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Evaluation of Anatomical Variation of Human Coccyx on Magnetic Resonance Imaging

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ABSTRACT

Introduction:
The coccyx, a triangular bone forming the last part of the vertebral column, acts as the weight-bearing structure when a person is seated, and is the site of insertion of the pelvic floor tendons and numerous ligaments attached to it. The main objective of this study was to investigate the morphology and morphometry of the coccyx on lumbar spine MRI images in asymptomatic individuals among Nepalese adults.

Methods:
This study was conducted retrospectively on the lumbar spine images of 190 adult population without a history of trauma in the coccyx region, from April to September 2019. The coccygeal vertebrae count, the number of bone segments, and intercoccygeal and joint fusions were determined from the sagittal plane images. In addition, the length and angles were also measured**.**

Results:
One hundred and ninety patients, with a mean age of 43.91 years, were enrolled in the study. Among the 4 types of coccyx; the most common type was type II (46.3%), followed by type I (40.5%). The coccyx was formed from 4 vertebral segments in 21.1% (n=41) individuals, 3 vertebral segments in 45.3% (n=86) individuals, 2 vertebral segments in 31.1% (n=59) individuals and 1 vertebral segment in 2.1% (n=4) individuals.

Conclusions:
In our study, type II coccyxes predominated. The prevalence of sacrococcygeal and intercoccygeal fusion, as well as the number of coccygeal vertebrae, were similar in the Nepalese population and the Western population**.**

Keywords: *Bone; Coccyx; Individuals; Segments; Vertebrae*

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INTRODUCTION

The coccyx comprises the terminal vertebral segments of the human spine1 and is composed of three to five individual segments of vertebrae. The base of the coccyx articulates with the sacrum at the sacrococcygeal junction, and the angulation and degree of fusion between individual coccygeal segments are also variable. The coccyx acts as a weight-bearing structure when a person is seated and is the site of insertion of the pelvic floor tendons.[2,3] The coccygeal segment represents 0.4% of the dry weight of the vertebral column.[4] The coccyx is divided into four types; type I-slightly curved forward with its apex directed downward and caudally, type II-more forward marked curvature and forward-pointing apex, type III-very sharp forward angulation, and type IV-showing subluxation at the sacrococcygeal or intercoccygeal joint.[5] The coccyx generally has been studied with the use of cadaveric materials, plain radiography, computed tomography (CT) and magnetic resonance imaging (MRI).[1,3,5,6,7] Coccydynia, first described by Simpson in 1859, is disabling pain in the coccyx that is usually provoked by sitting or changing from a sitting to a standing position.[8] This tailbone pain may radiate rostrally to the sacrum or lumbar spine or laterally to the buttocks. One-third of patients have associated back pain, contributing to misdiagnosis.[5,9,10,11] It is well known that females have a 4 to 5 times higher incidence of Coccydynia than men.[11] Coccydynia can result from external trauma; repetitive minor trauma such as prolonged sitting on hard, uncomfortable surfaces; and internal trauma during childbirth. Other causes such as a local tumour, inflammation, disc degeneration, and idiopathy, have also been proposed.[12,13]

This study can be used for evaluating the association between coccygeal morphology and risk for developing coccydynia and its management. The main objective of this study is to investigate the morphology and morphometric variation of the coccyx on the MRI lumbar spine in asymptomatic individuals.

METHODS

A descriptive, cross-sectional study design was utilized for this study which was performed inthe Department of Radiology, Chitwan Medical College for a period of 6 months from April to September 2019. All consented adult patients referred for an MRI of the lumbar spine, without prior history of coccygeal pain or trauma were consecutively included in the study. Ethical approval was sought from IRC-CMCTH.

Demographic and participant data such as age, gender, coccygeal type, sacral straight length, coccygeal straight length, sacrococcygeal angle, intercoccygeal angle, number of coccygeal segments were collected and history of coccygeal trauma was taken by questionnaire. MR Imaging was performed on Philips Achieva 1.5T (Philips Electronics, Netherlands) in the sagittal plane. T1 weighted images with TR and TE of 400 and 8 ms respectively and T2 weighted images with TR and TE of 3000 and 120 ms respectively were used for the evaluation. Slice thickness of 4mm with an interslice gap of 0.4mm with 320x240 matrix and 350mm FOV were used. The morphological and morphometric variables assessed on MR imaging were:

a) coccygeal type,
b) number of bony segments of the coccyx,
c) bony spicules,
d) coccygeal straight length,
e) sacral straight length,
f) sacrococcygeal angle, and
g) inter coccygeal angle.

