Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: January 19, 2023; Accepted: March 3, 2023
doi:10.2399/ana.23.1382652

anatomy
An International Journal of Experimental and Clinical Anatomy

Magnetic resonance imaging evaluation of coccyx morphology and morphometry in childhood

Muhsin Özgün Öztürk[1], Berna Uçan[2], Kemal Buğra Memiş[1], Sonay Aydın[1]

[1]*Department of Diagnostic Radiology, Erzincan Binali Yıldırım University Mengücek Gazi Training and Research Hospital, Erzincan, Türkiye*
[2]*Department of Pediatric Radiology, Etlik City Hospital, Ankara, Türkiye*

Abstract

Objectives: Pain around the coccyx is referred to as coccydynia. Inter coccygeal and sacrococcygeal angles as well as some types of coccyx may be associated with idiopathic coccydynia. The aim of this retrospective study was to evaluate the morphology and morphometry of the coccyx using MRI and to determine whether morphologic-morphometric features are associated with coccydynia in the pediatric population.

Methods: This study was performed retrospectively on children aged 10–17 years who underwent pelvic and sacral magnetic resonance imaging for non-trauma related reasons. Inter coccygeal-sacrococcygeal angles and coccyx types were determined using sagittal T1- and T2-weighted images. Gender-specific assessments were made for intercoccigeal and sacrococcygeal angles as well as coccyx types based on Postacchinni and Massobrio classification. In statistical analysis, a p-value less than 0.05 was considered statistically significant.

Results: One hundred and fifty-six children were included in the final analysis (108 girls, 48 boys). The mean age of the cases was 13.8 years (10–17). Type 1 was the most common type overall, accounting for 57.7% of the population. The sacrococcygeal angles of boys were significantly higher than those of girls. A significant negative correlation was found between age and sacrococcygeal angle. In children with Type 1 and Type 2 coccyx, girls had significantly higher intercoccigeal angles than boys. The intercoccigeal angle varied significantly in each coccyx type and the intercoccigeal angles increased significantly as the coccyx type increased (from Type 1 to Type 4). The most common coccyx type in the coccidynia group was Type 2, while the most common type in the control group was Type 1. The mean intercoccigeal angles of children with coccidynia were significantly higher than those of the control group.

Conclusion: Coccydynia is a symptom with many possible reasons rather than a diagnosis. Coccyx morphology and morphometry can be associated with idiopathic coccydynia. To better understand these morphological and morphometric features, especially in the pediatric population, larger population studies are required.

Keywords: coccyx; intercoccygeal angle; MRI; sacrococcygeal angle

Anatomy 2023;17(2):55–61

Introduction

The coccyx is thought to be named after its resemblance to the beak of the cuckoo bird.[1] It is the triangular terminal bone of the spine and consists of three to five segments with different disc spaces. Except for the first intercoccygeal joint, the intercoccygeal disc spaces are normally fused.[2,3] The coccyx faces inferiorly and anteriorly from the sacral apex.[1] It is very important for maintaining weight support while sitting.[4] It provides an attachment surface for the sacro-coccygeal, sacro-spinous and sacro-tuberous ligaments, such as the levator ani and iliococcygeus muscles.[2]

Coccydynia is a term used to describe pain around the coccyx. The causes of coccydynia have been demonstrated by various studies. It may be idiopathic or caused by tumor, inflammation, trauma or disc degeneration.[5–7] It is known that women are affected by coxidynia four to five times more than men.[6,7] The morphology of the coccyx varies considerably in the population. Four types of morphological variants have been described by

Postacchinni and Massobrio: Type 1, found in more than 50% of the population, is characterized by a slight ventral curvature with a caudally tapering apex of the coccyx; Type 2 involves a more pronounced ventral curvature with an anteriorly directed apex, found in 8–32% of the population; Type 3 has an acute anterior angulation without subluxation and is found in 4–16% of the population; Type 4 is characterized by subluxation at the sacro-coccygeal or inter-coccygeal joint.[8]

Compared with normal individuals, the incidence of Type 1 coccyx is lower and the incidence of Type 2, 3 and 4 coccyx is higher in patients with coccidynia.[2] Similarly, Woon et al.[9] showed that the incidence of coccidynia was higher in patients with marked ventral curvature of the coccyx. However, the Postacchinni and Massobrio classification is based on description rather than any measurement that can objectively show the differences between the groups.[10]

The intercoccigeal angle is the angle between the first and last segment of the coccyx.[10] According to Kim and Suk[11] this angle is a useful radiologic assessment that can accurately determine the increased angular deformity of the coccyx. In their study, they also found that patients with coccydynia and asymptomatic population differed significantly in terms of intercoccigeal angles.

