



COMPUTED TOMOGRAPHY-BASED EVALUATION OF SACROCOCCYGEAL MORPHOLOGY IN ADULT PATIENTS WITH CHRONIC COCCYDYNIA: A RETROSPECTIVE STUDY

Halil Büyükdoğan¹, Hüseyin Buğra Altundal², Ekremcan Karaer², İbrahim Taşkın Rakıcı³, Sinan Erdoğan¹

¹İstinye University Faculty of Medicine, Gaziosmanpaşa Hospital, Department of Orthopedics and Traumatology, İstanbul, Türkiye

²University of Health Sciences Türkiye, İstanbul Training and Research Hospital, Department of Orthopedics and Traumatology, İstanbul, Türkiye

³University of Health Sciences Türkiye, İstanbul Training and Research Hospital, Department of Radiology, İstanbul, Türkiye

ABSTRACT

Objective: Chronic coccydynia is persistent pain in the coccygeal region whose aetiology is multifactorial and remains unclear. Variations in sacrococcygeal morphology, angular alignment, and fusion patterns may have clinical relevance in these patients. Computed tomography provides detailed visualisation of the bony anatomy of the sacrococcygeal region. This study aimed to evaluate the sacrococcygeal angle, the intercoccygeal angle, and the S5-Co1 fusion status in adult patients with chronic coccydynia and to examine their associations with age, sex, and categorical age groups.

Materials and Methods: This retrospective study included 122 patients aged 20-60 years with chronic coccydynia who had available sagittal computed tomography images suitable for sacrococcygeal morphometric assessment. Sacrococcygeal angle, intercoccygeal angle, and S5-Co1 fusion were assessed on sagittal computed tomography images. Patients were analysed by sex, age group, and fusion status. Normality was evaluated using the Shapiro-Wilk test, and appropriate parametric or non-parametric tests were applied. A p-value <0.05 was considered statistically significant.

Results: The mean age was 37.89±12.10 years, and 78 patients were female. The mean sacrococcygeal and intercoccygeal angles were 68.47±15.05° and 38.64±19.09°, respectively. S5-Co1 fusion was present in 53 patients. The intercoccygeal angle was lower in females than in males (35.73±18.63° vs. 43.79±19.00°, p=0.024). Patients with S5-Co1 fusion had a smaller sacrococcygeal angle than those without fusion (65.30° vs. 72.20°, p=0.006). No significant differences were observed among age groups.

Conclusion: In adult patients with chronic coccydynia, the intercoccygeal angle differed by sex, and S5-Co1 fusion was associated with a smaller sacrococcygeal angle. These findings suggest that computed tomography-based assessment of sacrococcygeal morphology may provide useful structural information in symptomatic patients with chronic coccydynia.

Keywords: Coccydynia, coccyx, computed tomography, intercoccygeal angle, sacrococcygeal fusion

INTRODUCTION

Coccydynia is pain localised to the coccygeal region and may persist beyond the acute phase. Trauma, childbirth, obesity, degenerative changes, and abnormal coccygeal mobility have been implicated, but the underlying mechanism often remains unclear, particularly in patients without an obvious precipitating factor⁽¹⁻⁵⁾. Chronic coccydynia can be clinically challenging, especially in patients who do not respond adequately to conservative treatment, and therefore may require further radiological evaluation and interventional pain

procedures^(6,7). Because variations may influence pain in this region in coccygeal alignment, segmental anatomy, and joint mobility, radiological evaluation is important for understanding the possible structural background of chronic symptoms.

