

Is this coccyx fractured, or is it a normal variant? A cohort study

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All procedures in this study involving human
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No conflict of interest was declared by the
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Abstract

Background/Aim: The coccyx has several variants which could sometimes be confused with fractures. Our study aimed to alert physicians about the types of coccyges that can be easily confused with coccyx fractures in daily practice.

Methods: Mid-sagittal and mid-coronal computerized images of 75 patients were analyzed to determine the types of coccygeal fracture, the coccyx types, number of segments, joint fusion, coccygeal bony spicules, subluxation, sacrococcygeal angle (SCA), intercoccygeal angle (ICA), and lateral deviation of the coccyx.

Results: The mean age of the patients was 43.5 (13.6) years. There were 33 (44%) males, and 42 (56%) females. While 57 (76%) patients were thought to have a coccygeal fracture, only 18 patients (24%) actually had them. There was a significant difference between the coccyx types mistaken for fractures and actual coccygeal fractures ($P<0.001$).

Conclusion: It is essential to know the coccyx types and distinguish normal variants from fractures. If the difference between coccyx fractures and coccyx types is known and the patients are informed accordingly, both the loss of workforce decreases, and the necessary treatment can be started early.

Keywords: Back injuries, Coccyx, Spinal injuries, Spinal fractures

Introduction

The coccyx is derived from the Greek word "kokkūs" because it resembles the inclined beak of a cuckoo. The coccyx is a triangular-shaped bone consisting of 3 to 5 fused vertebral segments at the terminal part of the vertebra [1]. It is a vital structure because it forms a leg of the tripod together with the two ischia and is an adhesion site for numerous pelvic muscles and in the pelvic region [2].

Local pain on the coccyx, "coccydynia" [3], was first described by Simpson in history [2]. The etiology is multifactorial, and the most common cause is trauma. Structurally, the most common causes of coccydynia are instabilities and bone spicules. Coccydynia can be seen after an external trauma, such as a fall, an internal trauma caused by birth, or because of microtrauma due to prolonged sitting on hard and uneven surfaces. Female gender and obesity are predisposing factors that increase the risk of coccydynia. It should also be remembered that non-organic causes may present as somatization [4].

Coccyx fractures are the most critical cause of coccydynia which occur after external and internal (obstetrical fractures) trauma. After external traumas, flexion (type 1) and compression (type 2) fractures are seen. Extension (type 3) fractures occur after internal traumas. All three types of fractures affect different areas. Flexion (type 1) fractures affect the sacrococcygeal area consisting of the lower sacrum (S5) or upper coccyx (Co1). Compression (type 2) fractures affect the Co1 and Co2 vertebrae. Compression (type 2) fractures are vertical, and the fracture line extends from the upper to the lower endplate. The lower coccyx is affected in extension (type 3) fractures [5].

In clinical examination, the sacrococcygeal area should be inspected for the presence of pilonidal sinuses or cysts. Masses and muscle spasms in the surrounding tissues are also evaluated. Localized tenderness and swelling may often be revealed by palpation of the sacrococcygeal region. In most cases of coccydynia, a rectal examination with a thumb and an index finger is essential. The coccyx is grasped and evaluated for pain, tenderness, crepitation, and sacrococcygeal hypo-hypermobility. Pain can be elicited by rectal manipulation of the coccygeal segments or sacrococcygeal joint in patients with coccydynia.

Fracture, mass, and degenerative changes can be evaluated in more detail. A dynamic X-ray is obtained while the patient is sitting and standing. Typically, the coccyx moves between 5-25 degrees on the anterior or posterior axis in the sitting position and returns to its normal position when the patient stands up. The presence of >25 degrees or <5 degrees movement is considered abnormal [6]. This imaging reveals abnormalities such as luxation and subluxation in 70% of patients with coccydynia. In the recent years, MRI was used as a second-line diagnostic method to investigate the coccyx. It can reveal edema and inflammation in the tissue. Hyperintense signal increases are noteworthy, especially in T2-weighted STIR images, and indicate local inflammatory lesions. MRI is also used to exclude mass diagnosis in persistent pain [3].

In coccydynia treatment, it is possible to achieve up to 90% success with conservative methods [2]. Initially, seat cushions, NSAIDs, hot-cold applications, and manipulations are

recommended, and lifestyle changes are implemented. Treatment methods such as steroid injection [7] and blockade [8] are also available for long-term pain. In case of persistent pain, coccygectomy [9] is the last option.

