# Fabellar prevalence, parameters and association with medial meniscal tear: causality or coincidence?

**Jingyu Zhong**
Tongren Hospital, Shanghai Jiao Tong University School of Medicine
**Guangcheng Zhang**
Shanghai Jiao Tong University Affiliated Sixth People's Hospital
**Liping Si**
Tongren Hospital, Shanghai Jiao Tong University School of Medicine
**Yangfan Hu**
Shanghai Jiao Tong University Affiliated Sixth People's Hospital
**Yaohua He**
Shanghai Jiao Tong University Affiliated Sixth People's Hospital
**Weiwu Yao** ( yaoweiwuhuan@163.com )
Tongren Hospital, Shanghai Jiao Tong University School of Medicine

**Research Article**

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# Abstract

**Background:** Fabella is a sesamoid bone of knee that has potential biomechanical function. The correlation between medial meniscal (MM) tear and fabella has not been rigorously examined. The aim of this study is to examine the fabellar prevalence and parameters in Chinese population and test the hypothesis that fabellar presence and morphology are associated with MM tear.

**Methods:** A total of 1011 knee magnetic resonance imaging scans were analyzed. The fabellar presence was documented and parameters were measured. Further ratios were calculated to present fabellar morphology. Differences among subgroups were compared and correlation of fabellar presence and parameters with advancing age was assessed by Spearman correlation analysis. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to investigate whether factors have relationship with MM tear. Diagnostic performance of risk factors was assessed and cut values were determined.

**Results:** The overall prevalence of fabellae was 39.8% and increased with the increasing age ($r = .237$, $P < .001$). The fabellar were larger in male and ones with an articulating groove (all $p < .001$). The length/thickness ratio and width/thickness ratio were found significantly different between gender, age and articulating groove condition (all $P < .05$) and showed a moderate correlation with age ($r = .463$, $p < .001$; $r = .303$, $p < .001$), respectively. Fabella presented more often in knees with MM tears with a multivariate OR of 2.960 (95% CI, 1.853-3.903). Age, fabellar length, width, length/thickness ratio and width/thickness ratio yielded an area under the ROC curve (AUC) of 0.604-0.766 to predict an MM tear. In combination with age, fabellar width and length/thickness ratio, the diagnostic performance was improved to an AUC of 0.791 (95% CI, 0.744-0.837), a sensitivity of 73.0% and a specificity of 74.6% (OR, 7.939; 95% CI, 4.094-12.852).

**Conclusion:** The presence of fabellae, increased fabellar length and width as well as flatter fabellar morphology, are significantly associated with an increased risk for MM tear. These findings might aid clinicians in identifying patients at risk for a MM tear and informing them.


# Background

Fabella is a small fibrocartilaginous body or sesamoid bone usually embedded in the tendon of the lateral head of the gastrocnemius muscle and articulated with the posterior surface of the lateral condyle of the femur [2,3]. Fabellae are usually accompanied by oblique popliteal ligament (OPL) and fabellofibular ligament (FFL), indicating its potential biomechanical function [2,3,12]. In most cases, fabellae are reported in the lateral head of gastrocnemius, but they are found in the medial head with a much lower frequency[17]. The frequency of occurrence of fabellae ranges from 3.1 to 86.9% [31,37] among global regions, ethnicities and observational methods. An ossified fabella is usually seen at the age of 12 years or older, meanwhile, cartilaginous fabellae are not able to be seen radiologically, but by magnetic resonance imaging (MRI) or anatomic methods[9,17]. Moreover, mathematic procedures calculating either per person, per knee or per gastrocnemius head, arises the confusion in discussing the prevalence of fabella [12,13,37]. Previous studies revealed that both genetic and environmental factors played a role in fabella development[10,30] and showed that Asian people, older people and knee osteoarthritis patients would present with fabellae more frequently [10,12,14,15,17,20,37]. The size of fabellae varies from a tiny dot to a body of width of 22 mm [24]. Large ones are more likely to be associated with articular grooves and larger ones were considered to have greater clinical significance [5]. The fabella is believed to be involved in the stabilization of posterolateral corner of the knee [8,12,20,37] and seemed to serve as suspension for the ligaments evolving from its base and affects how loads are transferred from the gastrocnemius to the femur, tibia and fibula [12].