The coccyx shows considerable anatomical variation. Classical radiographic studies described different coccygeal configurations and suggested that ventral angulation, subluxation, and abnormal alignment may be associated with idiopathic coccygodynia^(8,9). Dynamic radiographic studies later emphasised the role of abnormal mobility, including hypermobility and luxation^(10,11). More recent

Address for Correspondence: Halil Büyükdoğan, İstinye University Faculty of Medicine, Gaziosmanpaşa Hospital, Department of Orthopedics and Traumatology, İstanbul, Türkiye

E-mail: drbuyukdogan@outlook.com

ORCID ID: orcid.org/0000-0002-0202-444X

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computed tomography (CT) and magnetic resonance imaging (MRI) studies have evaluated coccygeal type, bony spicules, subluxation, sacrococcygeal and intercoccygeal fusion, and angular morphometric parameters⁽¹²⁻¹⁸⁾. Among these, the sacrococcygeal and intercoccygeal angles are commonly used to describe sagittal alignment. Previous studies suggest that the intercoccygeal angle may differ between patients with coccydynia and asymptomatic individuals, whereas findings regarding the sacrococcygeal angle and sacrococcygeal fusion are less consistent⁽¹⁴⁻¹⁸⁾.

Age- and sex-related differences further complicate the interpretation of coccygeal morphology. CT- and MRI-based studies have shown that coccygeal curvature, angular parameters, fusion patterns, and coccygeal length may vary across populations^(13,19-28). Although Turkish population data are available for general coccygeal morphology, data specifically focusing on patients with chronic coccydynia and evaluating angular parameters together with S5-Co1 fusion remain limited^(20,21,27,28). Therefore, this study aimed to evaluate the sacrococcygeal angle, intercoccygeal angle, and S5-Co1 fusion status in adult patients with chronic coccydynia using sagittal CT images, and to examine their associations with age, sex, and age groups.

MATERIALS AND METHODS

Study Design and Patient Selection

This retrospective radiological study was conducted after approval was obtained from the University of Health Sciences Türkiye, İstanbul Training and Research Hospital Institutional Ethics Committee (approval no: 224, date: 12.09.2025). Patient data were retrospectively reviewed with ethics committee approval, and all data were anonymized before analysis. The study was performed in accordance with the principles of the Declaration of Helsinki.

The medical and radiological records of adult patients evaluated for chronic coccydynia at two centres between May 2022 and December 2023 were retrospectively reviewed. Chronic coccydynia was defined as pain localised to the coccygeal region persisting for at least 3 months, consistent with previous studies⁽¹⁻⁵⁾. The study cohort was limited to patients aged 20 to 60 years with chronic coccydynia and sacrococcygeal CT images available in the institutional imaging archive. Direct radiographs were not used in this study because standardised, high-quality radiographs that consistently demonstrated the sacrococcygeal bony anatomy and allowed the planned measurements were not available for all patients. Furthermore, the number of patients with available MRI scans was limited. Therefore, patients with appropriate sagittal CT images that enabled radiological analysis of bony morphology, angular alignment, and S5-Co1 fusion status were included in the study. Patients with a history of pelvic or sacrococcygeal fracture, previous surgery or instrumentation involving the

sacrococcygeal region, bone metastasis, tumour, infection, or destructive bone lesions affecting the sacrum or coccyx were excluded.

Demographic data, including age and sex, were recorded. Patients were also categorised into four age groups: 20-30 years, 31-40 years, 41-50 years, and 51-60 years.

Radiological Evaluation

All radiological evaluations were performed using sagittal CT images of the sacrococcygeal region. The assessed radiological parameters were the sacrococcygeal angle, intercoccygeal angle, and the presence of S5-Co1 fusion.

The sacrococcygeal and intercoccygeal angles were selected as angular morphometric parameters because they have been used in previous radiological studies evaluating coccygeal morphology and coccydynia^(13-17,22,23). The presence of sacrococcygeal fusion was assessed radiologically, consistent with previous CT- and MRI-based studies investigating sacrococcygeal morphology and fusion patterns^(13-17,19-21,24,25).

