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Morphological Characteristics of Os Subfibulare Related to Failure of Conservative Treatment of Chronic Lateral Ankle Instability

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Abstract

Background: The os subfibulare is usually asymptomatic and found incidentally on radiographs. However, sometimes it may cause subfibular pain and may be associated with chronic lateral ankle instability (CLAI). We hypothesized that os subfibulare could interrupt the talofibular space causing impingement, resulting in chronic pain and functional instability around the lateral malleolus. The purposes of this study were to analyze morphologic characteristics of os subfibulare, and to evaluate the clinical significance of the os subfibulare in patients with CLAI.

Methods: Between November 2011 and April 2015, 70 patients who had both computed tomography (CT) and magnetic resonance imaging (MRI) among 252 patients who visited our hospital with the symptom of lateral ankle instability were included in this study. The location of the ossicle was classified into 3 zones in reference to the attachment site of the lateral ankle ligaments. The impingement was classified into 2 groups according to the presence of talofibular encroachment. Digital radiographs were used to measure the ossicle width and shape determined by the length and width on an magnetic resonance (MR) image.

Results: The most common shape of ossicles was oval, and the most common location of ossicles was at the anterior talofibular ligament (ATFL) attachment site. Sixty-one percent of patients showed talofibular impingement on coronal MR images. In 48 cases, the dimension of fibula plus os subfibulare was larger than that of the contralateral normal fibula. The larger size and talofibular impingement of the ossicle were associated with greater need for operative treatment in patients with ankle instability.

Conclusion: The morphologic analysis of the os subfibulare revealed that there might be impingement of the talofibular space by the ossicle in some patients. We suggest that morphologic characteristics of the os subfibulare should be considered when selecting treatment options in patients with CLAI and os subfibulare.

Level of Evidence: Level III, retrospective comparative series.

Keywords: os subfibulare, morphologic analysis, radiologic assessment, chronic lateral ankle instability

Introduction

The os subfibulare is commonly known as a small, well-corticated separated ossicle of the distal fibula.[8] There are 2 common theories regarding the etiology of the os subfibulare. The first theory is that it is thought to be an accessory ossification center resulting from an anomalous ossification.[4,8,13] The second theory is that the lateral ossicles result from an avulsion fracture in which either a cartilaginous fragment or an osseous fragment is avulsed from the tip of the fibula.[3,7,11,15]

The os subfibulare is usually asymptomatic and found incidentally on radiographs. However, sometimes it may cause subfibular pain because of recurrent irritation of soft tissue surrounding the ossicle10 and may be associated with chronic lateral ankle instability (CLAI) resulting from

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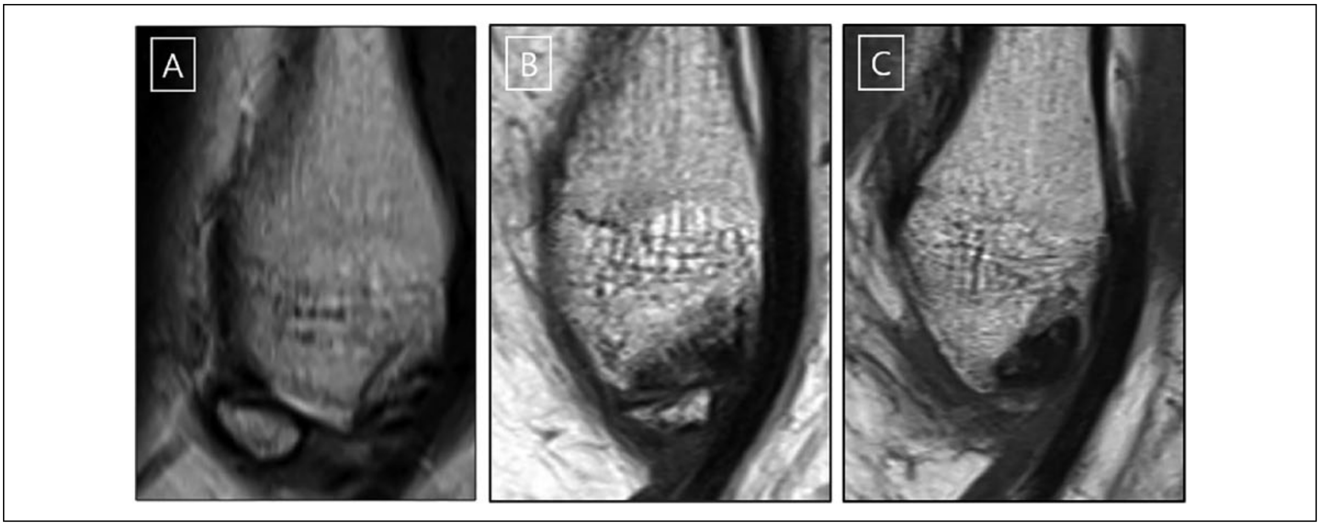