The coccyx morphology of the patients was evaluated from the computed tomography images obtained to exclude vertebral injury. This study aimed to raise awareness about coccyx structures and typical variants that can easily be confused with coccyx fractures in daily practice.

Materials and methods

The ethics approval for this retrospective study was received from Atatürk University Faculty of Medicine, Clinical Research Ethics Committee (meeting number: 08, decision no: 07, date: 26.12.2019). This study was conducted in accordance with the STROBE guidelines.

The files of patients presenting to the emergency service between December 2018 and December 2019 were retrospectively scanned. One hundred and thirty-six patients were consulted for coccyx fractures by doctors working in the emergency department. Inclusion criteria were complete bone development and patients with no additional fractures. Exclusion criteria from the study were incomplete bone development, presence of iliac bone fracture, sacroiliac joint luxation, and presence of femoral head or neck fracture.

After the implementation of the inclusion and exclusion criteria, 75 patients were included in this study. Seventy-five patients who underwent vertebral tomography in the emergency department due to simple trauma were evaluated. Computed tomography images of the patients were evaluated by a single orthopedic surgeon (AZ).

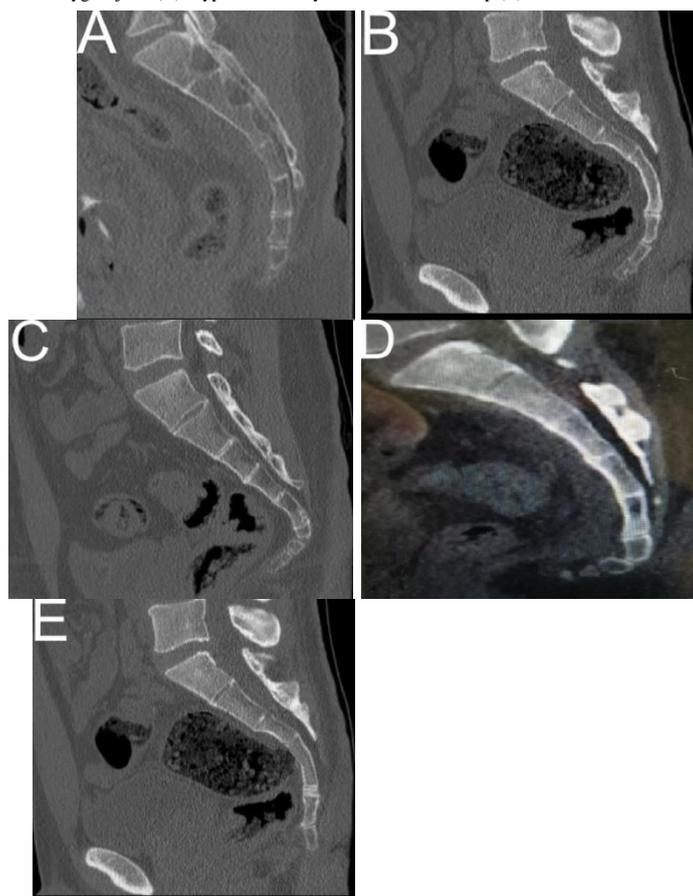
Mid-sagittal and mid-coronal images were obtained from the computed tomography images of the patients. From these images, the type of coccyx (Figure 1), number of segments, joint fusion, coccygeal bony spicules, subluxation, sacrococcygeal angle (SCA), intercoccygeal angle (ICA), and lateral deviation of the coccyx were evaluated (Table 1).

Table 1: Definitions of terms

	Definition [10]
Joint fusion	Bony continuity between adjacent vertebrae on all sagittal slices (at sacrococcygeal and/or intercoccygeal joints)
Coccygeal types	Type 1 is a slightly curved coccyx pointing downwards; type 2 is more curved and points forwards; type 3 is sharply angulated at the first or second intercoccygeal joint; type 4 is a coccyx with an anterior subluxation at the sacrococcygeal or first intercoccygeal joint; and type 5 is a coccyx with a retroverted tip.
Bony spicule	A bone spicule projecting from the terminal coccygeal segment
Joint subluxation	Abnormal translation between two adjacent vertebrae at the intervertebral disc.
Lateral deviation of the tip of the coccyx	Determined by measuring the angle between the tip of the coccyx and a line passing through the middle of the sacrum
Sacrococcygeal angle	Formed by the intersection of a line between the midpoint of the upper borders of S1 and Co1 and a line between the latter and the tip of the coccyx
Intercoccygeal angle	The intercoccygeal angle formed between the lines intersecting the middle of the first and last coccygeal segments in the median plane. Sacrococcygeal joint angle (S5-Co1) and the first and second intercoccygeal joint angles (Co1-Co2 and Co2-Co3) were also measured.

