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Morphometric evaluation of coccyx in patients with coccydynia and classification

Koksidinialı Hastalarda koksiksin morfometrik değerlendirilmesi ve klasifikasyonu

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ABSTRACT

Aim: This study aimed to aimed to classiffication the morphological and pathological anatomic features of patients with coccydynia.
Patients and Method: Patients over 16 years of age who were admitted to Alanya Alaaddin Keykubat University Educational Research Hospital with complaints of coccydynia between April 2015 and April 2018, were included in the study. The sitting and standing coccyx and anterior-posterior pelvic radiographs of the patients were examined retrospectively.
Results: It was observed that coccyx scoliosis, hypermobility, and dislocation were unrelated to sacrococcygeal angulation. There was a positive correlation between sacrococcygeal and intercoccygeal angles in the measurements of sitting and standing coccyx radiographs of the patients. There was a correlation between the length of the sacrum and length of the coccyx and also the intercoccygeal angle and coccyx length in the unoperated patients. There was a positive correlation between length of the sacrococcygeal joint and sacrococcygeal angle in males. Fusion in the sacrococcygeal joint was less in females.
Conclusion: In the evaluation of patients with coccydynia, it should not be forgotten that the coccyx is a spinal segment which can move in all planes and develop pathology. Side and AP positioned sitting and standing dynamic radiography is an effective method for the detection of pathology in this patients. New classification including pathology in all three planes is needed in the classification of patients with coccydynia. We believe that our classification will eliminate this deficit.

Keywords: coccydynia, coccyx, classification, Morphology

ÖZ

Amaç: Koksidinalı hastalarda morfolojik ve patolojik anatominin özellikleri sınıflandırmayı amaçladık.
Hastalar ve Yöntem: Nisan 2015 - Nisan 2018 tarihleri arasında Alanya Alaaddin Keykubat Üniversitesi Eğitim Araştırma Hastanesine koksidina yakınması ile başvuran 16 yaş ve üzerindeki hastalar çalışmaya dahil edildi. Hastaların oturarak ve ayakta çekilen koksiks ve ön-arka pelvis grafileri retrospektif olarak incelendi.
Bulgular: Koksiksin skolyozunun, hipermobilitesinin ve dislokasyonunun sakrokoksigeal açılanma ile ilişkili olmadığı görüldü. Hastaların oturarak ve ayakta çekilen koksiks grafi ölçümlerinde sakrokoksigeal ve interkoksigeal açıları arasında pozitif yönlü anlamlı bir ilişki bulundu. Ameliyat olmamış hastalarda sakrum ve koksiks uzunluğu arasında ve interkoksigeal açı ve koksiks uzunluğu arasında ilişki bulundu. Erkeklerde sakrokoksigeal eklem uzunluğu ile sakrokoksigeal açı ilişkili bulundu. Kadınlarda sakrokoksigeal eklemde füzyonun daha düşük olduğu tespit edildi.
Sonuç: Koksidina yakınması ile gelen hastalar değerlendirilirken koksiksin tüm düzlemlerde hareket edebilen ve patoloji geliştirebilen bir omurga segmenti olduğu unutulmamalıdır. Bu hastaların yan ve AP pozisyonda oturarak ve ayakta çekilen dinamik direkt grafilerle değerlendirilmesi patolojinin bulunmasında etkili bir yöntemdir. Koksidinalı hastalarının sınıflandırılmasında her üç düzlemde patoloji içeren yeni sınıflandırma gereklidir. Sınıflandırmamızın bu eksikliği gidereceğini düşünmekteyiz.

Anahtar Sözcükler: Koksidinia, Koksiks, Sınıflandırma, Morfoloji

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INTRODUCTION

The coccyx is a conical, distal-most section of the spine, usually consisting of 3-4 segments. Although the sacrococcygeal junction may rarely fuse, it usually remains mobile for life [1,2].

