

A Study on Anatomical Variations of Sacral Foramina and its Clinical Relevance

MRITUNJAY PANDEY¹

ABSTRACT

Introduction: The Sacrum is a large, triangular, shield-shaped bony structure, formed by the fusion of five individual sacral vertebrae. Ventral surface of sacrum bears four pelvic sacral foramina allowing the passage of ventral rami of upper four sacral spinal nerves and the lateral sacral arteries. The posterior surface of sacrum bears four dorsal sacral foramina, lateral to the articular tubercles. The dorsal sacral foramina allow passage of dorsal rami of upper four sacral spinal nerves.

Aim: The present study was carried out to evaluate the numerical variations of pelvic and dorsal sacral foramina of dry human sacrum.

Materials and Methods: A descriptive osteological study was done to look for numerical variations in the number of pelvic and dorsal sacral foramina. Hundred dry adult human sacrum were collected from the Department of Anatomy of Nilratan Sircar Medical College, Kolkata over a period of 2011-2013. Any variations in the number of segments of sacrum were examined. Identification of six segmented sacrum with five pairs of sacral

foramina and four segmented sacrum with three pairs of sacral foramina was performed. The data was collected and statistical analysis was done in simple percentage form.

Results: Hundred dry adult human sacra were examined for the number of pelvic and dorsal sacral foramina. Three sacra (3%) were found with three pairs of sacral foramina and two sacra (2%) with five pairs of sacral foramina. In one (1%) of the sacrum, lumbosacral transitional vertebra was seen with five foramina on left side and four foramina on the right side of median sacral crest. All other sacra have normal four pairs of sacral foramina.

Conclusion: Variation in segmental composition of sacrum results in lumbarisation or sacralisation with altered number of sacral foramina. Persons with these variations may often presents with low back pain. This knowledge of lumbarisation and sacralisation must be kept in mind while doing surgical and anaesthetic procedures in this region. Information of segmental variations of sacrum is important for anaesthetists, surgeons, obstetricians, radiologists and forensic experts.

Keywords: Dorsal sacral foramina, Low back pain, Pelvic sacral foramina, Sacrum

INTRODUCTION

The sacrum is a large, triangular, shield-shaped bony structure, formed by the fusion of five individual sacral vertebrae. It forms a link between spine and a pair of hip bones, forming posterosuperior wall of the pelvic cavity wedged between the two hip bones [1]. The line of fusion between five individual sacral vertebrae is represented by four transverse ridges, present on the anterior surface of sacrum. Lateral to these transverse ridges, there are four pelvic sacral foramina allowing passage to ventral rami of upper four sacral spinal nerves and the lateral sacral arteries [Table/Fig-1]. The posterior surface of sacrum bears four dorsal sacral foramina, lateral to the articular tubercles. The dorsal sacral foramina allow passage of the dorsal rami of upper four sacral spinal nerves.



[Table/Fig-1]: Normal Sacrum with four pairs of sacral foramina on each side.

Normally, the sacrum is formed by the fusion of five individual sacral vertebrae, but various anatomical variations have been reported. One of the most common variations is sacralisation where complete fusion of fifth lumbar vertebra with first sacral vertebrae or complete fusion of 1st coccygeal vertebrae with apex of the sacrum occurs, giving rise to a six segment sacrum [2]. Both these conditions give rise to five pairs of sacral foramina. Another less common variation is unilateral sacralisation of fifth lumbar vertebra giving rise to five sacral foramina on one side and four sacral foramina on the other side. Lumbarisation of first sacral vertebra is another form of variation, where first sacral vertebra separates from sacrum leading to reduction in the number of sacral constituents. Lumbarisation of first sacral vertebra results in six lumbar vertebrae. Lumbarisation and sacralisation occurs due to defect in the segmentation of the lumbosacral spine during development [3]. This increase or decrease in the number of sacral segments also affects the number of sacral foramina, leading to increase or decrease in the number of sacral foramina. Several studies have been done to report the numerical variations of sacral foramina across the globe and along different regions of India. Most of those studies have described only one form of variation of sacral foramina. Insufficient literature is available regarding the variations of sacral foramina in eastern Indian population. The present study is an attempt to study various forms of numerical variations of sacral foramina among the people of Eastern India. Knowledge of these variations in the number of sacral foramina is important because dorsal sacral foramina serve as an important landmark for epidural anaesthesia and analgesia for surgeries in pelvic region.

MATERIALS AND METHODS

A descriptive osteological study was done to look for numerical variations in the number of pelvic and dorsal sacral foramina.

Hundred dry adult human sacra were collected from the students and the Department of Anatomy of Nilratan Sircar Medical College and Hospital, Kolkata over a period of January 2011 to March 2013. These bones were observed for numerical variations in the number of sacral foramina. Any variations in the number of segments of sacrum were investigated. Identification of six segmented sacrum with five pairs of sacral foramina and four segmented sacrum with three pairs of sacral foramina performed. The specimen with lumbarisation and sacralisation were examined and evaluated for the degree of lumbarisation and sacralisation and recorded.