The fabella is usually believed to be a benign anatomical variant detected occasionally in routine radiological examinations; nevertheless, under rare circumstances, it is related with several conditions, disorders and diseases, such as common perineal neuropathy, chondromalacia, nerve palsy, poplitealartery entrapment syndrome, rheumatoid arthritis and osteoarthritis [1,2,4,6,14,15,28,37]. Most interestingly, its presence and degeneration are correlated with age and knee osteoarthritis [14,15]. The dislocation, fracture and even the presence itself can cause medical issues [11,18,38]. Surgical procedures also have association with fabella. In cases of total knee arthroplasty, the patients with a left fabella occasionally suffered from postsurgical complications, snapping painfully over the replaced knee joint [21]. Fabella excision in fabella syndrome patients demonstrated improvements in clinical outcomes [7]. In our institution, we noticed that some of the patients with a fabella might complain a postolateral pain of knee after an arthroscopic meniscectomy. The anatomical and clinical effects of the fabellae are interesting to orthopedics and radiologists, and further studies on fabella are encouraged.

However, limited fabella-related studies were published, the majority of which were small sample size studies. Most of them were performed by roentgenogram methods which had a lower sensitivity in cartilage fabellae in comparison to those by MRI or anatomic methods and was unable to describe the characteristics of the fabellae in detail. On the other hand, most studies discussing the association between medical conditions and fabellae were case reports. To the best of our knowledge, no study focused on the relationship between ligaments or meniscus injuries and fabellar presence.

The purpose of this study was to examine fabellar prevalence and parameters in Chinese population and to determine whether fabella and meniscal or ligament injury are correlated. It was hypothesized that fabellar presence and parameters were related to some of the knee ligaments or meniscus disorders and could not be treated as a simple normal anatomic variant.

## Methods

## Patients

A retrospective review was conducted of consecutive patients who underwent MRI for knee pain at our institution through October 2019 (Fig. 1). Patients were excluded before analysis as follows: (a) postsurgical scans;(b) difficult to discriminate the fabella and posterior osteophytes or loose bodies; (c) conditions not suitable for evaluation including knee malalignment, acute injury, gouty arthritis, rheumatic arthritis, synovitis, tumors etc.; (d) poor image quality or nonstandard posture. Thus, a total of 1011 knee MRI scans were recruited for the final analysis. Clinical data, including age, gender, side of the knee, and related medical history were retrieved from institutional database records.

This study was approved by the Ethics Committee of our institution and written informed consent was waived due to its retrospective observational nature. All methods and procedures were performed in accordance with the relevant guidelines and regulations.

## MRI measurements

MRI scans were performed on 3.0T superconducting MRI scanners (Achieva, Philips Healthcare, Amsterdam, Netherlands; Ingenia, Philips Healthcare, Amsterdam, Netherlands; Magnetom Verio, Siemens Healthineers, Erlangen, Germany; Signa, GE Healthcare, Waukesha, WI, USA) with a standard protocol included at standard axial, coronal and sagittal imaging planes, at the slice thicknesses of 3 to 5 mm for each plane. MRI sequences included T1-weighted imaging, T2-weighted imaging and/or proton density weighted imaging. All MRI scans were reviewed by a radiologist and an orthopedist independently using a reader (TViewU64, Winningsoft inc., Shanghai, China).

In our pilot study, only medial meniscal (MM) tear was found to be related to presence of fabella ($p = 0.032$). However, we decided to document patients with anterior cruciate ligament (ACL) rupture, posterior cruciate ligament (PCL) rupture, and lateral meniscal (LM) tear, which might be interested to orthopedists. In our formal study, the presence of ACL rupture, PCL rupture, LM tear and MM tear were documented. The final decision was reached with consensus after discussion in uncertain cases.

In patients where a fabella was present, two readers measured the maximum length, thickness and width, distance between the fabella and the insertion of the lateral head of the gastrocnemius onto the femur (DFI) based on MRI films on sagittal, coronal or axial view of the knee, independently [5] (Fig. 2a-b). Intraclass correlation coefficient (ICC) was used to assess the interobserver reliability. To assess intraobserver reliability, measurements in a random sample of 50 knees was repeated by the radiologist 2 weeks later. The presence of any articulating facet was documented, which was defined as either a flat or concave contour of the lateral femoral condyle (Fig. 2c-d). The definition and measurements ware described previously [5]. The length/thickness ratio, width/thickness ratio and length/width ratio of fabellae were calculated to present its morphology.