Magnetic resonance imaging (MRI) is a useful technique to evaluate the anatomic and morphometric features of the sacrococcygeal region.[4,9] Many studies have investigated the relationship between coccidin and morphologic-morphometric features of the coccyx in adults using computed tomography (CT) and MRI.[1,2,4,6,9] To our knowledge, there is no previous study investigating the relationship between coccygeal morphology-morphometry and coccydynia in the pediatric population. In this study, MRI was used to investigate coccyx morphology and morphometry in children to understand the relationship between different coccyx types and intercoccigeal-sacrococcygeal angles in relation to coccydynia.

Materials and Methods

This study was performed retrospectively in a pediatric population aged 10–17 years who underwent pelvic and sacral MRI for any reason other than trauma in the Radiology Clinic of Erzincan Binali Yıldırım University Mengücek Gazi Training and Research Hospital between January and December 2019, and those with coccydynia were identified through the hospital information system. Exclusion criteria included history of trauma, bone dysplasia, skeletal immaturity (not allowing measurement of the intercoccigeal or sacrococcygeal angle) and incomplete penetration of the coccyx into the imaging field. Thus, among 170 children screened with pelvic or sacral MRI; 14 were excluded and 156 children (48 boys, 108 girls) were included in the final analysis.

A 1.5 Tesla MRI scanner (Magnetom Aera, Siemens Healthcare GmbH, Erlangen, Germany) was used. Evaluation of the coccyx type and measurement of the intercoccigeal-sacrococcygeal angles were performed using sagittal T1- and T2-weighted images. After acquisition, the images were sent to the workstation where two expert radiologists performed the morphologic evaluation and morphometric measurements in consensus. The type of coccyx was determined for each patient according to the Postacchinni and Massobrio categorization:[8]

- **Type I:** Slight ventral curvature of the coccyx with a caudally tapering apex
- **Type II:** More pronounced ventral curvature with apex facing anteriorly
- **Type III:** Acute anterior angulation without subluxation
- **Type IV:** Subluxation of the sacro-coccygeal or inter-coccygeal joint

Coccyx types and the intercoccigeal-sacrococcygeal angle were evaluated according to gender groups. The angle formed between the lines drawn at the midpoints of the first and last coccygeal vertebrae was used to calculate the inter coccygeal joint angle.[12] Inter coccygeal angle measurement is shown in **Figure 1**. To determine the sacrococcygeal angle, a line through the middle of the superior and inferior tips of S1 and another line through the middle of the superior and inferior tips of the first coccygeal vertebrae were used.[12] Sacrococcygeal angle measurement is shown in **Figure 2**.

Data analysis was performed using SPSS version 20 (Social Sciences Software for Windows, IBM Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test was used to determine whether the data were normally distributed. Mean and standard deviation were used to present normally distributed numerical variables. Categorical variables were reported using numbers and percentages. Fisher's chi-square test was used to compare the percentages of coccidine between coccyx types. Inter coccygeal and sacrococcygeal angles were compared between sexes and between coccidynia and non-coccidynia groups using Student's t-test. The presence of coccidynia was compared between genders using Fisher's chi-square test. The difference in the intercoccigeal angle between the four coccyx type subgroups was tested with one-way ANOVA test. Possible correlations between age and intercoccigeal and sacrococcygeal angles were tested with Pearson's correlation. A p-value less than 0.05 was considered statistically significant.