Inclusion criteria: Hundred dry adult human sacra of all ages were included, irrespective of their sex. Bones included were free of any signs of fracture.

Exclusion criteria: Sacra having some parts broken or showing some loss of osseous material have been excluded from study.

Photographs of all sacra showing numerical variations of sacral foramina have been taken. Pictures of some of the normal sacra with all five segments have also been captured for this study.

STATISTICAL ANALYSIS

Data is collected and statistical analysis is done in the form of simple percentage of all kind of numerical variations of the bones.

RESULTS

Hundred dry adult human sacra were examined for the number of pelvic and dorsal sacral foramina. Following observations have been made:

1. Three sacra (3%) were found with three pairs of sacral foramina [Table/Fig-2-4]. These three sacra were composed of four pieces of sacral vertebrae and there is incomplete fusion between individual sacral vertebrae.



[Table/Fig-2]: Sacrum showing lumbarisation of first sacral vertebra with three pairs of sacral foramina on each side.



[Table/Fig-3]: Sacrum showing lumbarisation of first sacral vertebra with three pairs of sacral foramina on each side.



[Table/Fig-4]: Sacrum showing lumbarisation of first sacral vertebra with three pairs of sacral foramina on each side.

2. Two sacra (2%) were found with five pairs of sacral foramina [Table/Fig-5,6]. Both of these sacra show sacralisation of lumbar vertebrae.



[Table/Fig-5]: Sacrum showing sacralisation of fifth lumbar vertebra with five pairs of sacral foramina on each side.

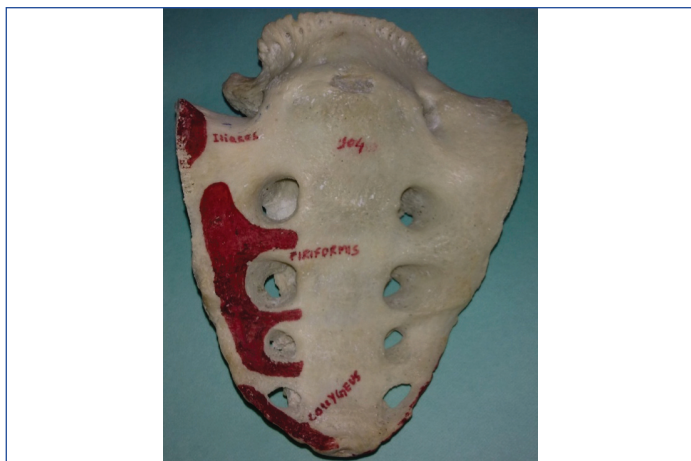


[Table/Fig-6]: Sacrum showing sacralisation of fifth lumbar vertebra with five pairs of sacral foramina on each side.

3. In one (1%) of the sacrum, lumbosacral transitional vertebra [4] was seen with five foramina on left side and four foramina on the right side of median sacral crest [Table/Fig-7].
4. All other sacra have normal four pairs of sacral foramina [Table/Fig-1].

DISCUSSION

The detailed study of sacrum is of great relevance, since this route is frequently utilised for caudal epidural anaesthesia for the diagnosis and treatment of lumbar spine disorders and various other surgeries.



[Table/Fig-7]: Sacrum showing partial sacralisation of fifth lumbar vertebra with five pairs of sacral foramina on left side and four pairs of sacral foramina on right side.

The knowledge of sacral anatomy is also important for epidural analgesia. The procedure of caudal epidural anaesthesia requires the identification of sacral cornua. Sacralisation of coccygeal vertebra will lead to difficulty in marking this landmark and results in failure of epidural anaesthesia. However, in this study any such sacralisation of coccygeal vertebra was not found. In this study, bilateral sacralisation of fifth lumbar vertebra with five pairs of sacral foramina is seen in 2% of sacra; whereas unilateral sacralisation is seen in 1% sacrum bearing five sacral foramina on left side and four sacral foramina on right side.

Various anatomical variations have been reported in relation to the composition of sacrum leading to variation in the number of sacral foramina. Khanna J and Chauhan R, reported five pairs of sacral foramina in 10% of specimen and unilateral sacralisation with five sacral foramina on left side in 1.6% of sacra [5]. Nagar S et al., conducted study on sacral foramina in west Indian population and found 16.9% of sacra with five pairs of sacral foramina [6]. They reported incidence of complete bilateral sacralisation of fifth lumbar vertebra and complete bilateral sacralisation of coccygeal vertebra in 7.9% and 8.9% of specimens respectively. Singh R reported a sacrum with five pairs of dorsal sacral foramina [7]. The fifth pair developed due to sacralisation of first coccyx with the fifth sacral vertebra. Singh was of opinion that due to this fusion, coccyx becomes fixed and there is no increase in anteroposterior diameter of pelvic outlet leading to prolonged second stage of labour and perineal tears [7].