# Statistics

Statistical analysis was performed by SPSS 26.0 (SPSS inc., Chicago, IL, USA). Continuous variables were stated as the mean ± standard deviation (SD), and categorical variables were stated as percentages and frequency distributions. To assess intergroup differences, the independent samples t test was used for continuous variables showing a normal distribution, the Mann-Whitney U test for nonnormally distributed variables; the chi-square test for categorical variables, and Fisher exact test for those with small sample sizes. To assess multigroup differences with heterogeneity of variance, the Kruskal-Wallis H test was used. The Spearman nonparametric correlation test was used for correlative analysis. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to investigate whether the gender, knee side, age and fabellar presence were in relation to MM tear. Multiple logistic regression analysis was used to estimate adjusted ORs and 95% CIs of weather factors have relationship with MM tear. For each parameter, the receiver operating characteristic (ROC) curve and the area under the curve (AUC) and its 95% CI were calculated. The AUC was tested by z test with a significance level of 0.5. Indexes whose AUC differed significantly from 0.5 were included in a logistic regression model. The maximal Youden index was used to determine the optimal cutoff value. In the case of multiple cutoff values, the diagnostic OR was used. Accordingly, there was a unique cutoff value for every index. The diagnostic performance of the indexes was analyzed by calculations including AUC, Youden index, cutoff value, sensitivity, specificity, accuracy and diagnostic OR via logistic regression model and chi-square test. All of the statistical tests were 2-sided, and P values < 0.05 were considered to statistical significance if not stated otherwise.

# Results

### Patients and MRI measurements

A total of 465 males and 546 females aged ranging from 8 to 91 years (41.47 ± 15.39, mean ± SD, years) were included (Appendix Table 1), of which 46 had ACL rupture, 12 had PCL rupture, 183 had MM tears, 110 had LM tears and 709 had none of above. 527 right knees and 484 left ones were examined. The excellent reliability of the measurements was established with minimum ICC of 0.851 (95% CI 0.822-0.876) for the interobserver reliability and 0.880 (95% CI 0.797-0.930) for the intraobserver reliability (Appendix Table 2).

### Fabellar prevalence and parameters

The overall fabellar prevalence was 39.8% (Table 1). There was no significant difference in fabellar prevalence between gender or knee sides. The prevalence of fabellae was significantly different among age groups ($p < 0.001$)

and weakly correlated with age, which increased from young to old age groups (r = 0.237, $p < 0.001$).

Overall, the length, thickness and width of the 402 fabellae were 7.52 ± 2.15 (mean ± SD, range 2.19-15.47) mm, 4.53 ± 1.54 (1.56-11.05) mm and 6,47 ± 2.25 (1.68-13.44) mm, respectively (Appendix Table 3). The DFI was 33.0 ± 4.6 (22.4-45.5) mm. The size of fabellae in men were found to be consistently larger and the DFI longer than those in women (all $p < 0.001$). However, there was no significant difference of fabellar parameters between knee sides. Among the 402 knees with fabellae, articulating facets were noted in 179 knees, with 50 concave and 129 flat. Generally, the size of fabellae with articulating facets were larger than that without (all $p < 0.001$). Analysis of the size of the fabellae according to age groups showed that, the length ($p < 0.001$) and thickness ($p = 0.011$) of fabellae and DFI were significantly differed.

The length/thickness ratio and width/thickness ratio were found to be significantly different between gender, age and articulating groove condition, but not knee sides (Table 2). Specially, those ratios showed a moderate correlation with age (r = 0.463, $p < 0.001$; r = 0.303, $p < 0.001$), respectively, which increased from young to old age groups in patients elder than 20 years.

### Fabella and MM tear

For knee injuries, no significant difference in fabellar prevalence in knees with or without ACL rupture, PCL rupture or LM tear was found (Table 1). However, the fabellar prevalence was 66.7% in knees with MM tear, which was higher than the 33.8% prevalence in knees without ($p < 0.001$; Appendix Table 4). The presence of fabellae was found in relation to MM tear in subgroups, in male ($p < 0.001$) and female (P < 0.001) patients, in right ($p < 0.001$) and left ($p < 0.001$) knees, and in all age groups, except for patients under 20 years ($p = 0.435$).

Since fabellar presence was more often in knees with MM tears, the univariate OR of 3.914 (95% CI 2.788-5.496) was calculated (Appendix Table 5). Age was also found as a risk factor after logistic regression. Multiple logistic regression analysis revealed that fabellar presence and age were predictive for MM tears. Adjusted OR indicated that MM tear increased with fabellar presence and from young to old age groups (Table 3).