The sacrococcygeal angle was measured on sagittal CT images to evaluate the angular alignment between the sacrum and coccyx (Figure 1A). The intercoccygeal angle was measured to assess sagittal angulation between coccygeal segments (Figure 1B). S5-Co1 fusion was recorded as present or absent according to the continuity of the bony structure between the fifth sacral vertebra and the first coccygeal segment on sagittal CT images (Figure 1C). All measurements were performed once by a single radiologist. Representative CT images demonstrating the measurement of the sacrococcygeal angle, intercoccygeal angle, and S5-Co1 fusion are shown in Figure 1.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 27.0.1 (IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed using the Shapiro-Wilk test, and variance homogeneity was evaluated using Levene's test. Descriptive data were presented as mean $\pm$ standard deviation or median (range) for continuous variables, and as number and percentage for categorical variables. Since age and sacrococcygeal angle were not normally distributed, non-parametric tests were used for these variables, whereas parametric tests were used for the normally distributed intercoccygeal angle. Accordingly, the Mann-Whitney U test,



Figure 1. Representative sagittal computed tomography images demonstrating radiological measurements and fusion assessment. (A) Measurement of the sacrococcygeal angle. (B) Measurement of the intercoccygeal angle. (C) Presence of S5-Co1 fusion

Kruskal-Wallis test, Student's t-test, one-way analysis of variance, chi-square test, and Spearman correlation analysis were used where appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 122 patients were included in the study. The mean age was 37.89 ± 12.10 years. Seventy-eight patients were female (63.93%), and 44 were male (36.07%). S5-Co1 fusion was present in 53 patients (43.44%) and absent in 69 patients (56.56%). The mean sacrococcygeal angle was $68.47 \pm 15.05^\circ$, and the mean intercoccygeal angle was $38.64 \pm 19.09^\circ$. Demographic and radiological characteristics are summarised in Table 1.

When patients were compared by sex, the sacrococcygeal

Table 1. Demographic and radiological characteristics of the study population

Variable	Value
Number of patients	122
Age, years, mean $\pm$ SD	37.89 ± 12.10
Age, years, median (range)	37.00 (20-60)
Sex, n (%)	
Female	78 (63.93)
Male	44 (36.07)
Age group, n (%)	
20-30 years	41 (33.61)
31-40 years	35 (28.69)
41-50 years	21 (17.21)
51-60 years	25 (20.49)
Sacrococcygeal angle, $^\circ$, mean $\pm$ SD	68.47 ± 15.05
Sacrococcygeal angle, $^\circ$, median (range)	69.70 (14.30-89.60)
Intercoccygeal angle, $^\circ$, mean $\pm$ SD	38.64 ± 19.09
Intercoccygeal angle, $^\circ$, median (range)	39.30 (0.00-85.00)
S5-Co1 fusion, n (%)	
Present	53 (43.44)
Absent	69 (56.56)

Data are presented as mean $\pm$ SD, median (range), or number (%), as appropriate. SD: Standard deviation, S5-Co1: Fifth sacral vertebra-first coccygeal segment

angle did not differ between females and males [68.45 (14.30-89.60) vs. 71.45 (34.40-88.60) degrees, $p=0.311$]. However, the intercoccygeal angle was lower in females than in males ($35.73 \pm 18.63^\circ$ vs. $43.79 \pm 19.00^\circ$, $p=0.024$) (Figure 2A). S5-Co1 fusion rates were similar between females and males (43.59% vs. 43.18%, $p=1.000$) (Table 2).

Patients with S5-Co1 fusion had a smaller sacrococcygeal angle than those without fusion [65.30 (14.30-88.60) vs. 72.20 (34.40-89.60) degrees, $p=0.006$] (Figure 2B). In contrast, age [35.00 (20-60) vs. 37.00 (20-60) years, $p=0.735$], sex distribution ($p=1.000$), and intercoccygeal angle ($36.47 \pm 18.73^\circ$ vs. $40.30 \pm 19.32^\circ$, $p=0.273$) did not differ according to fusion status (Table 3).

No significant differences were observed among age groups in terms of sacrococcygeal angle, intercoccygeal angle, or S5-Co1 fusion status ($p=0.820$, $p=0.690$, and $p=0.610$, respectively). In correlation analyses, age was not associated with sacrococcygeal angle ($r=-0.06$, $p=0.520$), intercoccygeal angle ($r=-0.11$, $p=0.240$), or S5-Co1 fusion ($r=-0.03$, $p=0.735$).