Coccydynia was first used by Simpson in 1859 to describe pain surrounding the coccyx exacerbated by sitting [1-3]. Its etiology includes sitting for long periods of time, falling, traumas that may occur during birth or spinal surgery, and less frequently, chordoma, intraductal schwannoma, perineural cysts, giant-cell tumor, and intraosseous lipoma. However, cases where the cause is not found are also quite frequent [1-3]. Conservative methods such as use of donut-shaped cushions, rest, medical treatment, physical therapy, massage, radiotherapy, psychotherapy, sacral rhizotomy, manipulation, epidural injection, and local injection have been successfully applied in the treatment of coccydynia [1-4]. Coccygectomy surgery is performed in patients who do not benefit from conservative treatment methods [3,5].

Direct coccyx radiography along with computed tomography (CT), three dimensional CT, and magnetic resonance imaging (MRI) is used to evaluate patients with coccydynia, which is more frequently observed in women than in men. However, direct radiography is frequently used for evaluation due to its fast results, ease of access, low price, and easy dynamic filming [6-9].

It has been reported that the morphological and pathoanomical features of the coccyx are important in the development of coccydynia. Clinical studies use the Postacchini-Massobrio classification, which is based on the angle of the sagittal plane between the sacrum and the coccyx, and revised in 2010 to assess the coccyx. The movement and hypermobility of the coccyx's sagittal, coronal, and horizontal plane may lead to coccydynia [1,2,10-12]. In this study, we aimed to classiffication the morphological and pathological anatomic features of patients with coccydynia.

PATIENTS AND METHODS

In our study, patients aged 16 years or older who were admitted to Alanya Education and Research Hospital between April 2015 and April 2018 with complaints of coccydynia were screened retrospectively. Patients with clear imaging of sitting and standing, side direct coccyx radiography, and direct posteroanterior pelvis radiography were included in the study. Patients with tumors in the coccyx region and patients who had previously undergone surgery in this region for another reason were excluded from the study. Our work was approved by the Ethics Committee of Alaaddin Keykubat University (date 06.07.2018 number 2 decision 8).

On the direct coccyx radiographs of the patients, sacrum length, coccyx length, sacrococcygeal joint length, sacrococcygeal angle and intercoccygeal angle were measured. The number of coccyx segments and presence of fusion in the sacrococcygeal joint were evaluated. Additionally, intercoccygeal and sacrococcygeal angles were measured for scoliosis, and degree of dislocation in patients with dislocation was measured with dynamic radiography. For dynamic radiography, direct side coccyx radiographs of the patients were taken in standing position and after 15 minutes of standing, in an upright sitting position (Figure 1a,b). The angle between the midpoint of the sacrum's upper endplate and the midpoint of the upper endplate of the first coccyx segment (cocx 1), and the angle between the line drawn from there to the end of the coccyx was evaluated as sacrococcygeal angle (Figure 2a). The angle between the line drawn from the first cocx midpoint to the second cocx rear lower corner and the line drawn from this point to the extreme end of the coccyx was evaluated as the intercoccygeal angle (Figure 2b). On the anterior-posterior pelvic radiography, the angle between the line drawn from the midpoint of the upper endplate of the sacrum to the midpoint of the upper endplate of cocx 1 and the line drawn from this point to the tip of the coccyx was evaluated as the scoliosis angle (Figure 3). Patients who underwent surgery were identified among these patients.

Statistical Analysis

All measurements were evaluated by anatomists using the Winsoft RIS / PACS Ver.2.2.39 imaging server. IBM SPSS for Windows version 20.0 software program (IBM Corp., Armonk, NY, USA) was used for statistical analysis.