In 402 patients with fabellae, their parameters were compared (Appendix Table 6). The length ($p < 0.001$) and width ($p = 0.001$) of fabellae, but not thickness or DFI, were significantly larger in knees with MM tear than those without. The length/thickness ratio ($p < 0.001$) and width/thickness ratio ($p < 0.001$) were found larger in knees with MM tear than those without, but no significant difference in length/width ratio ($p = 0.408$) was found (Table 2). Subgroup analysis showed similar pattern in both gender, knee sides, articulating groove subgroups and elder patients.

The highest AUC among fabellar parameters was reported for length/thickness ratio (0.706; 95% CI, 0.649-0.763), with a sensitivity of 64.8% and specificity of 70.4% to predict MM tear (Table 4, Fig. 3, Appendix Table 7 and 8). The calculated cutoff of 1.776 (Youden index = 0.352) was associated with an increased risk for MM tear (OR = 4.361, 95% CI 2.777-6.848) and allowed an accurate allocation to the knees with MM tear versus those without in 69.4% of the cases. The combination via logistic regression resulted in an AUC of 0.791 ($p < 0.001$, OR = 7.939, 95% CI 4.094-12.853), higher than length/thickness ratio alone with AUC of 0.706 ($p = 0.024$; Table 4). However, the AUC of combination was not significantly different from age with AUC of 0.766 ($p = 0.473$; Table 4).

## Discussion

The findings showed a relatively high prevalence of 39.8% in Chinese population, and demonstrated that fabella presence and parameters are related to MM tear. The fabellar parameters varies between gender, age, articulating groove condition, MM tear, but not side of legs. Multivariate analysis showed that both fabellar presence and age were risk factors for MM tear, which indicated that the fabella is more than a normal anatomic variant. A prediction model combined age, width, length/thickness ratio showed a good diagnostic performance with AUC of 0.741, and might aid clinicians in identifying patients at risk for an MM tear and informing the patients for their higher MM tear risk.

# Fabellar prevalence and parameters varies

To date, several fabella-related studies were presented (Appendix Table 9). The existing studies detected fabella with method of ranging sensitivity and calculated fabellae in varies ways in a relatively small sample size, which might arise controversial results [9,12,37]. Additionally, most of the previous studies only documented the presence of fabellae, but not parameters, which hindered further exploration of mechanisms of fabellar development and its potential role in knee biomechanics. However, our protocol, which calculated every knee in a large sample of Chinese population screened by MRI might avoid these disadvantages and allow detailed measurements to infer how the fabella influences the MM.

The fabellar prevalence ranged among ethnic groups, from 3.1 to 31.3% in Caucasian populations and from 30.6 to 92% in Asian populations [3,5,8,9,10,12,14,15,16,17,20,23,24,25,26,27,30,31,33,34,36,37]. Our study agreed with relatively high prevalence reported in Asian population [3,5,9,14,15,20,23,33,37]. Previous study suggested that the form of fabella was genetically controlled; however, related genes and pathways were unknown [8]. On the other hand, the ossification of fabellae was correlated to environmental factors, such as mechanical stimuli [9], which was supported by an Asian lifestyle, including kneeling, squatting and tailor sitting. All above give persistent pressure of the fabellae [5,37].

There was controversial relationship between age and fabellar prevalence. Most studies reported no relationship between age and fabellar prevalence [3,5,8,12,24,30,33]. However, a positive correlation between age and fabellar presence was observed in our study, similar to a large sample size study reported by Hou et al [14]. These controversial results were assumed to be attributed to the small sample size, which might not be powerful enough to detect such relationship, and radiological methods they used, which could not distinguish cartilaginous fabellae.

For the size of fabellae, the larger dimensions were recorded in male than female as reported before [5,25]. In our study, there is 44.5% of fabellae with articular grooves on the lateral femoral condyle, less than previous studies [5,17]; yet we agreed with the fact that a fabella with an articular facet was more likely to be larger [5]. These findings supported that the larger fabellae might be more efficient in shifting load through surrounding structures[5,25]. The fabellar length and thickness varied among age groups and a trend for this pattern was discovered for width; however, no consistent correlation between age and fabellar parameters was found in our study.

To present fabellar morphology, fabellar length/thickness ratio, width/thickness ratio and length/width ratio were calculated. We found that the smaller the fabellae, the larger the length/thickness ratio and width/thickness ratio, i.e., the flatter the fabellae, which reflected the biomechanical advantage of larger fabellae [5,25].