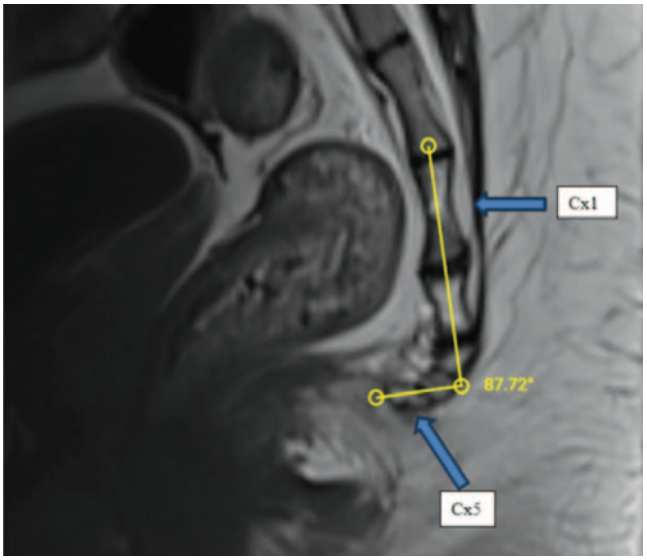

Figure 1. T1-weighted sagittal MRI section. The **intercoccigeal angle** was measured as the angle formed between the lines drawn through the midpoints of the first and last coccygeal vertebrae. The first coccygeal (C×1) and fifth coccygeal vertebra (C×5) are indicated by **blue arrows**.

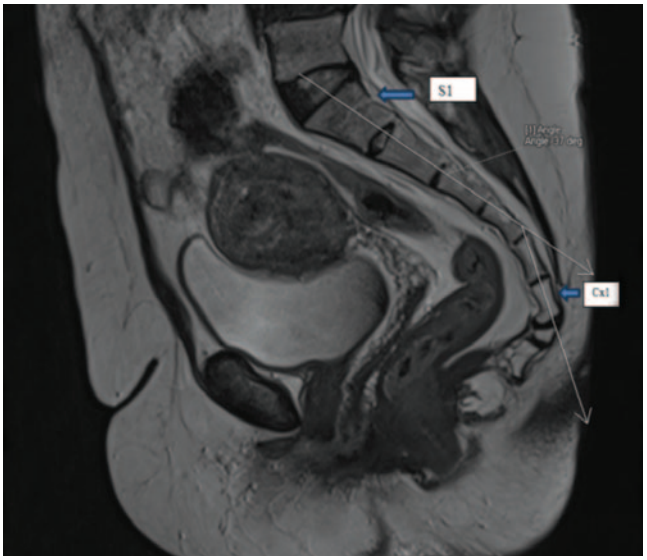

Figure 2. T1-weighted sagittal MRI section. The **sacrococcygeal angle** was measured as the angle between a line through the middle of the upper and lower endplates of S1 and another line through the middle of the upper and lower endplates of the first coccygeal vertebra. The first sacral (S1) and first coccygeal vertebra (C×1) are indicated by **blue arrows**.

Results

One hundred and fifty-six children were included in the final analysis. One hundred and eight of the children were girls (69.2%) and 48 were boyes (30.8%). The mean age was 13.8 years (mean: 10–17 years).

In the whole group, 90 children (57.7%), 61 girls and 29 boys, had Type 1 coccyx. This was the most common type observed in our study. **Table 1** shows the distribution of coccyx types by gender in the general population (including subjects with and without coccydynia). **Figures 3** and **4** show the four different types of coccyx seen in the subjects. The mean sacrococcygeal angle was found to be 92.2°±14.0, with a range of 40.0° to 140.0°. The mean sacrococcygeal angle in males and females was 98.3°±13.4 and 80.1°±14.1, respectively. The sacrococcygeal angle in male children was found to be significantly higher than that in females ($p<0.05$). A significant negative correlation was found between age and sacrococcygeal angle ($r=0.79$).

The mean intercoccygeal angle in overall population was 43.2°±10.5 with a range of 0° to 93.0°. The mean intercoccygeal angle in males and females was 37.7°± 10.2 and 46.9°±9.1, respectively. In the children who had Type 1 and Type 2 coccyx, the intercoccygeal angle in girls was significantly higher than that in boys ($p<0.05$). The intercoccygeal angles were significantly increased with increasing coccyx type (from Type 1 to Type 4) ($p<0.05$). The mean, minimum and maximum intercoccygeal angles in different coccyx types were shown in **Table 2**.