DISCUSSION

The present study evaluated sacrococcygeal angle, intercoccygeal angle, and S5-Co1 fusion status in adult patients with chronic coccydynia using sagittal CT images. The main

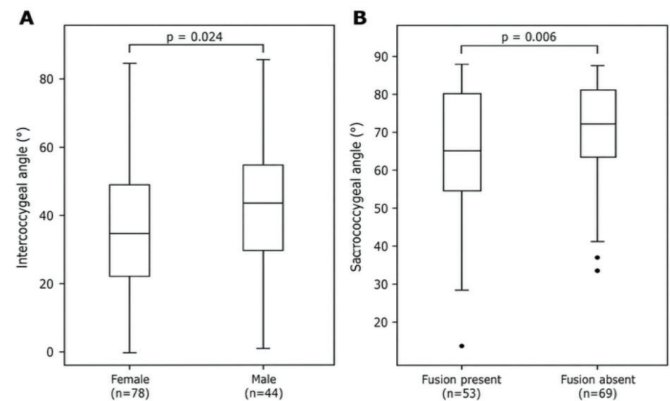


Figure 2. Boxplot comparisons of the main radiological findings. (A) Intercoccygeal angle according to sex. (B) Sacrococcygeal angle according to S5-Co1 fusion status

Table 2. Comparison of demographic and radiological parameters according to sex

Variable	Female (n=78)	Male (n=44)	Test	p-value
Age, years, median (range)	39.50 (21-60)	32.50 (20-58)	Mann-Whitney U	0.001
Sacrococcygeal angle, $^\circ$, median (range)	68.45 (14.30-89.60)	71.45 (34.40-88.60)	Mann-Whitney U	0.311
Intercoccygeal angle, $^\circ$, mean $\pm$ SD	35.73 ± 18.63	43.79 ± 19.00	Student's t-test	0.024
S5-Co1 fusion, n (%)			Chi-square	1.000
Present	34 (43.59)	19 (43.18)		
Absent	44 (56.41)	25 (56.82)		

Age and sacrococcygeal angle were compared using the Mann-Whitney U test due to non-normal distribution. Intercoccygeal angle was compared using Student's t-test. Categorical variables were compared using the chi-square test. SD: Standard deviation, S5-Co1: Fifth sacral vertebra-first coccygeal segment

Table 3. Comparison of demographic and radiological parameters according to S5-Co1 fusion status

Variable	Fusion present (n=53)	Fusion absent (n=69)	Test	p-value
Age, years, median (range)	35.00 (20-60)	37.00 (20-60)	Mann-Whitney U	0.735
Sex, n (%)			Chi-square	1.000
Female	34 (64.15)	44 (63.77)		
Male	19 (35.85)	25 (36.23)		
Sacrococcygeal angle, °, median (range)	65.30 (14.30-88.60)	72.20 (34.40-89.60)	Mann-Whitney U	0.006
Intercoccygeal angle, °, mean ± SD	36.47±18.73	40.30±19.32	Student's t-test	0.273
Age and sacrococcygeal angle were compared using the Mann-Whitney U test due to non-normal distribution. Intercoccygeal angle was compared using Student's t-test. Categorical variables were compared using the chi-square test. SD: Standard deviation, S5-Co1: Fifth sacral vertebra-first coccygeal segment				

findings were that the intercoccygeal angle was significantly lower in female patients than in male patients, and that patients with S5-Co1 fusion had a significantly smaller sacrococcygeal angle than those without fusion. In contrast, age and age groups were not significantly associated with sacrococcygeal angle, intercoccygeal angle, or fusion status. These findings suggest that angular morphology and fusion-related alignment may represent relevant radiological characteristics in patients with chronic coccydynia.

Coccydynia is a multifactorial condition, and a single anatomical or clinical factor cannot usually explain its pathophysiology. Prior radiographic, dynamic, CT, and MRI studies have associated coccygeal pain with alignment, mobility, subluxation, fusion patterns, bony spicules, and angular morphometric parameters^(1-5,8-11,13-18,29). In this context, our study adds to the literature by focusing specifically on CT-based angular measurements and S5-Co1 fusion in a symptomatic adult cohort.

