Original Article

http://dergipark.org.tr/en/pub/anatomy
*Received: April 10, 2022; Accepted: November 25, 2022*
doi:10.2399/ana.22.3239832

anatomy
An International Journal of Experimental and Clinical Anatomy

# Tarsal coalition in the Turkish population: an MRI study

**Semra Duran, Esra Çıvgın**

*Department of Radiology, Ankara City Hospital of Turkish Ministry of Health, Ankara, Türkiye*

## Abstract

**Objectives:** Tarsal coalition describes a complete or partial union of two or more tarsal bones. We aimed to determine the anatomical features of tarsal coalition in patients undergoing ankle magnetic resonance imaging (MRI) and to report tarsal coalition prevalence in the Turkish population.

**Methods:** A total of 1075 ankle MRI were evaluated and patients with tarsal coalition were included to the study. Statistical analyses were performed to check whether there is a correlation between the presence of the tarsal coalition and age, gender and side (right/left) and to identify the talar beak sign accompanying the coalition and the presence of edema or cyst in the bones.

**Results:** We detected tarsal coalition in 18 patients (a total of 21 ankles) (1.68%). Out of these, seven were females (1.32%) and eleven were males (2.04%). The mean age was 37.22±14.23 years. Three (0.28%) patients had bilateral coalition. Eight patients (0.56%) had tarsal coalition on the right ankle and 13 patients (1.12%) had on the left. We detected osseous talocalcaneal coalition in 3 patients, non-osseous talocalcaneal coalition in 6 patients, non-osseous calcaneonavicular coalition in 10 patients and non-osseous cuboid navicular coalition in 2 patients. Talar beak was found in 11 (52.38%) patients, edema or cysts in the bones forming the coalition were found in 11 (52.38%) patients.

**Conclusion:** The prevalence of the tarsal coalition was determined to be 1.68 % in a Turkish population and was more common among men. Calcaneonavicular coalition followed by talocalcaneal coalition are the most common types.

**Keywords:** edema; magnetic resonance imaging; talar beak; tarsal coalition

Anatomy 2022;16(3):165–171 

## Introduction

Tarsal coalition (TC) is defined as an abnormal union of two or more bones of the hindfoot or midfoot and is thought to be the result of the failure of segmentation of primitive mesenchyme. These unions can be osseous (synostosis), cartilaginous (synchondrosis), or fibrous (syndesmosis).[1-4]

Although it is difficult to determine the prevalence of TC due to asymptomatic cases, previous studies have reported a prevalence of 1–13%.[3,5–7] The most common TCs are talocalcaneal and calcaneonavicular and the prevalence of bilateral occurrence of TC is 50–60%.[2,4,8]

TC can restrict normal subtalar motion (eversion, inversion, and anterior gliding) and cause pain, tenderness, peroneal tendon spasm, tarsal tunnel syndrome and flat foot deformity. TC can be asymptomatic and detected incidentally in these cases.[2,9]

Radiographs are used as the first-line imaging examination in diagnosis of TC. Computed tomography (CT) and magnetic resonance imaging (MRI) provide important information in understanding the anatomical features of the TC. MRI makes it possible to identify bone marrow edema which is common in the coalition region.[10]

We aim to determine the anatomical features of TC in patients undergoing ankle MRI and to report its prevalence in the Turkish population by examining a large series.

## Materials and Methods

We retrospectively evaluated 1075 ankle MRIs, performed between January and December 2021. The MRI examinations were performed for various reasons such as tendinopaty, pain, osteochondral lesion, ligament or tendon rupture). Patients younger than 18 years, or with a history of trauma and surgery, or with mass lesions, or