Figure 1. The location of the subfibular ossicle by T1-weighted magnetic resonance sagittal images: (A) Zone I, anterior talofibular ligament (ATFL) attachment site. (B) Zone II, calcaneofibular ligament (CFL). (C) Zone III, posterior talofibular ligament.

disruption of the fibrous or cartilaginous attachment of the ossicle.[1,9,11,16] There is still debate about the operative outcome of CLAI with an os subfibulare. Some have reported inferior outcomes after the modified Broström procedure with excision of the ossicle,[12] whereas others have reported similar clinical outcomes regardless of the presence of the os subfibulare.[1,6] Recently, Ahn et al[2] introduced the concept of talofibular bony impingement, suggesting that it might cause limitation of ankle motion. We hypothesized that os subfibulare could interrupt the talofibular joint space causing impingement, resulting in chronic pain and functional instability around the lateral malleolus.[5,10] The purposes of this study were to evaluate morphologic characteristics of the os subfibulare and the clinical significance of the os subfibulare in patients with CLAI.

Methods

Our study protocol was reviewed and approved by the institutional review board of our hospital. Between November 2011 and April 2015, 252 patients (age ranging from 16 to 70 years) visited our hospital with the symptom of lateral ankle instability including feeling unstable or subfibular pain for more than 1 year. Their medical records and radiographic examinations were reviewed retrospectively. Clinical information was collected from the medical records of 252 patients with a trauma history and/or repetitive ankle injury. We defined major trauma history and repetitive ankle injury as an injury requiring immobilization for more than 3 weeks and 2 or more ankle sprains in the last 12 months, respectively. From the 252 patients, 92 were found to have persistent subfibular pain and 1 or more subfibular ossicles on plain radiographs. Seventy of those 92 patients who had both computed tomography (CT) and magnetic resonance imaging (MRI) were included in this study. Patients were excluded from this study if they had degenerative arthritis or bilateral os subfibulare, were feeling unstable without pain, or they had a history of surgery associated with ankle inversion injury. There were 2 cases of bilateral os subfibulare. We decided to exclude them because they did not have a normal side for comparison. In cases of suspicious ankle instability, we routinely checked bilateral ankle radiographs to determine whether there was an apparent or relative mechanical instability of the ankle. Accordingly, all patients had bilateral stress radiographic varus/valgus stress test or anterior drawer test using a Telos device with 150 N force (Weiterstadt, Germany) and had evidence of instability on the radiographs (more than 10 mm anterior talar translation or 9 degrees talar tilt in relation to the opposite side).

Using 3 planes of magnetic resonance (MR) images (sagittal, coronal, and axial), the size, shape, and width of the ossicle and continuity between the ossicle and fibula were evaluated by 2 experienced foot and ankle orthopedic surgeons. The location of the subfibular ossicle was classified into 3 zones according to the attachment site of the lateral ankle ligaments (zone I, anterior talofibular ligament [ATFL] attachment site; zone II, calcaneofibular ligament [CFL]; and zone III, posterior talofibular ligament) in the MR sagittal view (Figure 1).

Then the impingement was classified into 2 groups according to the site of ossicles impinging on the talofibular interval on the coronal MR image: group I, impingement on the talofibular interval; and group II, no impingement on the talofibular interval (Figure 2).

