



## COCCYGEAL SACRALISATION – A STUDY

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### ABSTRACT

The coccyges are a series of rudimentary vertebrae forming the caudal termination of the vertebral column. At the cranial end of the sacrum when L5 fuses with S1, it is termed as Lumbar sacralisation. At the caudal end of sacrum, when first coccygeal vertebra fuses with the S5 it is termed as Coccygeal sacralisation. Hence when sacrum comprises of six vertebrae, it is always due to the loss of a vertebra from the lumbar region or coccygeal region. There is hardly any literature available related to the coccygeal region. It is important to study the variations at the caudal end of the sacrum not only to enhance the data base of anatomical variants of sacrum but also from the clinical point of view. Hence the study is aimed at identifying the prevalence of coccygeal sacralisation, classifying them and analysing details of the same. Materials and Methods: Total fifty adult dry human sacra with attached coccyx were examined in the Department of Anatomy of K. J. Somaiya Medical College with respect to five pairs of sacral foramina. Those vertebrae which exhibited lumbar sacralisation were excluded. They were grouped as follows: Type I Coccygeal sacralisation was formed by complete fusion of coccygeal vertebra with S5 vertebra. Type II Coccygeal sacralisation was formed by fusion of body with the apex of sacrum; and transverse process of Co1 vertebra with inferior lateral angle of sacrum but coccygeal cornua did not fuse with sacral cornua. Hence fusion was incomplete medially. Type III Coccygeal sacralisation was formed by fusion of body with apex of sacrum; and sacral cornua with cornua of coccygeal vertebra. The transverse process of Co1 vertebra does not fuse with inferior lateral angle of sacrum. Hence fusion was incomplete laterally. Observations: Eight sacra showed coccygeal sacralisation (16%) of which 4 (8%) were Type I showing complete fusion, 2 (4%) was of Type II showing incomplete fusion medially and 2 (4%) was of Type III showing incomplete fusion laterally. Conclusion: The classifications in the present study range from complete fusion of vertebrae to incomplete fusion of parts of the vertebrae. This is essential for diagnosis of sacralisation related diseases to understand the degree of ossification and the extent of fusion. Sacralisation of coccygeal vertebra may cause coccygodynia, caudal block failure, difficult second stage of labour, a difficult forceps delivery and perineal tear. Thus knowledge of sacralisation of lumbar and coccygeal vertebra is of utmost importance to anatomist, orthopaedicians, physicians, surgeons and obstetricians.

**Keywords:** *Sacrum, Coccyx, Coccygeal Sacralisation, Complete Fusion, Incomplete Fusion, Ossification, Coccygodynia, Caudal Block, Labour, Forceps Delivery, Perineal Tear, Orthopaedicians, Obstetricians.*

### INTRODUCTION

The coccyges are a series of rudimentary vertebrae forming the caudal termination of the vertebral column lying inferior to the apex of the sacrum. For the purposes of numbering the vertebral segments, and stipulated by the Terminologia Anatomica (TA), "Co" is used as the

abbreviation for each coccygeal level. Co1 is the largest, and the subsequent are smaller in size. Structure of IV disc is variable and age-related, ranging from fully developed to rudimentary with varying degrees of cystic or fibrotic change, to fusion of the vertebrae in the later decades.

The anterior surface is concave and posterior surface convex, both marked with three transverse grooves representing the fusions of the four separate vertebrae. There is a vertical row of tubercles on either side, which are rudimentary articular processes of the coccygeal vertebrae. The superior pair is the largest and is called the coccygeal cornua. They articulate with the sacral cornua to form the foramen for the transmission of the posterior division of the S5 nerve. The transverse processes are rudimentary and present as several eminences on the thin lateral surface. The most superior eminences join the lateral edges of the sacrum, forming the foramen for the transmission of the anterior division of S5 nerve. The inferior eminences subsequently decrease in size. From anterior to posterior, the lateral border gives attachment to the coccygeus, sacrospinous ligament, sacrotuberous ligament, and fibers of the gluteus maximus. Base is the proximal oval surface for articulation with the sacrum forming a fibrocartilaginous joint, Sacrococcygeal Symphysis; it shows passive minor flexion and extension and the joint typically fuses with age.[1,2]