In girls who had Type 1 and Type 2 coccyx, the mean intercoccygeal angles were 40.1°±10.5 and 55.1°±10.3; and in boys who had Type 1 and Type 2 coccyx they

Table 1
Distribution of coccyx types according to gender.

Coccyx types	Females (n, %)	Males (n, %)	Total (n, %)
Type 1	61 (56.4%)	29 (60.4%)	90 (57.7%)
Type 2	32 (29.6%)	12 (25%)	44 (28.2%)
Type 3	10 (9.2%)	5 (10.4%)	15 (9.6%)
Type 4	5 (4.6%)	2 (4.1%)	7 (4.4%)
Total	*108*	*48*	*156*

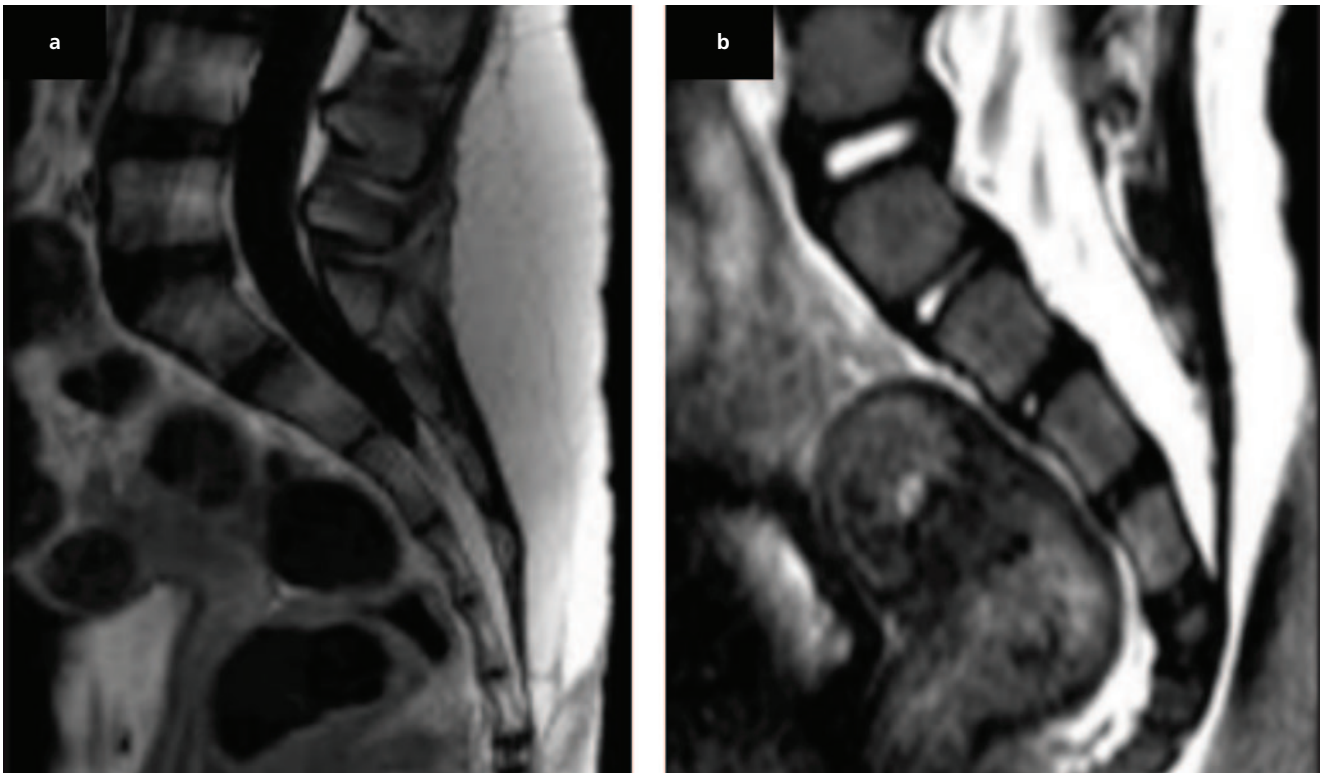

Figure 3. Type 1 coccyx (**a**) and Type 2 (**b**) coccyx are shown on sagittal MRI section.