**Table 1**
Sequences of MRI examination of the ankle joint.

| Pulse sequence | TR/TE (ms) | Matrix | Field of view (cm) | Slice thickness (mm) |
|---|---|---|---|---|
| Sagittal T1-weighted FSE | 720/10.69 | 320×256 | 17×17 | 3 |
| Sagittal FS proton-density weighted FSE | 2467/32.06 | 320×256 | 17×17 | 3 |
| Coronal FS T2-weighted FSE | 4479/89.73 | 320×256 | 18×18 | 3 |
| Axial T1-weighted FSE | 506/11.2 | 320×224 | 17×17 | 3 |
| Axial FS proton-density weighted FSE | 3131/42.85 | 320×256 | 17×17 | 3 |

**cm:** centimeter; **FS:** fat-suppressed; **FSE:** fast spin echo; **mm:** millimeter; **ms:** millisecond; **TE:** echo time, **TR:** repetition time.

with images that could not be evaluated due to operational artifacts or poor imaging quality were excluded from the study. Thus, a total of 1068 patients who met the criteria were included in the study. In the study group, 21 ankle MRI scans of 18 patients showed osseous/non-osseous TC.

The MRI images of patients were obtained with a 1.5 T MR scanner (Signa Explorer, GE Medical System, Milwaukee, WI, USA) equipped with an extremity coil. A standardized ankle MRI examination protocol was applied for each patient. The presence and characteristics of the TC were evaluated using all sequences in all three planes. The sequences included in the examination and their parameters are given in **Table 1**. The images were analyzed on the hospital picture archiving and communications system.

The diagnostic criteria for TC in this study were as follows: the presence of a bone bridge, narrowing of the joint surface, irregular cortical bone surface and the presence of subchondral bone edema or cyst formation adjacent to the affected joint.

Anatomical types of TC were classified according to the united tarsal bone as talocalcaneal (**Figure 1**), calcaneonavicular (**Figure 2**), and cuboideonavicular (**Figure 3**). The superior projection of the distal part of the talus was defined as the talar beak (**Figure 2**). The presence of cyst or edema was noted in both bones in the coalition (**Figures 2** and **3**).