The picture archiving and communication system (PACS) was used to measure the ossicle width and shape determined by the length and width on a sagittal MR image (Figure 3). An online photograph editor (Pixlr editor) was

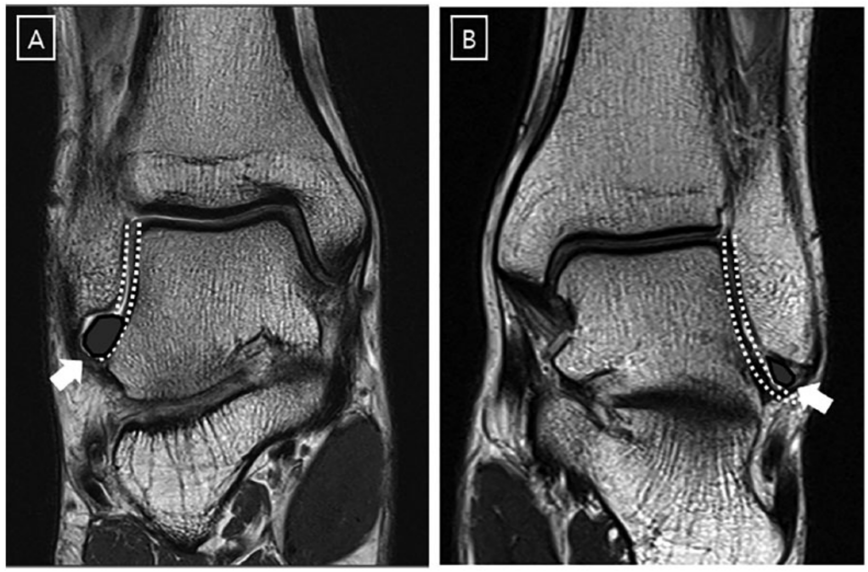

Figure 2. Impingement status on the talofibular joint on T1-weighted magnetic resonance coronal images: (A) Talofibular interval of the ankle (dotted line). (B) Group I, impingement in the talofibular interval (arrow). (C) No impingement in the talofibular interval (arrow).

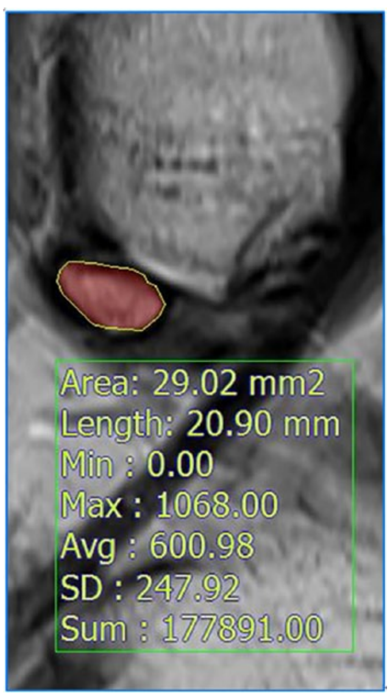

Figure 3. Measurement of the ossicle width and shape determined by the PACS system on a T1-weighted sagittal magnetic resonance image. PACS, picture archiving and communication system.

used to compare the difference in size and shape of both fibulae in both standing foot and ankle anteroposterior and lateral radiographs.

Operative treatment was selected when conservative treatment failed to relieve patients' discomfort associated with CLAI. The indications of operative treatment were as follows: (1) positive radiologic evidences of ankle instability in the varus stress test or anterior drawer test; (2) limited physical activities for more than 6 months with persistent pain and recurrent ankle sprain; and (3) sufficient trial of conservative treatment, including peroneal tendon strengthening and proprioceptive rehabilitation for more than 6 months. We performed excision of the ossicles and the modified Broström procedure for all patients who had an indication of operative treatment. All operations were performed by a single surgeon.

Chi-square and Student *t* tests were used to determine any statistical significance. The Cohen unweighted kappa was used to determine the degree of conformity between observers in evaluating the differences of the shape of both fibulae. Multiple regression analysis and odds ratios (ORs) were used to evaluate the risk factors associated with operative treatment in patients with CLAI. Logistic regression analysis was used to determine the correlation between the ossicle size and subfibular impingement on MR images. Statistical significance was considered when the *P* value was less than .05.

Results

Demographic and morphologic characteristics of the study population are summarized in Tables 1 and 2. Patients' mean age was 34.1 years (range, 16-65 years). Mean size of the ossicles was 34.5 mm^2. There were some comorbidities

Table 1. Demographic Characteristics of the Study Population.