Correlation between sacrum and coccyx length, between intercoccygeal angle and coccyx length, between joint length and sacrococcygeal angle, and between sacrum and coccyx length and intercoccygeal angle of patients who were and weren't operated were evaluated by Pearson correlation tests. Correlation between number of segments and angle types and the relationship between non-operative status and angle types were assessed with the Chi Square test. The t-test was used to determine whether there was a significant difference between intercoccygeal angle and sacrococcygeal angle and number of segments. Mann-Whitney U test was used to evaluate whether there was a significant difference between patients with and without coccyx retroversion, coccyx retroversion and gender, coccyx length, intercoccygeal angle, number of segments, number of sacrum, sacrococcygeal angle length, and length of coccyx in patients with and without scoliosis. P-value of less than 0.05 was considered statistically significant.

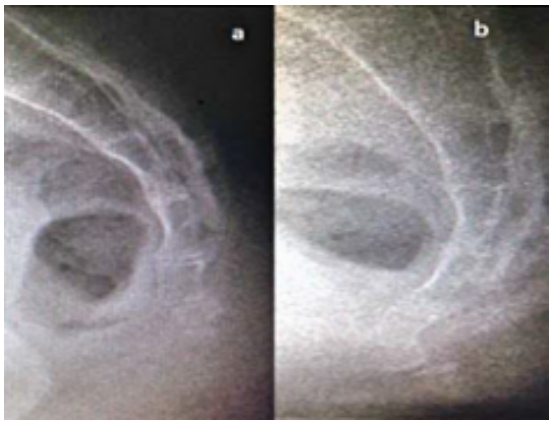

Figure 1. Dislocation of the distal posterior coccyx that is unevident in side coccyx radiography taken standing (a) is visible in radiography taken sitting (b)

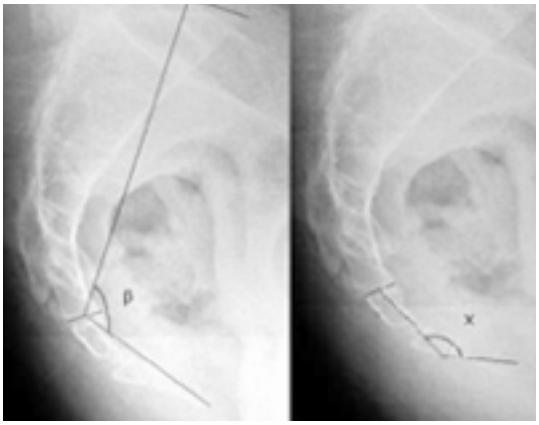

Figure 2. (a) Sacrococcygeal angle β, (b) Intercoccygeal angle x

Figure 3. The region marked α is assessed as the scoliosis angle

RESULTS

A total of 53 patients were male (34.2%) and 102 were female (65.8%). The mean age of all patients was 36.7 years (range 16 to 77 years), the average age of the female patients was 37 years (range 16 to 77 years), and the average age of the male patients was 35.8 years (range 16 to 63 years). The distributions of mean, standard deviation, median, minimum and maximum values of coccyx length, sacrum length, fusion age, sacrococcygeal joint length, sacrococcygeal angle and intercoccygeal angle according to gender are provided in Table 1. There was a positively low correlation between sacrum length and coccyx length ($p = 0.004$). Regarding the relationship between sacrum length and coccyx length in males, there was a moderately positive correlation ($p = 0.02$). There was no significant relationship between sacrum and coccyx length in women ($p = 0.07$). Regarding relationship between intercoccygeal angle and coccyx and sacrum lengths, only a significant relationship between intercoccygeal angle and coccyx length was found in males ($p=0.04$). The sacrococcygeal and intercoccygeal angles measured in the sitting and standing coccyx graphs of the patients are provided in Table 2. There was a positive correlation between sitting and standing sacrococcygeal ($p=0.01$) and intercoccygeal ($p=0.01$) angles.

Of the patients participating in the study, 57 (36.8%) had three and 98 (63.2%) had four segments. Of the participating males, 18 (34%) had three, 35 (66%) had four segments, and of the females, 39 (38.2%) had three and 63 (61.8%) had four segments.