# Fabella and MM tear: causality or coincidence?

Some of the studies suggested that fabellae were associated with medical conditions, such as osteoarthritis [7,14], but none of them considered fabellae as an influencing factor for knee ligaments or meniscus disorders. The presenting study first revealed that the fabellar presence and morphology was associated with MM tear. However, the causal mechanism needs to be confirmed by experimental study.

Age was a main confounding factor in this study. Although degeneration led to both presence of fabellae and MM tear [14,36], we found more fabellae in knees with MM tear among patients elder than 20 years. Further logistic regression showed that fabellar presence were independent risk factor for MM tear and a ROC analysis demonstrated that fabellar parameters had influence on the predictive model, indicating that there were mechanisms other than age-related degeneration contributed to the association between fabellae and MM tear. A radiographic analysis considering presence and severity of osteoarthritis might provide a chance to draw a more robust conclusion.

The fabellae in lateral head of the gastrocnemius muscle were surrounded by extremely complicated structures comprising OPL, FFL, and arcuate ligament [17,20,24,34,36,37]. These ligaments directly attach to fabella when it presents [35,37], but the FFL was reported to be more frequently detected when the fabella was absent [22,37]. Furthermore, the presence of FFL and arcuate ligament were inconsistent structures with fabella [20] and were considered only involved in posterolateral corner complex of knee [37]. Accordingly, they were insufficient to explain the association between fabella and MM tear.

On the contrary, OPL was a relatively consistent structure on the posterior aspect of the knee. The OPL originates from the posterior surface of the posteromedial tibia condyle, merges with fibers from the semimembranosus tendon and from the posteromedial part of the capsule, then converges and courses in a diagonal oblique course, and finally attaches to the fabella when that is present [13,35]. As a structure involved in both posteromedial and posterolateral corner [19], OPL plays a role in preventing excessive external rotation and extension of knee [20,35]. The fabella is considered as a stabilizer during this procedure [17]. For this purpose, forces might shift from fabella along OPL and separate into a horizontal force and a vertical force [35], then it could make a persistent stretch upon the fabella. As a result, its length and width are extended and thus a flatter morphology is showed. On the other hand, an equal, but opposite force influences the posteromedial corner chronically, hence leads to posteromedial corner disorders which decreases dynamic function of the MM and increased risk of injury[36]. This hypothesis might explain the flatter fabella seen in knees with MM tear. In knees where a fabella is absent, OPL attaches to the tendon of the lateral head of the gastrocnemius [35]. Without forces transferring from fabella, OPL might sustain less force as a dynamic knee stabilizer. Further experimental analysis is needed to determine causal relation between fabella and MM tear, especially the effect of OPL and other surrounding structures in development and degeneration of fabella.

# Clinical relevance

Okano et al [21] has described a patient experienced posterolateral knee pain after total knee arthroplasty due to fabella and cured the patient with fabellectomy. In our clinical settings, some patients with a fabella might complain a postolateral pain of knee after an arthroscopic meniscectomy. Since patients occasionally suffered from postsurgical complications supposed to be related to fabella, fabella should be seen not as a normal anatomic variant, but a structure with potential clinical significance. Although fabella syndrome could be cured with fabellectomy as Dekker et al [7] presented recently, preoperative planning is encouraged, especially in patients with posterolateral knee pain, which includes acquiring a detailed history, assessing the symptoms, performing specific tests concerning fabellar lesions, and radiological evaluation [14]. Intraoperatively, assessment of fabellar impingement against surrounding structures is needed, to avoid postsurgical complications. Patients' complain about posterolateral knee pain, should be taken seriously as a sign of potential biomechanical disbalance other than normal postoperative phenomenon, even in a patient underwent medial meniscectomy. These considerations might help the clinician to determine whether the fabella should be treated.

# Limitations

There are several limitations in our study. Firstly, our cross-sectional study was unable to make causal inferences. Moreover, we were not allow to include detailed information that might have influence on the fabella and MM tear [2,32], such as height, body mass, career and habits, into analysis. Secondly, only 12 patients with PCL rupture were identified during our inclusion period, which might cause a selection bias. Thirdly, plain films were not available for all included patients, therefore only MRI measurement were performed. Although MRI alone is sensitive enough for the detection of fabella and MM tears, and is adequate for this study, a combination of radiographic and MRI analysis might improve its clinical relevance for physicians and anatomists [14,37]. Fourthly, even though the defined cutoff values of fabellar parameters were given, their relation to MRI measurements lessened its clinical application. The validation for radiography or computed tomography was need. Lastly, our study did not provide experimental evidence for causal relation between fabella and MM tear.