Characteristics	Patients With Subfibular Pain (n = 70)
Age, y, mean (SD)*	34.0 (2.62)
Duration of pain, mo, mean (SD)*	13.1 (16.3)
Location of injury, right-left ankle	41:29
Gender, n (%)	
Male	36 (51)
Female	34 (49)
Main instability symptoms, n (%)	
Repetitive sprain	35 (50)
Feeling unstable	17 (24)
Swelling	18 (26)
Age group, y, n (%)	
<20	1 (2)
20-35	53 (76)
36-50	8 (11)
>50	8 (11)

*Standard deviation.

Table 2. Morphologic Characteristics of the Study Population.

Characteristics	Patients With CLAI (n = 70)
Size, mm^2, mean (SD)	34.5 (16.7)
Shape, n (%)	
Chip bone	7 (10)
Oval	49 (70)
Round	14 (20)
Location of ossicles,[a] n (%)	
Zone I	18 (24)
I + II[b]	30 (43)
Zone II	13 (20)
II + III[c]	2 (3)
Zone III	7 (10)
Impingement on talofibular joint, n (%)	
Congruent	28 (40)
Noncongruent	42 (60)
Comparison of fibular shape, n (%)	
Enlarged	48 (69)
Sustained	22 (31)
Shrunk	0 (0)

Abbreviation: CLAI, chronic lateral ankle instability.
[a]Location of the subfibular ossicle by T1-weighted magnetic resonance (MR) sagittal images.
[b]Frequency of ossicles that span zones I and II.
[c]Frequency of ossicles that span zones II and III.

in patients with CLAI. The degree of conformity between 2 observers was relatively high in the classification of the location and impingement of the subfibular ossicle (Cohen unweighted kappa values: 0.72 and 0.78, respectively)

Ossicle

All the ossicles had well-corticated and smooth margins. The most common shape of ossicles was oval, and the most common site of ossicles was zone I, which was defined as the ATFL attachment site on sagittal MR images.

Impingement

Of these 70 cases, 43 (61%) showed talofibular impingement on coronal MR images, whereas 28 cases showed normal congruency of the talofibular space. The results of the statistical analysis by logistic regression analysis showed that the size of the ossicle and location were independent variables affecting talofibular impingement.

Fibular Shape

A comparison between the shapes of ipsilateral and contralateral fibula in patients with CLAI (70 cases) is shown in Figure 4. Forty-eight cases had an enlarged fibular dimension (fibula plus os subfibulare) on plain radiographs.

MR Image Findings

The frequency of abnormal findings, including any increased signal on adjacent fibula or ligament between the ossicle and fibula, on MR images are presented in Table 3 and Figure 5. More abnormal findings were found between the ossicle and fibula than the adjacent fibula on MR images.

Operative Group

A comparison of the conservative treatment and operative treatment groups is presented in Table 4. When the factors associated with operative treatment were examined in multivariate analysis, we found that age; gender; the shape, location, and size of the ossicle; talofibular impingement; history of major trauma; and abnormal MR findings were associated with operative treatment in multiple logistic regression (Table 5).

The larger ossicles were more likely to be associated with more severe symptoms (OR 1.7; 95% confidence interval [CI]: 1.013, 1.235). Articular impingement had an OR for surgery of 12.57 (95% CI: 1.283, 121.21).

Discussion

In this study, we analyzed morphologic characteristics of the os subfibulare and found that there might be impingement of the talofibular interval by the ossicle in some patients. We also found out that the larger size and talofibular impingement of the ossicle were associated with greater