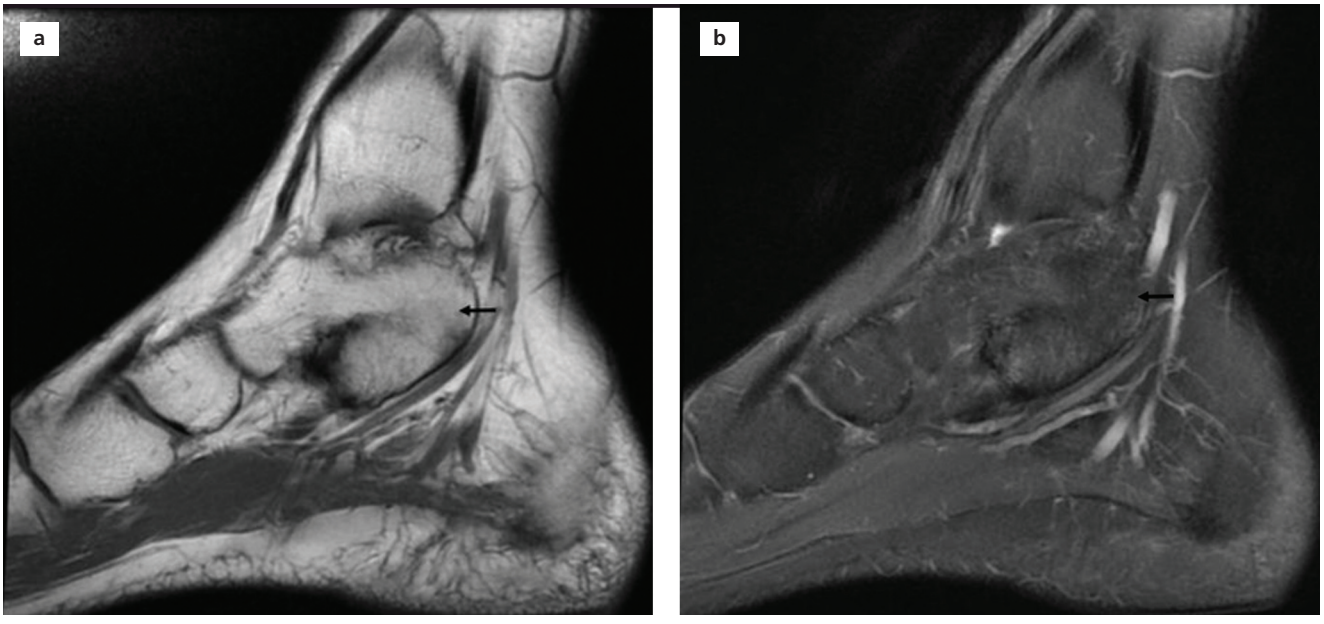


**Figure 1.** (**a**) Sagittal T1-weighted and (**b**) T2-weighted fat-suppressed images through the talocalcaneal joint show bone marrow signal (**black arrow**) continue across the fused articulation (osseous coalition) in the ankle MR images.

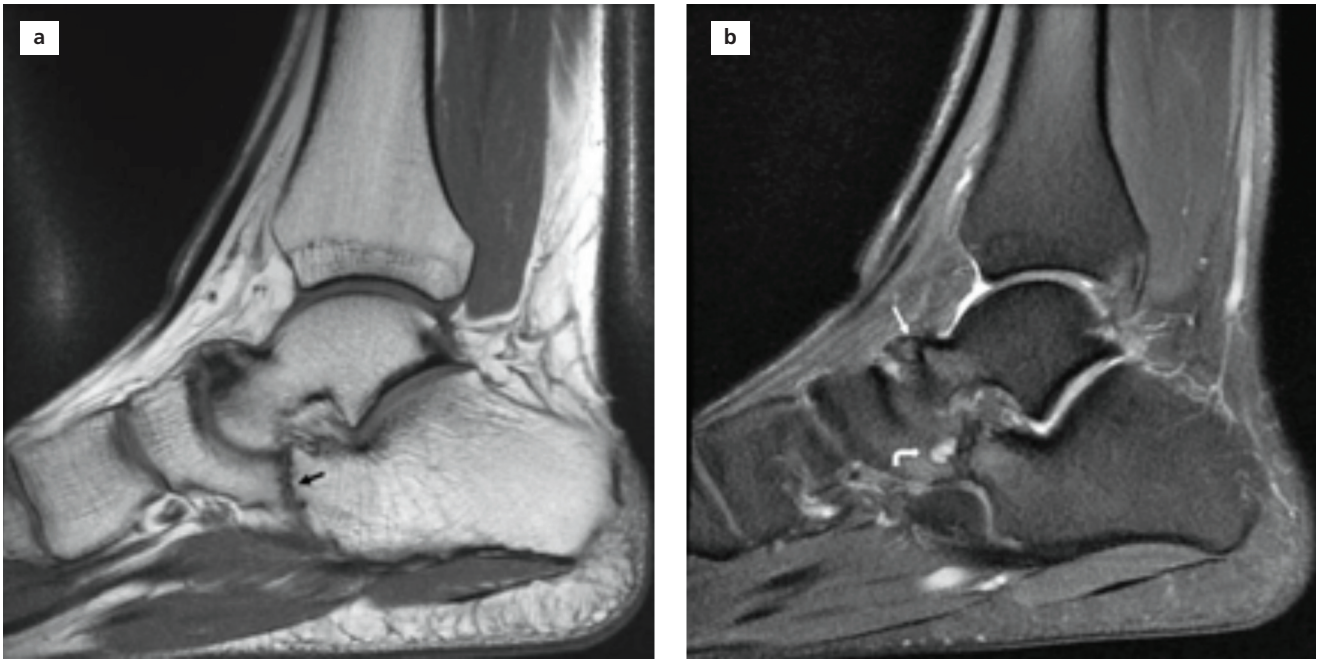


**Figure 2.** (**a**) Sagittal T1-weighted and (**b**) T2-weighted fat-suppressed images demonstrate the narrowing of the joint and irregularity of the bone margins in the calcaneonavicular joint. The sagittal T1-weighted image also shows the talar beak (**white arrow**) and accompanying medullary edema or cyst (**curved white arrow**).