Eighteen of our patients underwent coccygectomy surgery. When the operated patients were

classified according to Postacchini-Massobrio classification, it was observed that type 1 was most common, followed by type 2 and 6. There was no significant relationship between the presence or absence of surgery and angle type (p = 0.47).

Regarding the correlation between sacrum and coccyx length and intercoccygeal angle in operated and unoperated patients, there was only a positive relationship between coccyx length and sacrum length in unoperated patients (p=0.03). There was a positive correlation between intercoccygeal angle and coccyx length (p=0.01), however there was no significant correlation between intercoccygeal angle and sacrum length (p=0.25). There was no correlation between coccyx length, sacrum length, and sacrococcygeal angle in operated patients.

When correlation of sacrococcygeal joint length was evaluated according to gender, it was determined that the joint lengths of males were higher than females (p = 0.001). There was a significant relationship between joint length and sacrococcygeal angle in males (p = 0.019), but this difference was not significant in females (p = 0.754). There was no difference between joint length and intercoccygeal angle according to male (p = 0.862) or female (p = 0.118) gender.

There was no significant difference between male and female patients regarding presence of coccyx retroversion (p = 0.41). The mean, standard deviation, median, minimum and maximum values of sacrococcygeal angle and intercoccygeal angle of patients with and without retroversion are given in Table 2. There was also no significant correlation according to presence of coccyx retroversion and coccyx length (p=0.39), intercoccygeal angle (p = 0.19), sacrococcygeal angle (p = 0.72), segment number (p = 0.68), and sacrum length (p = 0.76). There was no significant different between joint lengths of patients with and without coccyx retroversion (p = 0.68).

Of the patients with scoliosis, 54% had right and 46% and left deviation. The mean, standard deviation, median, minimum, and maximum values of right and left deviations according to the genders of the scoliosis angle are given in Table 1. There was no significant difference between patients with and without scoliosis in terms of coccyx length (p = 0.09), sacrococcygeal angle (p = 0.57) and joint length (p = 0.29).

The rate of patients with forward slipping of the sacrococcygeal joint was 44% and the rate of backward slipping was 56%. The mean forward listhesis of the sacrococcygeal joint was 6,81mm (±2,12mm) and mean backward listhesis of the sacrococcygeal joint was 6,52 mm (± 1,88mm). The fusion rate was 24.5% for males and 9.8% for females. The average age of females with fusion in the sacrococcygeal joint was 43.1 years, while the average age of males was 36.5 years. There was no significant difference between patients with and without sacrococcygeal joint fusion, in terms of sacrococcygeal angle (p = 0.48), intercoccygeal angle (standing) (p = 0.38), intercoccygeal angle (sitting) (p = 0.71), sacrum length (p = 0.78), and sacrococcygeal joint length 0.82).

DISCUSSION

Postacchini and Massobrio [11] suggested that coccyx morphology played a role in the etiology of coccydynia. Maigne et al. identified anterior subluxation and emphasized the importance of coccyx hypermobility in coccydynia [13,14]. Kim and Suk [15] found that the scoliotic deformity of the coccyx could cause coccydynia. In a study by Nathan et al. [12] coccyx scoliosis and retroversion were also included in the Postacchini-Massobrio classification. [10] According to the Postacchini-Massobrio classification [10], type 1 coccyx was most common. [3,16] Some studies state that type 2 [3,6] and other state that type 1 [17] most commonly requires coccygectomy. In our study, type 1 coccyx was most common among patients with coccydynia and that type 1 most frequently required coccygectomy. When the types were compared, it was observed that type 1 was operated more frequently due to the higher amount; however there was no statistically significant difference between the types.

In our study, significant differences were observed in sacrococcygeal and intercoccygeal angles in the sagittal plane of coccyx side radiographs taken sitting and standing. Dynamic radiography showed that the coccyx which changed position on the sagittal plane could also change position on the horizontal or coronal planes in the same patient (Figure 1). A coccyx with angulation of the sagittal plane could have scoliosis in the coronal

Table 1.

