63cm and 0.57 relative standard deviation. This value was however 8.31cm, 8.36cm and 9.07cm for subjects of age groups ≤30, ≤40, and ≤50 respectively.

Similar set of study for determination of mean distance between midline to S3 for male was found to be ranging between 1.79 – 2.23cm with an average value of 1.98cm and 0.67 relative standard deviation. On the other hand the mean distance between midline to S3 for female was found to be ranging between 1.80 – 1.96cm with an average value of 1.92cm and 0.71 relative standard deviation. This value was however 1.93cm, 1.96cm and 1.98cm for subjects of age groups ≤30, ≤40, and ≤50 respectively. The results are summarized in [Table 2,3]. All associations between external measurements and length from tip of coccyx to S3 were not significant.

DISCUSSION

About a century ago, the anatomic variation in the relationship between the lumbar spines was first described in the literature and it still plays a vital role in spine deformity, pelvic trauma and low back pain. Role of bony landmarks on gender identification is emphasized by some reports. In the modern orthopaedic practices similar conventions are useful in which harmony between the different dimension parameter is sought. Hence, for the selection of sacral neuromodulation it is desirable to have certain dependable criteria.

In the present study entitled, "Surface and bony landmarks for sacral neuromodulation: An In-Vivo Study", an effort was made to establish relationship between mean distance from coccyx to S3 and mean distance between midline to S3 for a large population of 55 subjects of both genders. Both the parameters i.e., mean distance from coccyx to S3 and mean distance between midline to S3 was found to be higher in males than females. The result is in good compliance with certain other reports although it was statistically insignificant when study was carried out with 99% confidence level (P<0.001). Both the parameters i.e., mean distance from coccyx to S3 and mean distance between midline to S3 was also determined for the various age groups (≤30, ≤40, and ≤50) and observed that the distances increases with the increase in age. Results were found statistically insignificant when study was carried out with 99% confidence level (P<0.001).

Similar study was reported by Nicolette E. Deveneau et. al.[24], in 2014 measured and distances between external boney landmarks were obtained in 22 embalmed cadavers. They employed needles 9 cm superior to the coccyx and 2 cm lateral to midline. The position of S3, sacral length and location of the needle in relation to S3 was recorded after the dissection. The mean lateral distance between coccyx and S3 was found to be 9.26 cm (±0.84), Between S3 to midline 2.30 cm (±0.2); from S3 to needle 1.25 cm, and the needle was placed superior or inferior to S3; S2-S3 and S3-S4 where inter foramenal distance 1.48 cm (±0.30) and 1.48 cm (±0.24), respectively. The Mean distance between sacroiliac joint (SIJ) and S3 however shorter than S2 to SIJ.

The Similar results are reported by Katherine E. Husk25 in 2019 where anatomy and lead location of sacrum was evaluated by Fluoroscopic imaging. They reported more than 50% symptoms were improved and better clinical responses were observed after stage –I follow up. Out of 209 cases 187 (89.5%) were women and 22 (10.5%) men. Among them the success rates for primary implants and revisions cases were 83.3% and 89.4% respectively. Shorter implant durations (21.3 ± 22.2 vs 33.6 ± 25.8 months), straight vs curved lead (90.5% vs 80.5%) (All p = .05), higher body mass index (30.3 ± 7.8 vs 27.6 ± 6.1 kg/m2), were accounted as successful parameter for sacral neuromodulation. In assessing the 9 and 2 protocol, mean distance between midline and S3 did equal 2 cm: 1.9 ± 0.4 vs 2.0 ± 0.7 cm (p = .37), while mean distance between coccyx and S3 did not equal 9 cm: 7.4 ± 1.0 vs 7.2 ± 0.8 cm (p = .26).

CONCLUSION

The present study entitled, "Surface and bony landmarks for sacral neuromodulation: An In-Vivo Study" was performed for establishment of relationship between bony landmarks and neuromodulation in 55 healthy subjects of both the sex. Parallel to other test of Sacrum and other joint problems magnetic waves in MRI, produces very detailed images. Besides this it is a painless and safe procedure and helps to diagnose sacrum anatomy. Variations in sacral anatomy and lead placement did not predict SNM success. A distance 2 cm and 9 cm of the S3 from midline and coccyx is a reasonable starting landmark for sacral neuromodulation. There were a slight difference was observed from these values and variations were also seen with age and sex.