Data was analyzed using IBM SPSS Statistics Standard Concurrent User v. 26 (IBM Corp., Armonk, NY, USA). Kolmogorov-Smirnov test was used for the distribution and homogeneity analyses of the data. In addition to obtaining descriptive statistics, independent t-test analysis was applied to evaluate the mean differ-

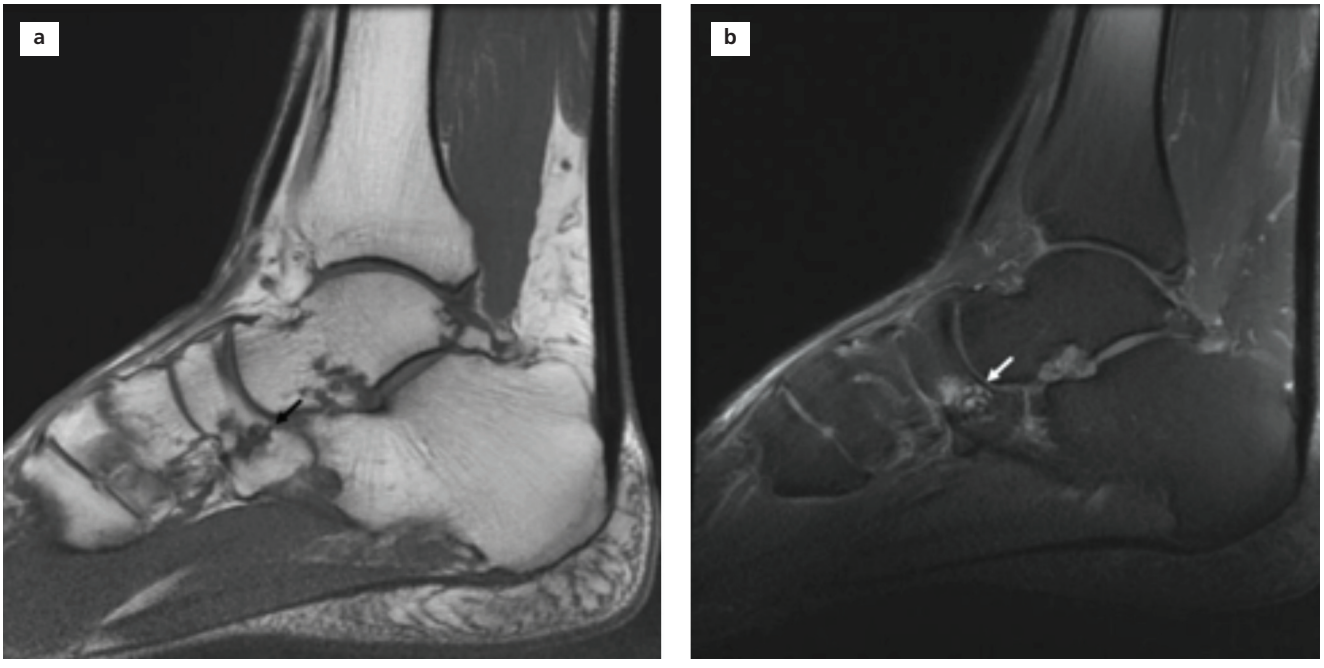


**Figure 3.** (**a**) Sagittal T1-weighted and (**b**) T2-weighted fat-suppressed images demonstrate the narrowing of the joint and irregularity of the bone margins in the cuboideonavicular joint (**black arrow**), and accompanying medullary edema/cyst (**white arrow**) on the bony surfaces.

ences between groups. Mann-Whitney U test was also conducted to differentiate inhomogeneous groups and Kruskall-Wallis test was used to compare three or more groups. A p-value of <0.05 was considered as statistically significant.