	Total			Female			Male		
	Mean ±SD	Median	Min-Max	Mean ±SD	Median	Min-Max	Mean ±SD	Median	Min-Max
Coccyx length	38.9±9.4	38.9	23.5-71.3	38.1±8.2	39	23.5-57.7	40.8±11.2	38.5	26.5-71.3
Sacrum length	129.3±14.9	130.7	89-169.7	128.6±15.5	128.6	89-167.7	130.7±13.9	133	89.0-156.8
Age of fusion	36.4±15.2	35.0	16-77	43.1±20.6	39.5	19-77	36.5±15.7	37	16-62
Sacrococcygeal joint length	9.6±2.4	9.6	3.7-16.4	9.2±2.4	9.2	3.7-16.4	10.5±2.1	10.2	7.10-16
Intercoccygeal angle	141.1±17.1	143.5	76.8-168.8	143.9±14.7	146.7	86.8-168.8	135.8±20.3	136.1	76.8-168.2
Sacrococcygeal angle	121.5±20.0	120.5	71.3-192	119.3±21.3	117.9	71.3-192	125.7±16.7	128.3	93.7-164.4
Right scoliosis	8.1±3.7	6.7	4.5-14.5	9.4±3.7	10.1	4.9-14.5	4.8±4.9	4.85	4.5-5.2
Left scoliosis	7.1±2.8	7.3	3.1-12.4	6.7±1.0	7.3	5.6-7.4	7.4±3.8	7.0	3.1-12.4

Mean, standard deviation, median, minimum, and maximum values of coccyx length, sacrum length, age of fusion, length of sacrococcygeal joint, sacrococcygeal angle, intercoccygeal angle, and right and left scoliosis according to gender

Table 2.

	Sacrococcygeal angle						Intercoccygeal angle					
	standing			sitting			standing			sitting		
	Mean ±SD	Median	Min-Max	Mean ±SD	Median	Min-Max	Mean ±SD	Median	Min-Max	Mean ±SD	Median	Min-Max
No retroversion	129.6°± 32.1°	114.7°	93.7°-186.6°	130.9°± 40.1°	110.4°	91°-194.7°	130.5 ±20.6	132.1°	86.8°-164°	124.4 °±26.9°	120.4°	85.4°-185.6°
Retroversion	180.1°± 18.9°	185.6°	177°-192°	186.8°± 12.4°	189.7°	181.3°-195.3°	155.7° ±11.1°	152.2°	143.5°-168.8°	159.1 ±23.7	150.3°	140.6°-197.1°

.Mean, standard deviation, median, minimum, and maximum values of sacrococcygeal and intercoccygeal angles of patients with and without retroversion

plane, or dislocation in the horizontal plane, and this is unrelated to the sacrococcygeal angle. For the coccyx which can be displaced in all three planes, we believe that a new classification is needed in the classification of patients with coccydynia (Table 3).

In an MRI study of coccyx morphology by Tetiker et al. [8] conducted with 456 healthy Turkish individuals with a mean age of 43.9 found the average coccyx length to be 35.6 mm. This value was evaluated as 38.5 mm for males and 34.5 mm for females, and males were longer than females. Lee et al. [7] found average coccyx length in males to be 37.9 mm and 34.4 mm in females. Indiran et al. [18] found average coccyx length as 33.8 mm in males and 31.5 mm in females. In our patients, we found average coccyx length of all patients to be 38.9 mm, 40.8 mm in males, and 38.1 mm in females. Of all studies, including ours, coccyx length was longer in males than in females as consistent to the literature.

In studies performed with multislice CT, MRI, and three-dimensional CT assistance, the sacrococcygeal angle of males was found to be higher than in females, and significant differences were found in comparison between males and females [5,6,8,15,16]. In our study, the sacrococcygeal angle of males was also higher than females. Previous studies have also evaluated intercoccygeal angles as slightly higher in males than in females. In our study, the intercoccygeal angle was found to be higher in females than in males, consistent with the literature.