The intercoccygeal angle is one of the most frequently used parameters for describing sagittal coccygeal angulation. Several studies have suggested that increased ventral angulation or a higher intercoccygeal angle may be more common in patients with idiopathic coccydynia than in asymptomatic controls^(12,14-18). Gupta et al.⁽¹⁵⁾ reported that the intercoccygeal angle was higher in patients with idiopathic coccydynia, whereas the sacrococcygeal angle did not differ significantly between patients and controls. Similarly, Kim and Suk⁽⁹⁾ found that radiological features differed between traumatic and idiopathic coccygodynia, with greater coccygeal angulation in idiopathic cases. These findings support the idea that segmental coccygeal angulation may be clinically relevant. However, because our study did not include an asymptomatic control group, our results should not be interpreted as showing whether the intercoccygeal angle is increased or decreased in chronic coccydynia compared with the general population. Rather, our data show that within a cohort of patients with chronic coccydynia, the intercoccygeal angle differed by sex.

Sex-related differences in coccygeal morphology have been reported in several imaging and anatomical studies. In many CT-based studies, males tend to have longer coccyges and larger sacrococcygeal dimensions. In contrast, females may have a

shorter, relatively straighter coccyx, although findings on angular parameters are not fully consistent across populations^(13,19-28,30). Woon et al.⁽¹³⁾ reported sex-related differences in normal adult coccygeal morphology on CT, and Yoon et al.⁽¹⁹⁾ similarly demonstrated that sacrococcygeal morphology may vary according to sex and age in a Korean population. Studies from Turkish and other regional populations also show that coccygeal morphology and angular measurements may vary considerably between populations^(20,21,27,28,30). In the present cohort, males had a higher intercoccygeal angle than females, while sacrococcygeal angle and S5-Co1 fusion did not differ by sex. This suggests that sex-related morphology may be parameter-specific. The higher proportion of female patients in our cohort is consistent with the well-documented female predominance of coccydynia. However, it should not be interpreted as evidence of causality in the absence of a control group.

The relationship between sacrococcygeal fusion and coccydynia remains less clear. Some MRI-based studies have suggested that sacrococcygeal fusion may be less frequent in patients with idiopathic coccydynia, supporting the hypothesis that persistent mobility at the sacrococcygeal joint may contribute to pain^(14,16,17). In contrast, older radiographic data and large CT-based population studies have shown that sacrococcygeal fusion is also common in asymptomatic adults and may vary according to age, sex, population, and imaging method^(8,13,19-25,27,28,31,32). In our study, S5-Co1 fusion was present in 43.44% of patients and was not associated with age or sex. However, patients with fusion had a smaller sacrococcygeal angle than those without fusion. This finding is important because it suggests that fusion may be related not only to the presence or absence of joint mobility, but also to the fixed sagittal alignment of the sacrococcygeal junction. Whether a smaller sacrococcygeal angle precedes fusion, results from fusion, or reflects a shared anatomical pattern cannot be determined from the present data.

Population-based CT studies provide useful context because sacrococcygeal and intercoccygeal fusion and angular variability are also common in asymptomatic adults^(13,19-21). Turkish population studies similarly report wide variability in coccygeal morphology and fusion patterns^(20,21). Compared with these studies, our cohort included only patients with chronic

coccydynia. It was restricted to the 20-60-year age range, which may partly explain why age and age groups were not significantly associated with fusion or angular parameters in our data.

The absence of a significant age-related relationship in our study deserves careful interpretation. Although several anatomical and imaging studies have reported that sacrococcygeal ossification or fusion becomes more frequent with age, particularly in older adults^(19,21,27,31,32), this relationship is not uniformly demonstrated across CT-based cohorts^(13,19-25). The upper age limit of 60 years and the symptomatic nature of our cohort may have reduced the ability to detect late-age-related fusion patterns.