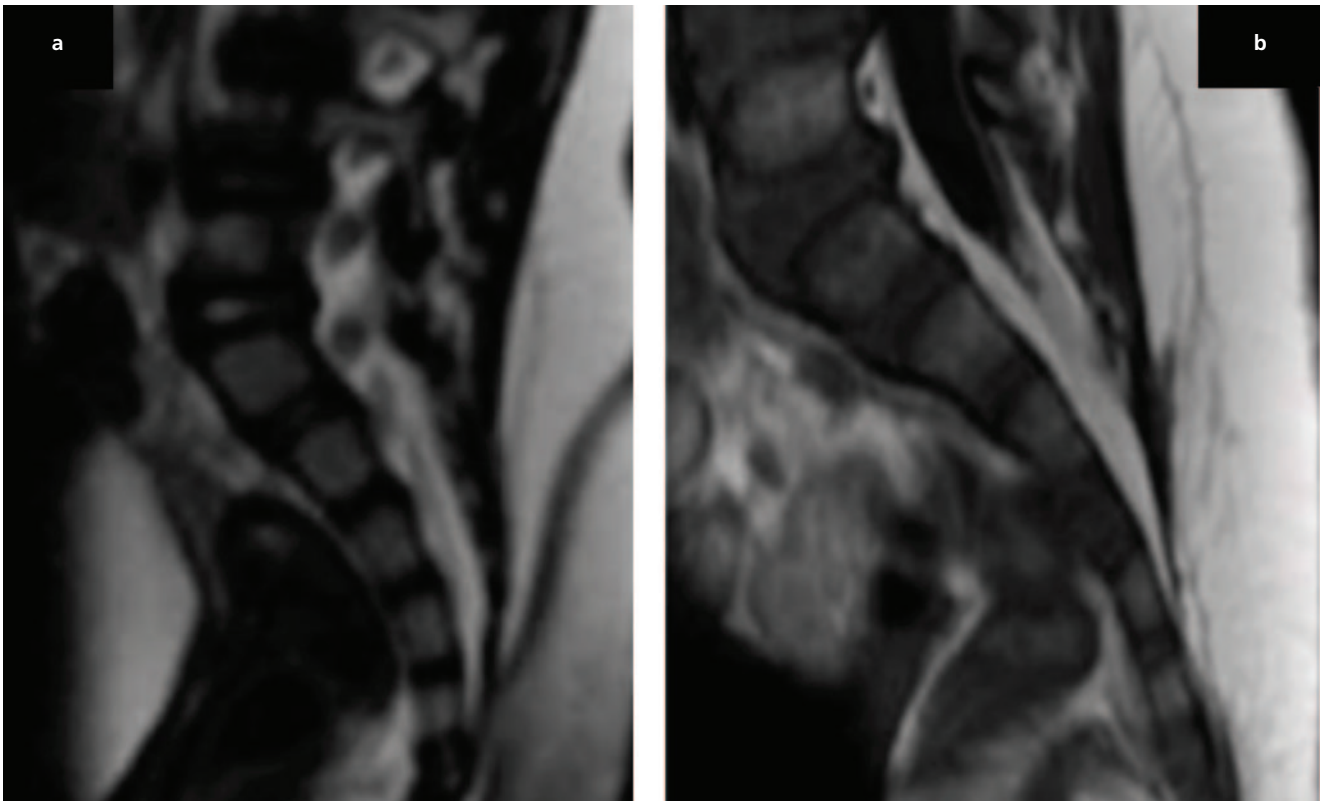

Figure 4. Type 3 coccyx (**a**) and Type 4 (**b**) coccyx are shown on sagittal MRI section.

were 33.0°± 9.6 and 46.2°±11.0; respectively. Due to the restricted number of patients who had Type 3 and 4 coccyx, we combined the subjects in these groups and assessed the mean intercoccygeal values for the female and male groups, which were 82.2°±8.1 and 79.1°±11.3; respectively. There was no statistically significant difference between boys and girls who had Type 3 and Type 4 coccyx (p=0.12).