It has been found that dynamic radiography of the coccyx taken sitting and standing is necessary to access hypermobility of the coccyx and that coccyx mobility is higher in patients with high body mass index. It is believed that stable imaging is inadequate for the assessment of the coccyx, a dynamic structure which constitutes one of the three

points used in the action of sitting [13,15,19,20]. In our study, significant difference was observed in intercoccygeal and sacrococcygeal angles between sitting and standing radiography.

Table 3.

Type	Morphologic classification of coccydynia
I	No angulation or slight forward inclination of the coccyx
I a	Dislocation
I b	Scoliosis
I c	Hypermobility
II	Angulation less than 90° of the sacrococcygeal joint or coccyx segments and sharp curvature forward
II a	Dislocation
II b	Scoliosis
II c	Hypermobility
III	Angulation greater than 90° of the sacrococcygeal joint or coccyx segments
III a	Dislocation
III b	Scoliosis
III c	Hypermobility
IV	Retroversion
IV a	Dislocation
IV b	Scoliosis
IV c	Hypermobility

Classification of coccydynia including pathologies of all three planes

A study conducted with MRI to determine the number of coccyx segments reported the coccyx was most frequently composed of three vertebra segments (42.1%), while another study conducted with multislice CT reported the coccyx was most frequently composed of four vertebra segments [8,18]. In our patients, coccyx was composed of three segments in 36.8% of the patients, and four segments in 63.2%. We believe this was due to MRI and CT having better imaging of bone, soft tissue, and joints. The literature does not report significant relationship between number of segments and sacrococcygeal angle [9]. We also did not find a relationship between sacrococcygeal angle and number of segments in all of our patients.

A study on healthy individuals reports sacrococcygeal joint fusion in 23.8% of males and 21.6% of females [8]. In our patients, fusion rate was 24.5% in males and 9.8% in females. We believe that coccydynia occurring more frequently in females than males may be due to less frequent sacroccocygeal joint fusion in females.

Studies on coccyx retroversion have defined the sacrococcygeal angle as the angle between the first segment of the coccyx and the fifth segment of the sacrum [9]. We believe the angulation of the farthermost point of the coccyx to be clinically relevant and that this point should be included in measurement. Imaging of the patients showed us that dislocations among coccyx segments may occur along with retroversion evident with sitting (Figure 1). This also leads us to believe that side radiography of the coccyx taken while standing, MRI, or three-dimensional CT is inadequate in assessing the patient, and that side and posteroanterior dynamic coccyx radiography taken sitting and standing may be effective in evaluation of the idiopathically considered or normal anatomically positioned coccyx [15,20].

A three-dimensional CT study on the Korean population found the mean right deviation of patients with scoliosis was 12.0° in females, 13.1° in males, and for left deviation, 15.2° in females and 13.1° in males [6]. In our study, mean right deviation was 9.4° in females and 4.8° in males, and in left deviation, 6.7° in females and 7.4° in males. These results led us to believe a difference due to racial factors.

In our study, correlation between sacrum and coccyx length and between intercoccygeal angle and coccyx length was found in unoperated patients. This suggests that individuals with anatomically compatible sacrum and coccyx lengths and compatible coccyx length and intercoccygeal angle are less operated.

Sacrococcygeal joint length was found to be longer in males and a relationship was found between sacrococcygeal joint length and sacrococcygeal angle. We believe that this is related to the fact that the operation frequency is less in males.

Limitations: Dynamic coccyx radiographies in healthy patients could compared with coccydynia patients but this was not done because of ethical rules.

CONCLUSION

The coccyx is a spinal segment that moves on three planes and may develop pathology. Dynamic direct side and posteroanterior radiography taken sitting and standing is an effective method to

determine pathology in patients with coccydynia. We believe that a new classification including patology in all three planes is needed in the classification of patients with coccydynia therefore, our classification will eliminate this deficit.

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