The lumbosacral spine supports and transmits body weight to the lower limb and help in maintenance of the upright posture. Normally sacrum is formed by fusion of five sacral vertebrae creating four pairs of sacral foramina which transmit sacral nerves. At times a variation occurs in which five pairs of sacral foramina are visible. This is due to attachment of an 'extra' vertebra either at the cranial end or at the caudal end of sacrum. At the cranial end L5 fuses with S1 resulting in sacralisation of lumbar vertebra. Similarly, at the caudal end, first coccygeal vertebra fuses with the S5. This is sacralisation of coccygeal vertebra. Hence when sacrum comprises of six vertebrae, it is always due to the loss of a vertebra from the lumbar region or coccygeal region. The coccyx along with ischial tuberosities acts as a support in a seated position. It contributes to voluntary bowel control and supports the position of the anus [3].

There is hardly any literature available related to the coccygeal region. It is important to study the variations at the caudal end of the sacrum not only to enhance the data base of anatomical variants of sacrum but also from the clinical point of view. Hence the study is aimed at identifying the prevalence of coccygeal sacralisation, classifying them and analysing details of the same.

## MATERIALS AND METHODS:

Total fifty adult dry human sacra with attached coccyx were examined in the Department of Anatomy of K. J. Somaiya Medical College. The analysis was done with respect to the number of sacral foramina present. The sacra with five pairs of sacral foramina were identified. Those vertebrae which exhibited lumbar sacralisation were excluded. They were grouped as follows

Type I Coccygeal sacralisation was formed by complete fusion of coccygeal vertebra with S5 vertebra.

The body, transverse process and cornua of coccygeal vertebra were fused with corresponding elements of S5 vertebra.

Type II Coccygeal sacralisation was formed by fusion of body with the apex of sacrum; and transverse process of first coccygeal vertebra with the inferior lateral angle of sacrum but coccygeal cornua did not fuse with sacral cornua. Hence fusion was incomplete medially.

Type III Coccygeal sacralisation was formed by fusion of body with the apex of sacrum; and sacral cornua with cornua of coccygeal vertebra. The transverse process of coccygeal vertebra does not fuse with inferior lateral angle of sacrum. Hence fusion was incomplete laterally.

From the 50 sacra used for study, eight sacra showed coccygeal sacralisation (16%) of which 4 (8%) were of Type I showing complete fusion, 2 (4%) was of Type II showing incomplete fusion medially and 2 (4%) was of Type III showing incomplete fusion laterally.

The incidence and frequency of occurrence has been displayed in Table I.

Remaining 42 were found to be normal (84%) having five vertebrae constituting four pairs of sacral foramina.

## DISCUSSION:

At the cranial end of the sacrum when L5 fuses with S1 it is termed as Lumbar sacralisation. Similarly, at the caudal end of sacrum, first coccygeal vertebra fuses with the S5 it is termed as 'Coccygeal sacralisation'. Lumbar sacralisation is a common anatomical variant studied by a few authors. To diagnose and treat clinical conditions related to sacrum it is important to be aware of both types of sacralisations. In the present study coccygeal sacralisation has been analysed and studied. There are few studies in literature where frequency of coccygeal sacralisation has been studied. The classifications in the present study range from complete fusion of vertebrae to incomplete fusion of parts of the vertebrae. This is essential for diagnosis of sacralisation related diseases to understand the degree of ossification and the extent of fusion [4].