The measurements were done as shown in figure 1. The obtained data were analysed using appropriate statistical software after due reviewing of accuracy and completeness in terms of descriptive statistics.

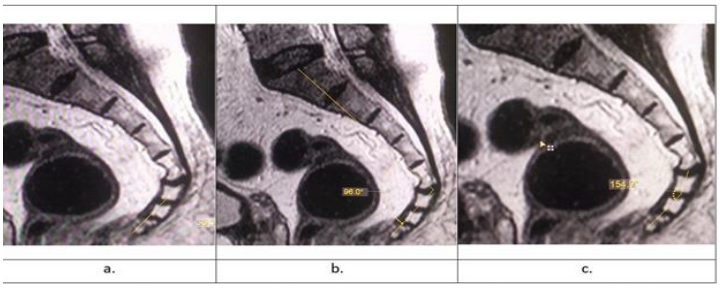

Figure 1: *Measurement of a. coccygeal straight length, b. sacrococcygeal angle, c. intercoccygeal angle*

RESULTS

Out of 190 patients, 34.7% (n=66) were male and 65.3% (n=124) were female. The age ranged from 15-84 years with a mean ± SD of 43.91±14.304, the minimum age was 18 years and the maximum age was 84 years. The most common coccygeal type-was type II [n= 88(46.3%)] followed by type I [n=

77(40.5%)], type III [n= 21(11.1%)] and type IV [n=4(2.1%)] respectively.

The study showed that the coccyx was composed of a single bony segment in 2.1% (n=4), 2 bone segments in 31.1% (n=59), 3 bony segments in 45.3% (n=86) and 4 bony segments in 21.6% (n=41) of the total population. Among the total population, 11.6% (n=22) had bony spicules whereas in 88.4 % (n=168) the spicules were absent.

The coccygeal straight length ranged from 16-48mm with the mean ± SD of 31.9184±5.31249mm. The range of sacral length ranged from 80-128mm with the mean ± SD of sacrum straight lengthwas 102.22±9.106mm. The minimum length was 81mm and the maximum length was found to be 124.40 mm. The range of intercoccygeal angle ranged from 100-164 degrees with the Mean ± SD 136.837±13.129 degrees. The maximum intercoccygeal angle was 163 degrees and the minimum intercoccygeal angle was 103.90 degrees. The range of sacrococcygeal angle ranged from 70-150 degrees with the Mean sacrococcygeal angle ± SD 107.1±10.827 degrees. The maximum sacrococcygeal angle was 148 degrees and the minimum was 70.9 degrees.

Regarding the association between sacral length and gender of the patients, the mean ± SD of (n=66) male patients was 107.383±8.818mm and the mean ±SD of (n=124) female patients was 99.48±8.028mm. There was a statically significant relation between sacrum straight length and gender of the patients which was shown by the Chi-square test (p=0.001) whereas regarding the association between coccygeal straight length and gender of the patients mean length ± SD of (n=66) male patients was 32.989±5.162 mm and mean ±SD of (n=124) female patient was 31.251±5.208 mm. Statically significant relation between sacrum straight length and the sex of the patients was shown by independent sample t-test (p=0.029). (Table 1)

The association between the mean sacrococcygeal angle and gender of the patient shows mean ±SD length of (n=66) male patient was 108.089˚±7.78 and the mean ± SD of (n=124) female patient was 107.280˚±11.76. There was a statically significant relation between the mean sacrococcygeal angle and gender of the patients, shown by independent sample t-test (p=0.02). However, the association between the mean intercoccygeal angle and gender of the patient showed the mean ± SD length of (n=66) male patients to be 132.93±13.36° and mean ±SD of (n=124) female patients to be 138.91±12.56° respectively. A statically significant relation was found between the mean intercoccygeal angle and gender of the patients as shown by independent sample t-test (p=0.003). (Table 1)

Table 1: Association of various parameters with gender

Variable	Mean ±SD		*P* (value)
	Male (66)	Female (124)	
Sacrum straight length	107.3833±8.8180	99.48±8.028	0.001
Intercoccygeal angle	132.93±13.36°	138.91±12.56°	0.003
Coccygeal length	32.989±5.126	31.251±5.208	0.029
Sacrococcygeal angle	108.089±7.78°	107.28±11.76°	0.02

In our study, regarding the distribution of coccygeal type according to the sex of the patients, among 66 male patients, 22 male patients had type I coccyx, 29 patients had type II, 13 had type III and 2 had type IV, whereas among 124 female patients, 55 had type I coccyx, 59 had type II, 8 had type III and 2 had type IV coccyx as shown in Table 2.