The hospital information system revealed the presence of coccydynia in 47 children, consisting of 30 girls and 17 boys. Additionally, the system detected 109 children, comprising of 78 girls and 31 boys, who did not have coccydynia. **Tables 3** and **4** demonstrate the distribution of coccyx types based on gender in children with and without coccydynia, respectively. The mean intercoccygeal angles of children with and without coccydynia were 66.2°±9.5 and 36.2°±10.8; respectively. Intercoccygeal angles of children with coccydynia were significantly higher than those without coccydynia (p<0.05).

The mean sacrococcygeal angle in children with and without coccydynia was found to be 75.2°±13.0 and 76.3°±15.1; respectively. No significant difference was found between coccydynia and the control group in terms of sacrococcygeal angle (p=0.13).

Table 2
The mean, min and max intercoccygeal angles in different coccyx types.

Intercoccygeal angle	Mean±SD	Min-Max
Type 1	35.8°±10.5	0°–44°
Type 2	51.6°±10.8	20°–61°
Type 3	70.1°±10.8	44°–81°
Type 4	80.1°±12.7	59°–93°

Discussion

Most previous research has focused on the management of coccydynia as well as its diagnosis and radiological categorization in adult populations. This study provides a comprehensive evaluation of coccyx types and intercoccigeal-sacrococcygeal angle measurements in children. The study included children with idiopathic coccidynia and healthy individuals. There are several studies evaluating coccyx types and coccygeal morphometry in the adult population.[1,2,4,6,8–13]

In the study by Geneci et al.[13] the mean sacrococcygeal angle measured in CT scans of adult cadavers was found to be 23.6°±16.50°. However, in our study with pediatric subjects, we observed that the mean sacrococ-

Table 3
Distribution of coccyx types according to gender in children with coccydynia.

Coccyx types in children with coccydynia	Females (n, %)	Males (n, %)	Total (n, %)
Type 1	5 (16.6%)	3 (17.6%)	8 (17.0%)
Type 2	12 (40.0%)	7 (41.1%)	19 (40.4%)
Type 3	8 (26.6%)	5 (29.4%)	13 (27.6%)
Type 4	5 (16.6%)	2 (11.7%)	7 (14.9%)
Total	*30*	*17*	*47*

Table 4
Distribution of coccyx types according to gender in children without coccydynia.

Coccyx types in children with coccydynia	Females (n, %)	Males (n, %)	Total (n, %)
Type 1	56 (71.7%)	26 (83.8%)	82 (75.2%)
Type 2	20 (25.6%)	5 (16.1%)	25 (22.9%)
Type 3	2 (2.5%)	0 (0%)	2 (1.8%)
Type 4	0 (0%)	0 (0%)	0 (0%)
Total	*78*	*31*	*109*

cygeal angle was significantly higher being 92.2°±14.0. This suggests that muscle tone surrounding the coccyx and sacrum may play a role in shaping this angle. Our study also supported the findings of three previous studies showing that the sacrococcygeal angle was significantly higher in males compared to females.[1,14,15]

Tetiker et al.[1] did not observe any gender difference in intercoccigeal angle. In our study, intercoccigeal angles of girls with Type 1 and Type 2 coccyx were found to be significantly higher than boys. Previous studies have suggested that these types of coccyxes are less prone to coccydynia.[11] There was no statistically significant difference between boys and girls in terms of intercoccigeal angle in Type 3 or 4 coccyxes. This may indicate that the intercoccigeal angle alone may not be the sole determinant of women's propensity to develop coccydynia.