## Results

A total of 1075 patients were included to this study. Of the 1068 patients without TC, 529 were females and 539 were males; 511 of the patients were evaluated for right ankle and 557 for left ankle. Osseous, non-osseous TC was detected in 18 patients (21 ankles) (1.68%). The mean age of the patients with the TC was 37.22±14.23 years. There was no significant difference between the male and female patients in terms of the mean age (p>0.05). **Table 2** presents the data on the mean age according to gender.

TC was detected in 7 of female patients (1.32%) and 11 of male patients (2.04%). There was a bilateral TC in three cases (0.28%); 2 males and 1 female. The TC was found in the right ankle in 8 patients (0.56%) and the left ankle in 13 (1.12%). **Table 3** shows the distribution of the osseous, non-osseous TC prevalence according to gender and side.

Osseous talocalcaneal coalition was detected in 3 ankles (14.2%), non-osseous talocalcaneal coalition in 6 ankles (28.5%), non-osseous calcaneonavicular coalition in 10 ankles (47.6%) of 8 patients, and non-osseous cuboidonavicular coalition in 2 ankles (9.5%). The distribution of these coalitions did not show correlation with age (p>0.05). The distribution of coalition types by gender is given in **Figure 4**.

In patients with bilateral ankle MRI, talocalcaneal and calcaneonavicular coalition was detected in both ankles. Among the patients with bilateral ankle MRI, only one female patient had different coalition types in their right and left ankles (non-osseous talocalcaneal coalition on the left, osseous talocalcaneal coalition on the right), and two male patients had the same type of coalition (non-osseous calcaneonavicular) in each of the ankle MRIs. When the pathologies accompanying the TC were analyzed; talar beak was found in 11 (52.38%) patients, edema or cysts in the both bones forming the coalition were found in 11 (52.38%) patients. Patients who had edema or cysts in the coalition were over 40 years of age. In 3 patients, talar beak and cysts or edema on the bone faces adjacent to the talar coalition were found together.

There was no correlation between pathologies accompanying the TC and gender (p>0.05). The histogram of the pathologies accompanying the TC according to age is given in **Figure 5**.

**Table 2**
Mean age according to gender.

| Sex | n | Min-max | Mean±SD | p-value |
|---|---|---|---|---|
| Female | 7 | 23–51 | 38.57±11.68 | 0.13 |
| Male | 11 | 18–58 | 36.36±16.44 | |

**SD:** standard deviation.

## Discussion

TC is defined as the absence of segmentation between two or more bones of the foot during embryological development due to failure of the joint cleft to develop.[1–6] Although the coalition may affect any tarsal joint, the calcaneonavicular joint is most commonly affected followed by the talocalcaneal joint; together these two coalitions account for 90% of all TC cases.[9]

**Table 3**
Distribution of osseous/non-osseous tarsal coalition prevalence according to gender and side.

| | | | | |
|---|---|---|---|---|
| Patients without osseous/non-osseous tarsal coalition | 1068 | | | |
| Patients with osseous/non-osseous tarsal coalition | 18 | 1.68% | | |
| Bilateral/female | 1 | 0.18% | | |
| Bilateral/male | 2 | 0.37% | | |
| Right/male | 4 | 0.74% | Right: 8 | 0.56% |
| Right/female | 2 | 0.37% | | |
| Left/male | 7 | 1.29% | Left: 13 | 1.12% |
| Left/female | 5 | 0.94% | | |