S: Sacrum, Co: Coccyx

Figure 1: Type 1 is a slightly curved coccyx pointing downwards (A). Type 2 is more curved and points forwards (B). Type 3 is sharply angulated at the first or second intercoccygeal joint (C). Type 4 is a coccyx with an anterior subluxation at the sacrococcygeal or first intercoccygeal joint (D). Type 5 is a coccyx with a retroverted tip (E).



Statistical analysis

IBM SPSS Statistics 22 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.) software was used to evaluate the findings obtained in this study. The normality of parameter distributions was assessed with the Shapiro Wilk test. Descriptive statistics (mean, standard deviation, frequency) and Student's t-tests were used to compare the parameters of the patients. Fisher's Exact tests, Fisher Freeman Halton tests, and Yates Correction for Continuity were used to compare qualitative data. Independent samples t-test was used to compare quantitative data. A P-value of <0.05 indicated statistical significance.

Results

There were 33 (44%) males, and 42 (56%) females. The mean age of 75 patients was 43.5 (13.6) (range: 19-70) years. Coccyx types, segmentation numbers, the presence of fusion, spicule, subluxation, lateralization, and types of coccyx fractures were shown in Table 2 according to the number and rates of patients.

The mean sacrococcygeal and intercoccygeal angles obtained in the computed tomography images of the patients with normal coccygeal variants was 110.2 (11.4) (range: 87-135) degrees, and 41.6 (11.8) (range: 20-70) degrees, respectively.

Seven (38.9%), eight (44.4%) and three (16.7%) patients had type 1, type 2, and type 3 fractures, respectively. A significant difference was found between patients with coccyx fractures and those with typical coccyx variants (P<0.001).

Table 2: The results of the patients

		Patients (n)	Percentage %	Total Patients (%)
Coccygeal types	1	25	43.9%	57 (76.0%)
	2	16	28.1%	
	3	10	17.5%	
	4	4	7.0%	
	5	2	3.5%	
Segmentation Numbers	2	10	17.5%	
	3	25	43.9%	
	4	20	35.1%	
	5	2	3.5%	
Fusion	No	44	77.2%	
	Yes	13	22.8%	
Spicule of coccyx	No	51	89.5%	
	Yes	6	10.5%	
Subluxation	No	49	86.0%	
	Yes	8	14.0%	
Lateralization	No	46	80.7%	
	Yes	11	19.3%	
Fracture	Type 1	7	38.9%	18 (24.0%)
	Type 2	8	44.4%	
	Type 3	3	16.7%	
P-value				<0.001

n: number

Discussion

Being the attachment point of many ligaments, muscles, and tendons, and changing angles in the standing and sitting positions, the coccyx has essential and dynamic functions in the human body. It consists of 3-5 fused vertebral segments. In 2013, Woon et al. found that the most common number of segments was 4, but ranged from 3-5, in a healthy adult coccyx when examined by CT [10]. Marwan et al. examined the coccyx morphology in the Arab community in 2014 [11] and reported that it most contained 3 fused segments (68%). In a study by Przybylski et al., 50.8% of coccyges had three fused segments [12]. In our study, the number of patients with three fused segments were 43.9%. The number of segments may vary between ethnic groups and from person to person. In daily practice, these morphological changes of coccyx should not be perceived as fractures or dislocations.

Different types of coccyges were described in the literature. The first classification was made radiologically by Postacchini in 1983 [13]. In his study, type 1 was the most common, with a rate of 68%. In 2004, Dennell et al. reported a retroverted coccyx [14]. In 2007, Kerimoglu et al. suggested that retroverted coccyx types be referred to as "type 0" [15]. In 2013, Woon et al. added the retroverted coccyx to the literature as "type 5" in tomographic image examination [10]. In our study, type 1 was the most common with a rate of 43.9%. The retroverted coccyx (type 5) was detected in only two patients.

In 2012, Woon et al. [1] performed sacrococcygeal and intercoccygeal measurements in 112 adult CT scans. The SCA and ICA were 166 and 143 degrees, respectively. No significant differences existed between the two genders in terms of both angles. SCA and ICA measurements of 202 patients in CT scans examined by Marwan [11] in the Arab population were 110.9 and 132.5 degrees, respectively. A significant difference was found between males and females. In our study, the SCA and ICA were 110 and 138 degrees, respectively. The two genders were similar in terms of SCA and ICA.