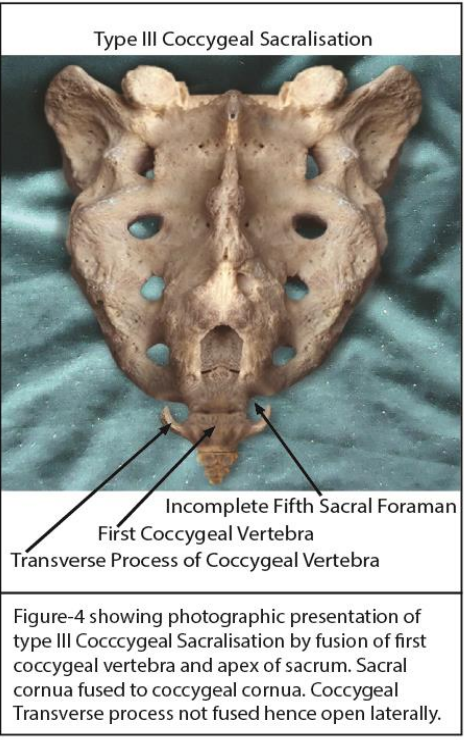
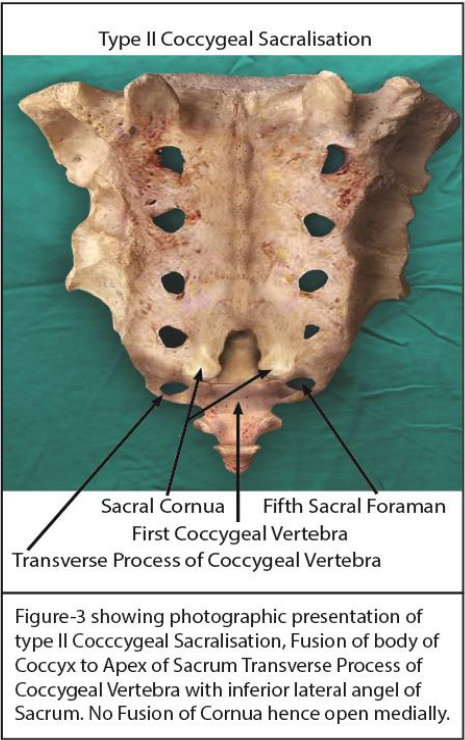
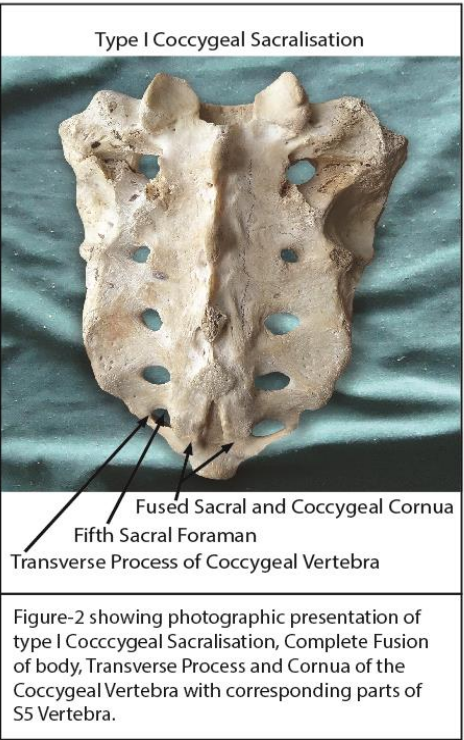
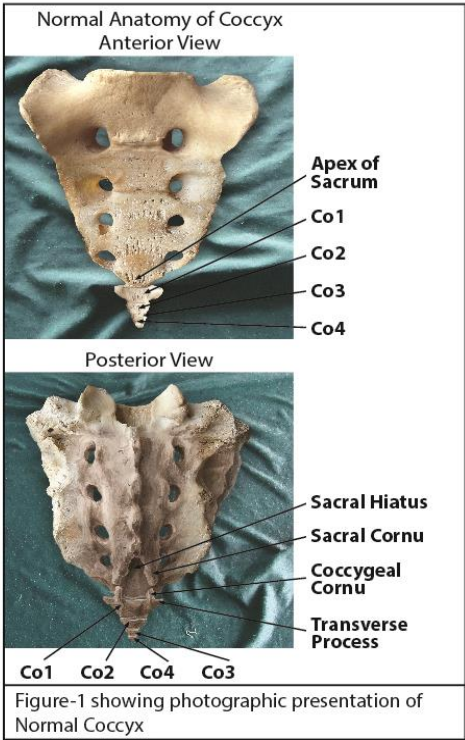
Incidence of sacralisation of coccygeal vertebra is 16% in present study which was lower than that of Rajani Singh (13.6%), Shailesh Kumar (23.8%), Vinod Kumar et al (21.3 %) and Postacchini F et al (37%) but higher than Vandana A Sharma et al (7.8%) . [5,6,7,8]

According to Dale R Broome the age at which fusion occurs between the coccygeal segments and S5 was extremely inconstant, taking place between the ages of 15 and 28, fusion of lateral element between S5 and the first coccygeal vertebra can ensue by the age of 27 [9]

Postacchini F et al studied the normal radiographic anatomy of the coccyx in 120 asymptomatic subjects and found that the sacro-coccygeal joint was fused in 44

Six pairs of sacral foramina have also been reported. This may be outcome of acquisitions of fifth lumbar vertebra at cranial end and coccygeal vertebra at

Observations





caudal end. These seven vertebrae create six pairs of sacral foramina [10].