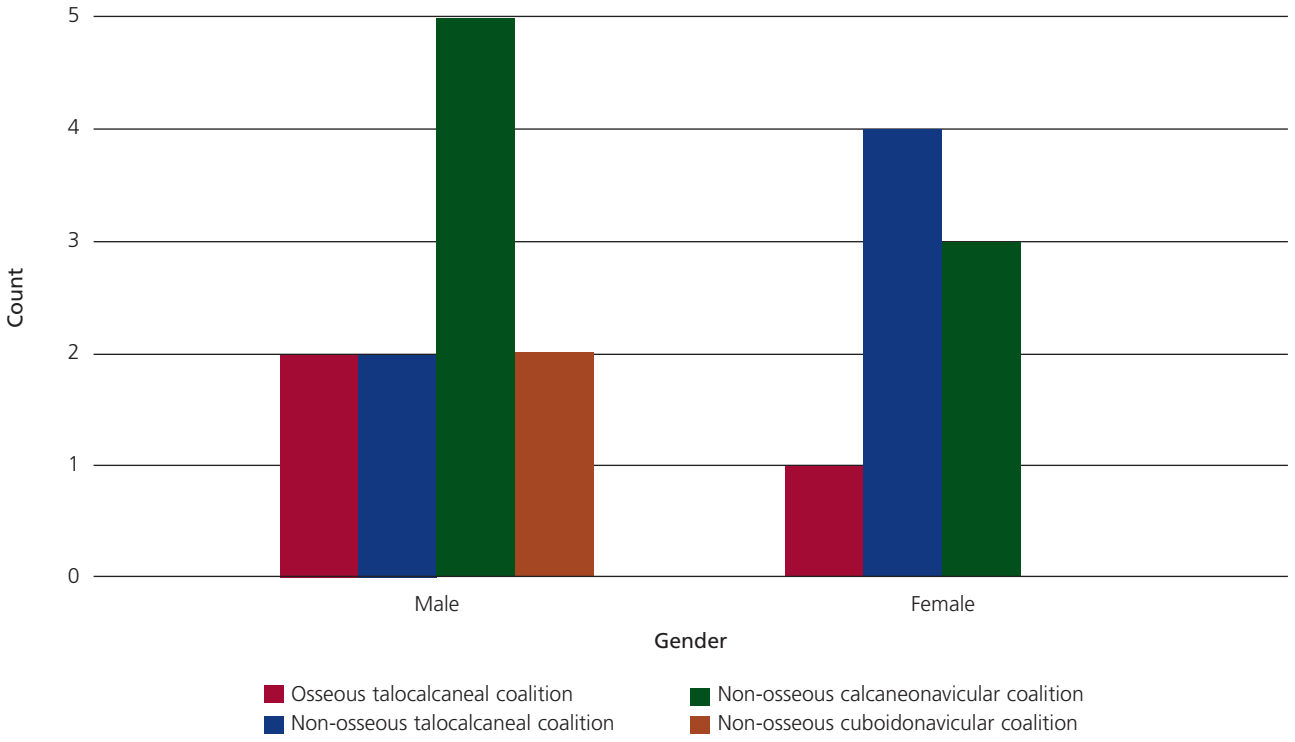


**Figure 4.** Distribution of coalition types by gender.

CT and MR imaging allow differentiation of osseous from non-osseous coalitions and reveal the extent of joint involvement as well as secondary degenerative changes. On MR images, bone marrow edema, abnormal articular orientation and joint space narrowing were frequently identified adjacent to the abnormal joint.[10]

Kim et al.[11] reported the prevalence of TC as 1% in their study including 733 patients, while Nalaboff and Schweitzer[6] reported the prevalence of TC as 11.5% in their MRI-based study including 574 patients. In our study, the prevalence was 1.68%.

Cilengir et al[12] reported non-osseous TC in 57 (87.6%) of 65 patients with TC. Cheng et al.[13] reported the rate of non-osseous TC as 89 % in their MRI-based study including 57 patients. In our study, the rate of non-osseous TC, which was 85.8%, was greater than the rate of osseous TC. Our findings were consistent with previous studies. This shows that the frequency of the osseous TC was lower than that of non-osseous TC.

Varner et al.[14] evaluated 32 ankles of the 27 patients with TC and reported 18 subtalar coalition, 14 calcaneonavicular coalition and 1 naviculocuneiform coalition. Nalaboff and Schweitzer[6] reported subtalar coalition in 18 (25.7%) patients and calcaneonavicular coalition in 50 (71.4%) patients of 70 patients with TC. In our study, the most common TC was calcaneonavicular, followed by talocalcaneal coalition. Naviculocuboid coalition was the least common TC.