Shams et al.[4] compared a group with coccidine with a control group in a study using MRI in adults and found that the most common coccyx type was Type 2 in both groups. Kim and Suk[11] also reported that the most common type in adult patients with coccidynia was Type 2. Yoon et al.[6] reported that the most common coccyx type in asymptomatic Korean adults was Type 2 and Kerimoğlu et al.[6,10] reported that the most common coccyx type in asymptomatic Turkish adults was Type 1. In our study, while Type 1 coccyx was the most common type in the control group, Type 2 coccyx was found to be the most common type in the coccydynia group. The fact that the rates of Type 3 and 4 were higher in coccydynia patients compared to the control group in our study suggests that Type 3 and 4 patients are more likely to develop coccidynia. On the other hand, we found only 2 children with Type 3 or Type 4 coccyx but without coccydynia. Shams et al.[4] and Kim and Suk[11] found a significant difference in intercoccigeal angles between the coccydynia group and the control group, which is compatible with our results. The increase in intercoccigeal angles in the coccidine group means that the coccyx exhibits more anterior curvature in coccidine patients compared to the control group. These findings suggest that forward curvature of the coccyx may cause compression and compression of adjacent tissues and nerves. Shams et al. and Gupta et al.

Shams et al.[4] and Gupta et al.[12] did not observe a statistically significant difference between the group with coccidynia and the control group in terms of sacrococcygeal angle, which is in agreement with our findings. These findings suggest that the sacrococcygeal angle may not have an important role as a cause of coccydynia.

Inter coccygeal angles were found to be significantly higher in the female pediatric population compared to males. This may explain the higher incidence of idiopathic coccidynia in females. However, in contrast to our findings, Yoon et al.[6] reported that the intercoccigeal angle was significantly higher in males than in females. All the studies we compared our results were carried out in adults. To the best of our knowledge, this study on coccyx morphology and morphometry is the first study undertaken in pediatric population.

Our study has some limitations. We did not assess the number and length of coccygeal vertebrae because of the large age-related variation in ossification and bone growth in the pediatric population. Other limitations include the retrospective nature of the study, the relatively small number of patients, and the consensus assessment of types and angles rather than interobserver agreement. Furthermore, weight, height and BMI were not included in our data, although they have been associated with certain morphologic or morphometric parameters of the coccyx in previous studies.[14] Furthermore, it was not possible to assess changes in the intercoccigeal angle and sacrococcygeal angle with the patient in a sitting or standing position.

Conclusion

Although the most common coccyx type in patients with coccidynia was found to be Type 2 in our study as well as in previous studies in the literature, coccidynia was present in almost all cases with Type 3 and Type 4 coccyx. These findings emphasize the relationship between coccyx types and coccidynia. In addition, intercoccigeal angles were significantly higher in patients with coccidynia, indicating that there is a relationship between intercoccigeal angle and coccidynia formation. However, the lack of a defined cutoff value for the intercoccigeal angle may hinder objectivity. Based on our research and other studies, if coccydynia patients have a Type 3 or Type 4 coccyx or a high intercoccigeal angle, it would be useful to consider these factors as potential causes of coccydynia. This will help avoid unnecessary examinations and investigations, saving both time and money. If a child is diagnosed with coccydynia, taking angle measurements and determining the type of coccyx can provide information about the cause. Taking these measurements routinely and determining the type of coccyx is very important as it can potentially prevent the need for extensive examinations and enable appropriate treatment to be started early. Further research with larger population samples is needed to study these morphologic and morphometric features of the coccyx, especially in pediatric demographics.

The results of this study once again emphasize that coccydynia is a symptom with many possible causes rather than a diagnosis. Idiopathic coccydynia appears to be asso-

ciated with coccyx morphology and morphometry. The coccyx may show morphologic and morphometric abnormalities associated with coccidynia. A thorough understanding of these features will help in the diagnosis of idiopathic coccidynia.

Conflict of Interest

There are no conflicts of interest to be disclosed.

Author Contributions

MÖÖ: designed the research study, performed the research, analyzed the data and wrote the manuscript; BU: designed the research study; KBM: performed the research, analyzed the data and wrote the manuscript; SA: designed the research study, contributed towards analytic tools, analyzed the data and wrote the manuscript. All authors have read and approve the final manuscript.

Ethics Approval

Approval for this study was obtained from the institutional ethics committee (Ethics Committee of Erzincan Binali Yıldırım University, Erzincan, Turkey, decision number: EBYU-KAEK-2022-11-E1457.3027-003, 17/11/2022).