### Clinical Significance:

Patients born with a congenital anomaly of the sacrum comprise a varied group ranging from an insignificant sacral or coccygeal defect revealed incidentally on radiography to those severely inconvenienced. Sacralisation of coccygeal vertebra may cause coccygodynia, caudal block failure, difficult second stage of labour and perineal tear. In sacralisation of coccygeal vertebra there are five pairs of sacral foramina and fifth pair transmits the S5 nerve and coccygeal nerve. Caudal anaesthesia is a widespread regional block used in children and for providing post-operative analgesia after lower trunk and lower limb operations. If the anaesthetist is unaware of coccygeal sacralisation, there may possibly be nerve block failure or insufficient analgesia after surgical procedures [11,12,13].

Usually first coccygeal vertebra is mobile and in the second stage of labour is pushed posteriorly resulting in an increase in the antero-posterior diameter of the pelvic outlet. This aids in parturition. When sacrum and coccyx are fused, coccyx becomes fixed and cannot be pushed behind. This leads to prolonged labour, perineal tear and a difficult forceps delivery. Hence, screening of all pregnant women should be done for this variant [14,15].

Thus knowledge of sacralisation of lumbar and coccygeal vertebra is of utmost importance to anatomist, orthopaedics, physicians, surgeons and obstetricians. Sacralization is also helpful for the forensic experts, anthropologists to differentiate the gender, sacral index etc [16]

### Embryological Basis:

Overexpression of Hox11 group of genes which is responsible for the genesis of sacral and caudal vertebrae can yield signs of sacralization or caudalization at other levels of the axial skeleton. The sacral structures as well as the caudal vertebrae require the activity of Hox 11 group of genes. Both areas are affected when all six Hox group 11 alleles are inactivated [17]. During developmental stages Hox group 11 genes seem to be active in somites fated to form caudal rather than sacral vertebrae [18]. Thus sacralisation of coccygeal vertebra with apex of sacrum is also caused by overexpression of Hox 11 genes in the somite stage. It has been shown that anomalous activity of the Notch, Wnt, and Fgf signalling pathways in the presomitic mesoderm also produces Hox-like transformations in the axial skeleton [19]. Regulatory genes for conversion of the mesenchyme into an epithelium of nephron appear to involve Pax2 and wnt4 [20]. Thus, sacralisation of fifth lumbar and first coccygeal vertebra may be associated with other skeletal deformity like cervical rib or genito-urinary tract anomalies in human

beings. The study can be extended to confirm this hypothesis [21].

**Table 1: Frequency distribution of lumbar sacralisation and coccygeal sacralisation**

	Total	Type I	Type II	Type III
Number of sacra	50			
Coccygeal Sacralisation	8 (16%)	4 (8%)	2 (4%)	2 (4%)

**Table 2. Comparison of incidences of Coccygeal sacralisation with our study.**

Author	Incidence (%)
Rajani Singh (2011)	13.6
Vandana A Sharma et al (2011)	7.8
Vinod Kumar et al (1992)	21.3
Postacchini F et al (1983)	37
Shailesh kumar et al (2012)	23.8
<b>Current study (2020)</b>	<b>16</b>

### CONCLUSION

At the cranial end of the sacrum when L5 fuses with S1, it is termed as Lumbar sacralisation. At the caudal end of sacrum, when first coccygeal vertebra fuses with the S5 it is termed as Coccygeal sacralisation. The classifications in the present study range from complete fusion of vertebrae to incomplete fusion of parts of the vertebrae. This is essential for diagnosis of sacralisation related diseases to understand the degree of ossification and the extent of fusion. To diagnose and treat clinical conditions related to sacrum it is important to be aware of both types of sacralisations. Sacralisation of coccygeal vertebra may cause coccygodynia, caudal block failure, difficult second stage of labour, a difficult forceps delivery and perineal tear. Thus knowledge of sacralisation of lumbar and coccygeal vertebra is of utmost importance to anatomist, orthopaedics, physicians, surgeons and obstetricians. Sacralization is also helpful for the forensic experts, anthropologists to differentiate the gender, sacral index etc.

### Competing interests:

The authors declare that they have no competing interests.

### Authors' contributions:

SR drafted the manuscript, performed the literature review & SPS assisted with writing the paper.

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