Some clinical studies have shown that TC is more common in males.[11,15,16] In our study, we found the incidence rate of TC as 2.4 % in males, which is similar to

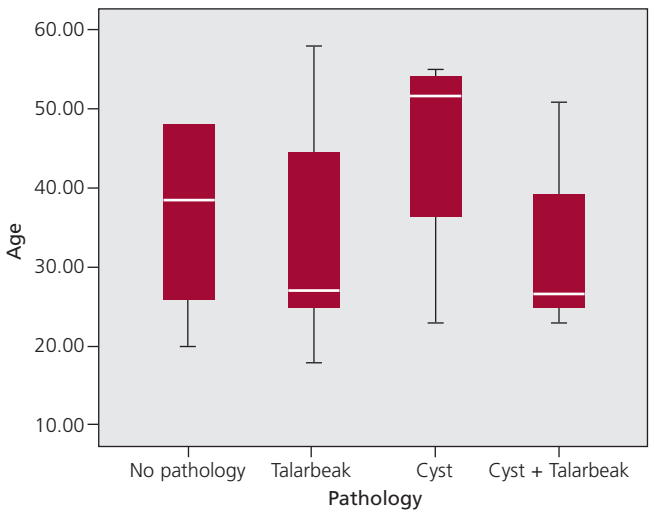


**Figure 5.** Histogram of pathologies detected with coalition by age.

the other studies. We also found that TC was more common in the left ankle in both genders.

Rühli et al.[17] found a bilateral TC in 2 of 7 calcaneonavicular TCs. Mendeszoon et al.[16] reported a bilateral incidence of 10% for talocalcaneal coalition and 21% for calcaneonavicular coalition. We found three patients (2 males, 1 female) with bilateral TC (0.28%). This low rate can be explained by the low number of bilateral examinations in our retrospective study. We found talocalcaneal and calcaneonavicular coalition in our all bilateral patients. In our only female patient, this talocalcaneal coalition was osseous in one ankle and non-osseous in the other.

The term "talar beak" refers to a flaring of the superior aspect of the talar head. This is an indirect sign of TC and is thought to occur as a result of impaired subtalar joint motion, causing the navicular bone to override the talus.[10] The talar beak sign may be seen in either calcaneonavicular or talocalcaneal coalition and is more common in talocalcaneal coalition.[2] The sensitivity and specificity of the talar beak sign for detecting talocalcaneal coalition are 48% and 91%, respectively.[8]

Nalaboff and Schweitzer[6] found the talar beak sign in 25 (50%) patients with calcaneonavicular coalition and 5 (27%) patients with subtalar coalition in their study of 70 patients with TC. Consistent with the aforementioned study, we found talar beak sign in 11 patients with TC, 5 with calcaneonavicular coalition and 6 with talocalcaneal coalition.

Lim et al.[4] found bone marrow edema in both bones in 37 (86%) of 43 ankles with MR imaging. We found medullary edema or cyst in both bones in 11 of 18 patients with TC. These patients were over 40 years of age. The non-osseous TC creates abnormal mechanical stress across the affected joint, causing bone marrow edema on the bony surfaces adjacent to the joint.[10]

Our study has some limitations. Our study was retrospective and consisted of symptomatic patients. The number of study population is small. Most of our patients' examinations were unilateral, which made it difficult to determine the bilateral prevalence. We did not access the clinical examination findings of the patients. Therefore, we could not evaluate the clinical impact of subchondral bone edema or cyst formation adjacent to the TC.

## Conclusion

The prevalence of the TC was found to be 1.68 % in a Turkish population and it was more common among men. Calcaneonavicular coalition followed by talocalcaneal coalition are the most common types of TC.

### Conflict of Interest

The authors declare no conflict of interest regarding the methods and results in this study.

### Author Contributions

SD: project development, data collection and analysis, manuscript writing, editing; EÇ: data collection and analysis, manuscript writing.