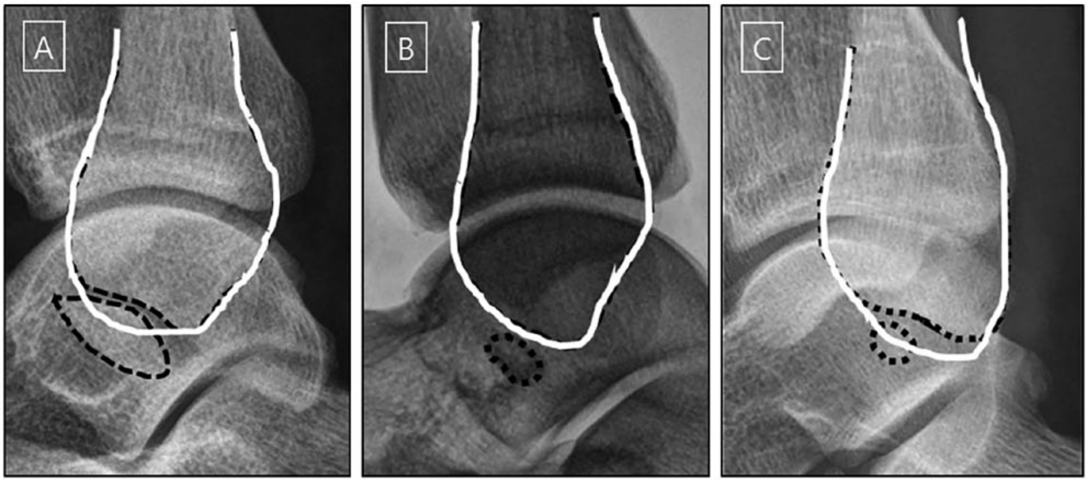

Figure 4. A comparison between the shapes of ipsilateral (black dotted line) and contralateral fibula (white line): (A) Enlarged fibula compared with the contralateral fibula. (B) Fibular shape with similar size compared with the contralateral fibula. (C) Smaller fibula compared with the contralateral fibula.

Table 3. The Frequency of Abnormal Findings on MR Images in Patients With Subfibular Pain.

Characteristics	Subfibular Ossicle, n (n = 70)	Abnormal Signal Intensity Around the Ossicle,[a] n (%) (n = 53)
Any increased signal		
On adjacent bone[b]		18 (34)
Between ossicle and fibula		35 (66)
Location of ossicles,[c]		
Zone I	18	7 (39)
I + II[d]	30	25 (83)
Zone II	13	2 (15)
II + III[e]	2	1 (50)
Zone III	7	0 (0)

[a]Discontinuity or a high-density signal of T2-weighted magnetic resonance (MR) on adjacent bones or between the larger ossicle and fibula.
[b]Increased signal on the T2-weighted MR images which suggest bony edema or stress reaction on fibula and talus bone.
[c]Frequency of abnormal finding of sagittal T2-weighted MR images between the ossicle and fibula according to location of ossicle in 35 of those 70 patients.
[d]Frequency of ossicles that span zones I and II.
[e]Frequency of ossicles that span zones II and III.

need for operative treatment in patients with ankle instability. In our study population, 37% (92 of 252) of patients with chronic ankle instability were found to have 1 or more subfibular ossicle on plain radiographs, which was more prevalent than approximately 1% incidence in the general population. All ossicles had well-corticated, smooth margins. The most common shape of ossicles was oval, and the most common location of ossicles was zone I, which was defined as the ATFL attachment site on sagittal MR images, suggesting that an avulsion-type injury might be a cause for development of os subfibulare.[14]

We compared the fibular shape of the affected and nonaffected sides using the lateral radiographs of 70 patients. In a comparison with the contralateral side, the fibular dimension (fibula plus os subfibulare) was enlarged in 48 cases, whereas 22 cases showed no difference or a smaller size (Table 2). Recently, Lee et al reported that 91.7% of avulsed fibular fragments showed an increase in the size of ossicles in a study of ankle inversion injury of skeletally immature patients.[15]

Of these 70 cases, 42 (61%) showed talofibular impingement on coronal MR images, whereas 28 cases showed normal congruency of the talofibular interval. In a group with impingement, 83% of patients had subfibular impingement which could be caused by the volume increment, morphologic change, and medial intrusion or breakage on the talofibular articular surface line by the subfibular ossicle of the fibula.

On MRI examinations, 53 (76%) showed abnormal findings such as high signal intensity on adjacent bones or ligament between the larger ossicle and fibula (Table 3), although continuity of the ATFL was usually maintained. Of these 53 cases, 18 (34%) showed increased signal on the T2-weighted MR images, which suggest bony edema or stress reaction on the adjacent bone. The larger the size of the avulsed fragment, the higher the tendency of medial translation and joint space intrusion.