The presence of subluxation, bone spicule, fusion, and lateralization may differ between ethnic groups. In Woon's study in 2012, subluxation was rarely found in the New Zealand population, bone spicule rate was 23%, and 57% of patients had fusion [1]. In the studies of Marwan [11] and Shalaby [16], subluxation was found in 31.7%, bone spicule, in 54%, fusion, in

38.6%, and lateralization, in 38.6% among the Arab population. In our study, the rates of subluxation, bone spicule, fusion, and lateralization were 14%, 10.5%, 22.8%, and 19.3%, respectively.

Coccyx types are often confused with coccyx fractures in daily practice. Flexion (type 1) fractures occur after a fall or impact that affects the sacrococcygeal joint. This fracture affects the S5 and Co1 vertebrae and forces the sacrococcygeal joint to flexion (Figure 2). Flexion fractures can be confused with type 2, type 3, and type 4 coccyges. Compression (type 2) fractures also occur after external trauma by the compression of the first independent coccygeal vertebra. These fractures which involve the Co1 or Co2 vertebrae are also named "nutcracker fractures" [5]. A compression fracture makes a vertical fracture line. These type 2 fractures are unstable. Furthermore, the fracture line could hardly be visible on standard radiographs. Dynamic radiographs or CT scans should be ordered to establish the diagnosis. Compression (type 2) fractures may be mixed with type 1 coccyges (Figure 3). Extension (type 3) fractures occur in obstetrical fractures and affect the lower coccygeal vertebra (Figure 4). These fractures are mostly confused with coccyges type 4 or type 5.

Figure 2: Flexion (type 1) fracture causes a forced flexion of the lower sacrum or upper coccyx. The arrow shows the fracture line.



Figure 3: Compression (type 2) fracture affects the first independent coccygeal vertebra. The arrow shows the fracture area.

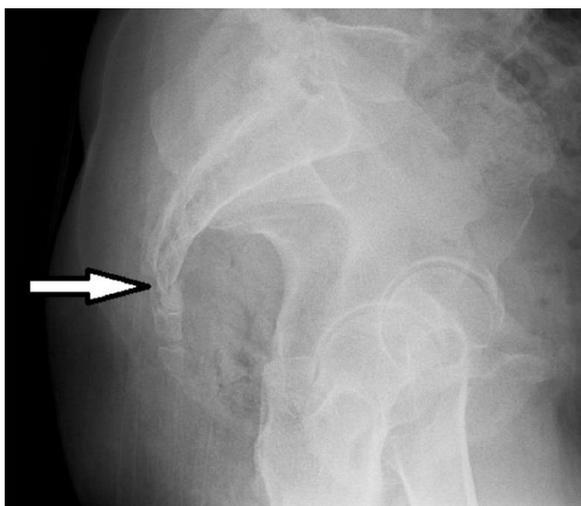
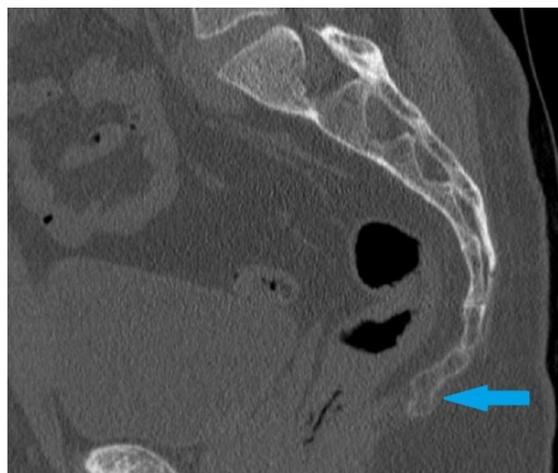


Figure 4: Extension (type 3) fracture occurs in obstetrical fractures and affects the lower coccygeal vertebra. The arrow shows the fracture line.



Limitations

The limitations of our study include the small number of patients, and its single centered design. Also, the patients were evaluated with CT imaging only. Simultaneous studies with multiple patients and CT and MR imaging results from many centers can provide more detailed information.

Conclusion

Some coccyx types could be confused with coccygeal fractures. To avoid this confusion, patients should be evaluated with computed tomography.

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