### Ethics Approval

The study was approved by the University of Health Sciences Ankara City Hospital Clinical Research Ethics Committee (No: E2-22-2766) and carried out in accordance with the Helsinki declaration of principles.

### Funding

The authors declare no financial support.

## References

1. Zaw H, Calder JD. Tarsal coalitions. Foot Ankle Clin 2010;15:349–64.
2. Lawrence DA, Rolen MF, Haims AH, Zayour Z, Moukaddam HA. Tarsal coalitions: radiographic, CT, and MR imaging findings. HSS J 2014;10:153–66.
3. Soni JF, Valenza W, Matsunaga C. Tarsal coalition. Curr Opin Pediatr 2020;32:93–9.
4. Lim S, Lee HK, Bae S, Rim NJ, Cho J. A radiological classification system for talocalcaneal coalition based on a multi-planar imaging study using CT and MRI. Insights Imaging 2013;4:563–7.
5. Linklater J, Hayter CL, Vu D, Tse K. Anatomy of the subtalar joint and imaging of talo-calcaneal coalition. Skeletal Radiol 2009;38:437–49.
6. Nalaboff KM, Schweitzer ME. MRI of tarsal coalition: frequency, distribution, and innovative signs. Bull NYU Hosp Jt Dis 2008;66:14–21.
7. Stormont DM, Peterson HA. The relative incidence of tarsal coalition. Clin Orthop Relat Res 1983;(181):28–36.
8. Crim JR, Kjeldsberg KM. Radiographic diagnosis of tarsal coalition. AJR Am J Roentgenol 2004;182:323–8.
9. Park JJ, Seok HG, Woo IH, Park CH. Racial differences in prevalence and anatomical distribution of tarsal coalition. Sci Rep 2022;12:21567.
10. Newman JS, Newberg AH. Congenital tarsal coalition: multimodality evaluation with emphasis on CT and MR imaging. Radiographics 2000;20:321–2.
11. Kim JH, Gwak HC, Lee CR, Kim YJ, Kim JG, Lee SJ, Lee JH, Park JH. Incidence of tarsal coalition: an institutional magnetic resonance imaging analysis. Journal of Korean Foot and Ankle Society 2016;20:116–20.

12. Cilengir AH, Bayraktar ES, Dursun S, Ozdemir M, Altay S, Elmali F, Tosun O. A retrospective magnetic resonance imaging analysis of bone and soft tissue changes associated with the spectrum of tarsal coalitions. Clin Anat 2023;36:336–43.
13. Cheng KY, Fuangfa P, Shirazian H, Resnick D, Smitaman E. Osteochondritis dissecans of the talar dome in patients with tarsal coalition. Skeletal Radiol 2022;5:191–200.
14. Varner KE, Michelson JD. Tarsal coalition in adults. Foot Ankle Int 2000;21:669–72.
15. Elkus RA. Tarsal coalition in the young athlete. Am J Sports Med 1986;14:477–80.
16. Mendeszoon M, Mendeszoon E, Orabovic S, Valentine C. Tarsal coalitions: a review and assessment of the incidence in the Amish population. The Foot Ankle Online Journal 2013;6:1.
17. Rühli FJ, Solomon LB, Henneberg M. High prevalence of tarsal coalition and tarsal joint variants in a recent cadaver sample and its possible significance. Clin Anat 2003;16:411–5.

**ORCID ID:**
S. Duran 0000-0003-0863-2443;
E. Çıvgın 0000-0003-4790-3146

**Correspondence to:** Semra Duran, Assoc. Prof., MD
Department of Radiology, Ankara City Hospital of Turkish Ministry of Health, Ankara, Türkiye
Phone: +90 312 552 79 51
e-mail: semraduran91@gmail.com

*Conflict of interest statement:* No conflicts declared.

 *How to cite this article:* Duran S, Çıvgın E. Tarsal coalition in the Turkish population: an MRI study. Anatomy 2022;16(3):165–171.