To highlight some of the limitations and future scope for the study it becomes essential to add that study could have extended to even larger population (1000 plus) for far better and accurate results and comparison can be made between identical parameters among the various reports from different countries.

REFERENCES

1. Hubsher C.P., Jansen R., Riggs D.R., Jackson B.J., Zaslau S. (2012). "Sacral nerve stimulation for neuromodulation of the lower urinary tract" (PDF). Can J Urol. 19 (5): 6480–4.
2. Hayden DM, Weiss EG (2011). "Fecal incontinence: etiology, evaluation, and treatment". Clin Colon Rectal Surg. 24 (1): 64–70.
3. Pascual, I., González-Gómez, C.C., Ortega, R., Jiménez-Toscano, M., Marijuán J.L., Lomas-Espadas, M., Fernández-Cebrián, J.M., García-Olmo D., Pascual-Montero, J.M. (2011). "Sacral Nerve Stimulation for fecal incontinence". Rev Esp Enferm Dig. 103 (7): 355–359.
4. Patel MM, Gupta BD, Singel TC. Sexing of sacrum by sacral index and kimura's base wing index. JIAFM. 2005;27(1):5–9.
5. Mishra SR, Singh PJ, Agrawal AK, Gupta RN. Identification of sex of sacrum of Agra region. J Anat Soc Ind. 2003;52(3):132–36.
6. Stewart TD. Hrdlicka's Practical Anthropometry. 4th edition. Philadelphia: The Wistar Institute of Anatomy & Biology; 1952. Measurement of Bones In; 172.
7. Thaha, MA; Abukar, AA; Thin, NN; Ramsanahie, A; Knowles, CH (24 August 2015). "Sacral nerve stimulation for faecal incontinence and constipation in adults". The Cochrane Database of Systematic Reviews (8): CD004464..
8. Deveneau NE, Greenstein M, Mahalingashetty A, Herring NR, Lipetskaia L, Azadi A, et al. Surface and boney landmarks for sacral neuromodulation: a cadaveric study. Int Urogynecol J. 2015;26(2):263–8.
9. Tanagho EA, Schmidt RA (1982) Bladder pacemaker: scientific basis and clinical future. Urol 20: 614–619
10. Matzel KE, Chartier-Kastler E, Knowles CH, Lehur PA, Munoz-Duyos A, Ratto C, et al. Sacral neuromodulation: standardized electrode placement technique. Neuromodulation. 2017;20(8):816–24.
11. O'Haire C, Gibbons P. Inter-examiner and intra-examiner agreement for assessing sacroiliac anatomical landmarks using palpation and observation: pilot study. Man Ther. 2000;5(1):13–20.
12. Gerber, S, Ollivier, L, Leclere, J, et al. Imaging of sacral tumours. *Skeletal Radiol*. 2008; 37(4): 277–89.
13. Llauger, J, Palmer, J, Amores, S, Bague, S and Camins, A. Primary tumors of the sacrum: Diagnostic imaging. *AJR Am J Roentgenol*. 2000; 174(2): 417–24.
14. Rohrschneider WK, Forsting M, Darge K, Tröger J. Diagnostic value of spinal US: comparative study with MR imaging in pediatric patients. Radiology. 1996;200:383–388.
15. Zanello M, Zerah M, Di Rocco F. Sacral dimple: what form of management is best? Arch Pediatr. 2015;22:1298–1301.
16. Shin HJ, Kim MJ, Lee HS, Kim HG, Lee MJ. Optimal filum terminale thickness cutoff value on sonography for lipoma screening in young children. J Ultrasound Med. 2015;34:1943–1949.

How to cite this article: Bhargava S, Tiwari D. Surface and Bony Landmarks for Sacral Neuromodulation: An In-Vivo Study. Ann. Int. Med. Den. Res. 2019; 5(6):MC09-MC12.

Source of Support: Nil, **Conflict of Interest:** None declared