CT has a clear role in evaluating the bony anatomy of the sacrococcygeal region. It allows detailed visualisation of segmental morphology, bony continuity, fusion, spicules, deformity, and angular alignment^(13,19-25,29). However, CT should not be interpreted as a routine first-line or cost-effective imaging modality for all patients with coccydynia. Direct radiography, particularly standardised sitting and standing dynamic lateral radiographs, remains clinically valuable for evaluating coccygeal mobility, hypermobility, and luxation^(10,11). In addition, radiographic and spinopelvic parameters have been investigated in patients with coccydynia. Ersen et al.⁽⁷⁾ evaluated pelvic incidence and coccygeal configuration and reported that higher pelvic incidence was associated with type 3 or type 4 coccygeal configurations and surgical treatment. In the present study, CT was used to evaluate bony sacrococcygeal morphology and S5-Co1 fusion status in patients with clinically obtained CT images available for retrospective analysis. Because standardised sitting and standing dynamic radiographs were not available for all patients, dynamic coccygeal instability could not be evaluated, and CT-based measurements could not be compared with dynamic radiographic parameters. MRI may also provide additional information on bone marrow oedema, soft-tissue inflammation, disc or joint changes, and other pain-generating conditions not visible on CT^(14-17,29). Therefore, CT-based morphometric parameters should be interpreted as part of a broader clinical and radiological assessment rather than as isolated diagnostic markers.

Study Limitations

This study has several limitations. First, its retrospective design limits the ability to establish causal relationships. Second, the absence of an asymptomatic control group prevents direct comparison with the general population. Therefore, the observed findings should be interpreted as radiological associations within a symptomatic cohort with chronic coccydynia rather than as definitive pathological risk factors. This limitation also restricts the ability to distinguish whether the observed angular and fusion-related patterns represent normal anatomical variation or morphology specifically associated with coccydynia. Third, the cohort was limited to patients with clinically obtained CT images available for retrospective analysis; therefore, CT should not be considered a routine or cost-effective imaging modality

for all patients with coccydynia, based on the present study. Fourth, standardised sitting and standing dynamic radiographs were not available for all patients; therefore, coccygeal mobility, hypermobility, and luxation could not be evaluated, and CT-based measurements could not be compared with dynamic radiographic parameters. Fifth, all measurements were performed once by a single radiologist; therefore, intraobserver and interobserver reliability analyses could not be performed. This limits the assessment of measurement reproducibility. Finally, MRI findings were not assessed; therefore, bone marrow oedema, soft-tissue inflammation, and other potential pain-generating abnormalities could not be evaluated.

CONCLUSION

In this series of adult patients with chronic coccydynia, the intercoccygeal angle was lower in females than in males, and S5-Co1 fusion was associated with a smaller sacrococcygeal angle. Age and age groups were not associated with the evaluated angular parameters or fusion status. These findings indicate that CT-based assessment of sacrococcygeal morphology may provide useful structural information in symptomatic patients with chronic coccydynia. Further controlled studies incorporating standardised dynamic radiographs, clinical outcome measures, and reproducibility analyses are needed to clarify the clinical significance of these findings.

Ethics

Ethics Committee Approval: This retrospective radiological study was conducted after approval was obtained from the University of Health Sciences Türkiye, İstanbul Training and Research Hospital Institutional Ethics Committee (approval no: 224, date: 12.09.2025).

Informed Consent: Patient data were retrospectively reviewed with ethics committee approval, and all data were anonymized before analysis.

Footnotes

During the preparation of this manuscript, the authors used AI tools to support language editing, manuscript section organization, and the refinement of academic wording. The authors critically reviewed and edited all AI-assisted outputs, verified the scientific content, statistical results, and references, and take full responsibility for the final content of the manuscript.

Authorship Contributions

Surgical and Medical Practices: H.B., H.B.A., S.E., Concept: H.B., S.E., Design: H.B., S.E., Data Collection or Processing: H.B., H.B.A., E.K., İ.T.R., Analysis or Interpretation: H.B., H.B.A., E.K., İ.T.R., Literature Search: H.B., H.B.A., E.K., Writing: H.B.

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