Funding

We have no financial relationships to be disclosed.

References

1. Tetiker H, Koşar Mİ, Çullu N, Canbek U, Otağ İ, Taştemur Y. MRI-based detailed evaluation of the anatomy of the human coccyx among Turkish adults. Niger J Clin Pract 20:136–42.
2. Garg B, Ahuja K. Coccydynia-a comprehensive review on etiology, radiological features and management options. J Clin Orthop Trauma 2021;12:123–9.
3. Balain B, Eisenstein SM, Alo GO. Coccygectomy for coccydynia: case series and review of literature. Spine (Phila Pa 1976) 2006;31: E414–20.
4. Shams A, Gamal O, Mesregah MK. Sacrococcygeal morphologic and morphometric risk factors for idiopathic coccydynia: a magnetic resonance imaging study. Global Spine J 2023;13:140–8.
5. Lirette LS, Chaiban G, Tolba R, Eissa H. Coccydynia: an overview of the anatomy, etiology, and treatment of coccyx pain. Ochsner J 2014;14:84–7.
6. Yoon MG, Moon MS, Park BK, Lee H, Kim DH. Analysis of sacrococcygeal morphology in Koreans using computed tomography. Clin Orthop Surg 2016;8:412–9.
7. Karadimas EJ, Trypsiannis G, Giannoudis PV. Surgical treatment of coccygodynia: an analytic review of the literature. Eur Spine J 2011;20:698–705.
8. Postacchini F, Massobrio M. Idiopathic coccygodynia. Analysis of fifty-one operative cases and a radiographic study of the normal coccyx. J Bone Joint Surg Am 1983;65:1116–24.
9. Woon JTK, Maigne J-Y, Perumal V, Stringer MD. Magnetic resonance imaging morphology and morphometry of the coccyx in coccydynia. Spine (Phila Pa 1976) 2013;38:E1437–45.
10. Kerimoglu U, Dagoglu MG, Ergen FB. Intercoccygeal angle and type of coccyx in asymptomatic patients. Surg Radiol Anat 2007;29: 683–7.
11. Kim NH, Suk KS. Clinical and radiological differences between traumatic and idiopathic coccygodynia. Yonsei Med J 1999;40:215–20.
12. Gupta V, Agarwal N, Baruah BP. Magnetic resonance measurements of sacrococcygeal and intercoccygeal angles in normal participants and those with idiopathic coccydynia. Indian J Orthop 2018; 52:353–7.
13. Geneci F, Denk CC, Uzuner MB, Ocak M, Dogan I, Sayaci EY, Gurses IA, Cay N, Baykal D, Celik HH, Comert A. Morphometric evaluation of coccyx with microcomputed tomography (micro CT) and computed tomography (CT) technology. Tıpta Yenilikçi Yaklaşımlar Dergisi 2022;3:1–19.
14. Woon JTK, Perumal V, Maigne JY, Stringer MD. CT morphology and morphometry of the normal adult coccyx Eur Spine J 2013;22:863–70.
15. Marwan YA, Al-Saeed OM, Bendary AM, Elsayed M, Azeem A. Computed tomography-based morphologic and morphometric features of the coccyx among Arab adults. Spine (Phila Pa 1976) 2014;39:1210–9.

ORCID ID:
M. Ö. Öztürk 0009-0000-3356-3481;
B. Uçan 0000-0002-2109-139X;
K. B. Memiş 0009-0007-6746-3906;
S. Aydın 0000-0002-3812-6333

Correspondence to: Muhsin Özgün Öztürk, MD
Department of Diagnostic Radiology, Erzincan Binali Yıldırım University Mengücek Gazi Training and Research Hospital, Erzincan, Türkiye
Phone: +90 507 514 56 86
e-mail: ozturk_bul@hotmail.com

Conflict of interest statement: No conflicts declared.

 How to cite this article: Öztürk MÖ, Uçan B, Memiş KB, Aydın S. Magnetic resonance imaging evaluation of coccyx morphology and morphometry in childhood. Anatomy 2023;17(2):55–61.