The results of multiple logistic regression analysis showed that talofibular impingement was highly related to patients' need for operative treatment. Articular impingement in the talofibular interval and larger ossicles were more likely to be associated with more severe CLAI. These

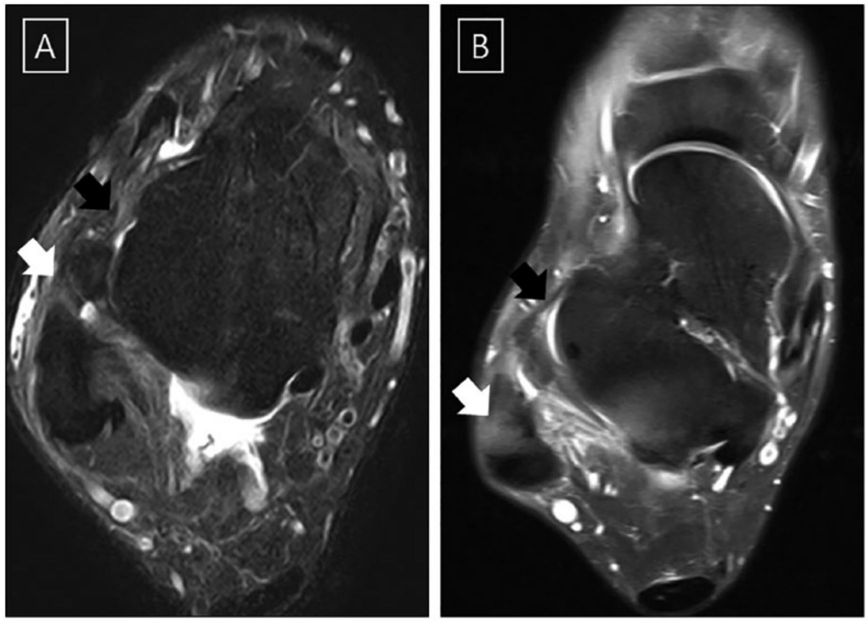

Figure 5. (A) Discontinuity or high density (white arrow) between the ossicle and fibula on axial T2-weighted MR image whereas the ligaments between the talus and ossicle are relatively normal in appearance (black arrow). (B) Increased signal that suggests bony edema or stress reaction of fibula (white arrow), whereas the ligaments between the talus and ossicle are well maintained (black arrow) on T2-weighted axial image.

Table 4. Comparison of Conservative Treatment Group and Operative Treatment Group.

Characteristics	Conservative Treatment (n = 35)	Operative Treatment (n = 35)	*P* Value[a]
Age, y, mean (SD)	34.1 (12.0)	33.7 (11.9)	.731
Size, mm^2, mean (SD)	31.1 (22.3)	40.3 (23.4)	.001
Shape of ossicle, n (%)			
Chip bone	5 (14.2%)	3 (8.5%)	.135
Oval	24 (68.5%)	23 (65.7%)	.076
Round	6 (17.1%)	9 (25.7%)	.645
Location of ossicle, n (%)			
Zone I and (I + II)[b]	25 (71.4%)	23 (65.7%)	.196
II and (II + III)[c]	8 (22.8%)	7 (20%)	.662
III	2 (5.7%)	5 (14.2%)	.209

[a]Logistic regression analysis.
[b]Frequency of ossicles that span zones I and II.
[c]Frequency of ossicles that span zones II and III.

results suggested that a larger ossicle would have less secure continuity between the ossicle and fibula, leading to more talofibular impingement of the ankle and more subfibular pain. For this reason, in CLAI, patients with a larger impinging ossicle in the talofibular interval are more prone to operative treatment.

There are several limitations of this study. First, this was a retrospective study, and the number of cases included was relatively small. Second, in order to obtain a more accurate subfibular impingement location of the subfibular ossicle, imaging study such as standing CT for both ankles would have been more useful than simple radiographs. Last, clinical comparison between nonoperative and operative treatment was not possible in this study because of the retrospective nature of the study. Prospective clinical evaluation would be more helpful to decide the clinical benefit of operative treatment more objectively in CLAI patients with os subfibulare.

Table 5. Odd Ratios and 95% CIs for Risk Factors Associated With Operative Treatment in CLAI Patients With Os Subfibulare.