The incidence of sacrum with three pairs of sacral foramina varies from 1.58%-6.7% in various studies conducted by different authors. Laishram D et al., reported 3 pairs of sacral foramina in 1.93% of sacrum whereas Shingh DI et al., reported 6.7% of sacrum with three pairs of sacral foramina [8,9]. According to some other studies, done by Khanna J and Chauhan R, (5%), Kubavat D et al., (1.58%) and Deepa T and John MK, (1.7%) estimated the variation in the prevalence of sacrum with three pairs of sacral foramina in different regions of India [5,10,11].

Variations in the number of sacral foramina due to sacralisation of 5th lumbar vertebra or lumbarisation of 1st lumbar vertebra may be attributed to prenatal developmental defects of the vertebrae

of this region. Formation of vertebrae occurs from the sclerotome portion of the somites, which develops from paraxial mesoderm. The sclerotome undergoes re-segmentation, where the caudal half of each sclerotome grows into and fuses with the cephalic half of each subjacent sclerotome [12]. Pattern of the shapes of vertebrae of different region is regulated by HOX gene. Thus, the lumbarisation of 1st sacral vertebra or sacralisation of fifth lumbar vertebra altering the number of sacral foramina, as seen in present study could have been due to mutation of HOX gene. Majority of people, presented with this variation since birth, i.e. congenital. In very few cases, it may occur as a result of trauma, ossification defects, some arthritic changes or as a result of surgeries where vertebral fusion have been done.

Limitation(s)

Sexual dimorphism of these variations could not be ascertained. Any association of low back pain with these variations of sacrum could not be explained as the sacra were collected from cadavers.

CONCLUSION(S)

The present study is an attempt to summarise the relevant anatomical divergences involving numerical variations of pelvic and dorsal foramina of the sacral vertebrae. Variation in segmental composition of sacrum results in lumbarisation or sacralisation with altered number of sacral foramina. Persons with these variations may often presents with low back pain. This knowledge of lumbarisation and sacralisation must be kept in mind while doing surgical and anaesthetic procedures in this region. Awareness about this variation is important while reporting X-ray, CT or MRI films. This information also bears a medicolegal importance for identification, if ante-mortem records are available [4]. Thus, the information of segmental variations of sacrum is important for anaesthetists, surgeons, obstetricians, radiologists and forensic experts.

REFERENCES

- [1] Standring S. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 41st Ed. London: Elsevier;2016;726-29.
- [2] Frymoyer JW, Hadler NM, Kostuik JP, Weinstein JN, Whitecloud TS. The Adult Spine: Principles and Practice. Vol 2. New York: Raven Press. 1991;2099.
- [3] Eyo M, Olofin A, Noronha C, Okanlawon A. Incidence of lumbosacral transitional vertebrae in low back pain patients. West Afr J Radiol. 2001;8(1):01-06.
- [4] Kanchan T, Shetty M, Nagesh KR, Menezes RG. Lumbosacral transitional vertebra Clinical and forensic implications. Singapore Med J. 2009;50(2):e85.
- [5] Khanna J, Chauhan R. Anatomical variations and clinical relevance of dorsal sacral foramina in North Indians. Int J Res Med Sci. 2013;1(3):263.
- [6] Nagar S, Kubavat D, Lakhani C, Parmar J, Gosai S, Uttakar K. A study of sacrum with five pairs of sacral foramina in western India. Int J Med Sci Public Health. 2013;2(2):239-42.
- [7] Singh R. Sacrum with five pairs of sacral foramina. Int J Anat Var. 2011;4:139-40.
- [8] Laishram D, Ghosh A, Shastri D. A study on the variations of sacrum and its clinical significance. IOSR-JDMS. 2016;15(6):08-14.
- [9] Shingh DI, Ajita R, Singh N. Variation in the number of sacral pieces. IOSR-JDMS. 2015;14(12):106-08.
- [10] Kubavat D, Nagar S, Lakhani C, Ruparelia S, Patel S, Varlekar P. A study of sacrum with three pairs of sacral foramina in western India. Int J Med Sci Public Health. 2012;1(2):127-31.
- [11] Deepa T, John MK. A study of lumbarisation of first sacral vertebra among the South Indians. Int J Med Res Health Sci. 2014;3(1):01-04
- [12] Sadler TW. Langman's Medical Embryology. 13th ed. Philadelphia: Wolters Kluwer. 2015:153.

PARTICULARS OF CONTRIBUTORS:

1. Associate Professor, Department of Anatomy, Mayo Institute of Medical Sciences, Barabanki, Uttar Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Mritunjay Pandey,
Associate Professor, Department of Anatomy, Mayo Institute of Medical Sciences,
Gadia, Barabanki, Uttar Pradesh, India.
E-mail: dr.mritunjaybmc@gmail.com

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? NA
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Jun 25, 2020
- Manual Googling: Aug 12, 2020
- iThenticate Software: Oct 23, 2020 (19%)

ETYMOLOGY: Author Origin

Date of Submission: Jun 15, 2020

Date of Peer Review: Jul 17, 2020

Date of Acceptance: Sep 07, 2020

Date of Publishing: Jan 01, 2021