Table 2: Frequency of various coccygeal types according to gender

Gender	Coccygeal type				Total
	Type I	Type II	Type III	Type IV	
Male	22	29	13	2	66
Female	55	59	8	2	124
Total	**77 (40.5%)**	**88 (46.3%)**	**21 (11.1%)**	**4 (2.1%)**	**190 (100%)**

DISCUSSION

The risk of developing coccydynia can vary with age, gender, type of coccyx and morphometry of coccyx. This study evaluated the sacrococcygeal morphology, morphometry and prevalence of the type of coccyx in the Nepalese population. To the best of our knowledge, this study is the first of its kind in Nepal using MRI.

This study resulted that the coccyx was formed mostly from 3 vertebral segments (45.3%), followed by 4 vertebral segments (21.1%), 2 vertebral segments (31.1%) and 1 vertebral segment (2.1%). There was no significant association between the number of vertebrae and gender. These findings are similar to the study done by H Tetiker et al. The similarity in the findings with the same study was demonstrated in the average length of the coccyx which was 35.6mm and the length was found to be longer in male than female.[14] The average length of the sacrum was also found to be 102.22±9.106 mm and was longer in males than females. Similar findings resulted in the study by Jason T.K.Woon et.al.[2]

The sacrococcygeal angle refers to the angle between the sacral apex and the base of the coccyx. In our study, the mean sacrococcygeal angle was 107.56±10.5 degrees and the sacrococcygeal angle was found to be greater in males than in the female. Analysis of sacrococcygeal morphology in Koreans was performed by Min Geun Yoon et al. who found the mean sacrococcygeal angle to be greater in males than in the female. These findings suggest that the coccyx is generally anteverted than retroverted.[15]

Similarly, in our study, the mean intercoccygeal angle was 136.837±13.129 degrees intercoccygeal angle was found to be greater in females than in males. Analysis of coccygeal morphology in the Indian population by Venkatraman Indiran et al. found that the mean intercoccygeal curvature angle was 140.94 degrees ±19.83 degrees in males and 145.10±19.60 degrees in females respectively. These findings suggest that the female coccyx is more anteriorly angulated than the male coccyx, which may predispose to the notion that females suffer from coccydynia more than males.[16]

In our study, there were 4 types of the coccyx, the most common being type II (46.3%) followed by type I (40.5%), type III (11.1%) and type IV (2.1%) respectively which in accordance with the study done in Korean population by Yoon MG et al. whereas similar study was done by Indiran V et al. in Indian population found that type I was the most common followed by type II, type III, and type IV. [5,16] Although all these were Asian studies, the differences may be attributed to sampling size and measurement techniques. Thus, the findings of our study are both in accordance with and discordance with the findings of various European and Asian researchers, which implies that there is a significant change in coccygeal morphology and morphometry from one demographic area to another.

This study and various other literature demonstrated the difference between the length and angles of the coccyx between gender. The reason behind this could be the difference in height among the subject gender. The major limitation of this study is that the height of the patients was not included. Another limitation is that measurements were performed with the patients in supine position. The dynamics of the coccyx may alter the angles and measurements. CT scan and intraoperative assessment are helpful. [2,14,15,25]

CONCLUSION

Type II was the most common coccygeal type followed by type I, type III and type IV respectively. Most of the coccyx was formed by three coccygeal segments followed by four segments, two coccygeal segments and one coccygeal segment. The male population had longer coccyx and sacrum than the female. Similarly, males had larger sacrococcygeal anglesthan females. However female intercoccygeal angle is larger than the male, so the female coccyx is more anteriorly angulated than the male coccyx. This also implies that females have a higher chance of developing Coccydynia than males.

CONFLICT OF INTEREST

None

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None

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