Factor	*P* Value[a]	OR (95% CI)
Age	.603	1.02 (0.946, 1.099)
Gender[b]	.982	1.01 (0.218, 4.760)
Ossicle		
Shape[c]	.143	1.04 (0.925, 1.264)
Location[d]	.058	1.51 (0.023, 2.055)
Size	.016	1.7 (1.013, 1.235)
Articular impinge[e]	.024	12.57 (1.283, 121.21)
Major trauma history[f]	.879	0.87 (0.122, 5.308)
Repetitive injury of ankle[g]	.825	0.92 (0.864, 1.162)

Abbreviations: CI, confidence interval; CLAI, chronic lateral ankle instability; OR, odds ratio.
[a]Logistic regression analysis.
[b]Male = 1; female = 0.
[c]Chip bone = 1; oval = 2; round = 3.
[d]Zone I = 1; zone II = 2; zone III = 3.
[e]Impingement on the talofibular joint = 0; no impingement = 1.
[f]Major trauma history = 1, defined as an injury with immobilization treatment >3weeks; no trauma history = 0.
[g]Repetitive injury = 1, define as 2 or more ankle sprains in the last 12 months); no repetitive = 0.

Conclusions

The morphologic analysis of the os subfibulare revealed that there might be impingement of the talofibular interval by the ossicle in some patients. Based on our results, we suggest that the morphologic characteristics of the os subfibulare should be considered when selecting treatment options in patients with CLAI and os subfibulare.

Declaration of Conflicting Interests

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References

1. Ahn HW, Lee KB. Comparison of the modified Brostrom procedure for chronic lateral ankle instability with and without subfibular ossicle. *Am J Sports Med*. 2016;44(12):3158-3164.
2. Ahn JY, Choi HJ, Lee WC. Talofibular bony impingement in the ankle. *Foot Ankle Int*. 2015;36(10):1150-1155.
3. Berg EE. The symptomatic os subfibulare. Avulsion fracture of the fibula associated with recurrent instability of the ankle. *J Bone Joint Surg Am*. 1991;73(8):1251-1254.
4. Bjornson RG. Developmental anomaly of the lateral malleolus simulating fracture. *J Bone Joint Surg Am*. 1956;38(1):128-130.
5. Busconi BD, Pappas AM. Chronic, painful ankle instability in skeletally immature athletes. Ununited osteochondral fractures of the distal fibula. *Am J Sports Med*. 1996;24(5):647-651.
6. Chun TH, Park YS, Sung KS. The effect of ossicle resection in the lateral ligament repair for treatment of chronic lateral ankle instability. *Foot Ankle Int*. 2013;34(8):1128-1133.
7. Ferran J, Blanc T. Os subfibulare in children secondary to an osteochondral fracture [in French]. *J Radiol*. 2001;82(5):577-579.
8. Griffiths JD, Menelaus MB. Symptomatic ossicles of the lateral malleolus in children. *J Bone Joint Surg Br*. 1987;69(2):317-319.
9. Hamilton WG, Thompson FM, Snow SW. The modified Brostrom procedure for lateral ankle instability. *Foot Ankle*. 1993;14(1):1-7.
10. Han SH, Choi WJ, Kim S, Kim SJ, Lee JW. Ossicles associated with chronic pain around the malleoli of the ankle. *J Bone Joint Surg Br*. 2008;90(8):1049-1054.
11. Hasegawa A, Kimura M, Tomizawa S, Shirakura K. Separated ossicles of the lateral malleolus. *Clin Orthop Relat Res*. 1996;330:157-165.
12. Kim BS, Choi WJ, Kim YS, Lee JW. The effect of an ossicle of the lateral malleolus on ligament reconstruction of chronic lateral ankle instability. *Foot Ankle Int*. 2010;31(3):191-196.
13. Kono T, Ochi M, Takao M, Naito K, Uchio Y, Oae K. Symptomatic os subfibulare caused by accessory ossification: a case report. *Clin Orthop Relat Res*. 2002;399:197-200.
14. Kwak YH, Lim JY, Oh MK, Kim WJ, Park KB. Radiographic diagnosis of occult distal fibular avulsion fracture in children with acute lateral ankle sprain. *J Pediatr Orthop*. 2015;35(4):352-357.
15. Lee DY, Lee DJ, Kim DH, Shin HS, Jung WI. Posttraumatic subfibular ossicle formation in children: experience in a single primary care unit. *J Pediatr Orthop*. 2018;38(9):e530-e535.
16. Pill SG, Hatch M, Linton JM, Davidson RS. Chronic symptomatic os subfibulare in children. *J Bone Joint Surg Am*. 2013;95(16):e115(111-116).