# Conclusion

The fabellar presence and morphology are significantly associated with an increased risk for MM tear, which might be underestimated and neglected in diagnostic workups before. The clinicians should pay attention to this structure with potential clinical significance, other than treat it as a normal anatomic variant.

# Abbreviations

ACL = anterior cruciate ligament

AUC = the receiver operating characteristic curve and the area under the curve

CI = confidence interval

DFI = distance between the fabella and the insertion of the lateral head of the gastrocnemius onto the femur

FFL = fabellofibular ligament

ICC = intraclass correlation coefficient

LM = lateral meniscus

MM = medial meniscus

MRI = magnetic resonance imaging

OPL = oblique popliteal ligament

OR = odds ratios

PCL = posterior cruciate ligament

ROC = receiver operating characteristic

SD = standard deviation

# Declarations

## Ethics approval and consent to participate

The study was approved by the Shanghai Jiao Tong University Affiliated Sixth People's Hospital review board and the requirement for written informed consent was waived due to its retrospective design.

## Consent for publication

Not applicable.

### Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### Competing interests

The authors declare that they have no competing interests.


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### Authors' contributions

Conceptualization: All authors; Methodology: All authors; Data curation, Formal analysis, Investigation, Validation: JYZ, GCZ; Software, Visualization: JYZ; Writing - original draft preparation: JYZ; Writing - review and editing: All authors; Funding acquisition, Supervision: WWY, YHH.


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### Authors' information


1 Department of Imaging, Tongren Hospital, Shanghai Jiao Tong University School of Medicine, No. 1111, Xianxia Road, Shanghai 200336, China

2 Department of Sports Medicine, Shanghai Jiao Tong University Affiliated Sixth People's Hospital, No. 600, Yishan Road, Shanghai 200233, China

3 Department of Radiology, Shanghai Jiao Tong University Affiliated Sixth People's Hospital, No. 600, Yishan Road, Shanghai 200233, China

4 Department of Orthopedics, Shanghai Sixth People’s Hospital, Jinshan Branch, No. 147 Jiankang Road, Shanghai 201500, China


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# Tables

**Table 1 The Fabellar Prevalence [a]**

| | Absent | Present | *P* value |
|---|---|---|---|
| Gender | | | |
| Male | 265 (57.0) | 200 (43.0) | 0.051 |
| Female | 344 (63.0) | 202 (37.0) | |
| Side | | | |
| Right | 303 (57.5) | 224 (42.5) | 0.063 |
| Left | 306 (62.3) | 178 (36.8) | |
| ACL rupture | | | |
| Yes | 30 (65.2) | 16 (34.8) | 0.658 |
| No | 579 (60.0) | 386 (40.0) | |
| PCL rupture | | | |
| Yes | 6 (50.0) | 6 (50.0) | 0.466 |
| No | 603 (60.4) | 396 (39.6) | |
| MM tear | | | |
| Yes | 61 (33.3) | 122 (66.7) | <0.001 |
| No | 548 (66.2) | 280 (33.8) | |
| LM tear | | | |
| Yes | 63 (57.3) | 47 (42.7) | 0.507 |
| No | 545 (60.6) | 355 (39.4) | |
| Age group[b] | | | |
| ≤20 | 58 (75.3) | 19 (24.7) | <0.001 |
| 21-30 | 136 (71.6) | 54 (28.4) | |
| 31-40 | 174 (65.7) | 91 (34.3) | |
| 41-50 | 114 (58.2) | 82 (41.8) | |
| 51-60 | 77 (57.5) | 57 (42.5) | |
| ≥61 | 50 (33.6) | 99 (66.4) | |
| Overall | 609 (60.2) | 402 (39.8) | - |

[a]Values are presented as n (%). *P* values refer to chi-square test for pooled values. *ACL* anterior cruciate ligament, *PCL* posterior cruciate ligament, *MM* medial meniscus, *LM* lateral meniscus.

[b]r = 0.237, P <0.001, Spearman nonparametric correlation test.

**Table 2 The Fabellar Parameters [a]**

| Fabellar parameter | Length, mm | Thickness, mm | Width, mm | DFI, mm | Length/Thickness | Width/Thickness | Length/Width |
|---|---|---|---|---|---|---|---|
| Gender | | | | | | | |
| Male (n = 202) | 7.96 ± 1.80 | 5.00 ± 1.61 | 6.86 ± 2.05 | 34.8 ± 4.5 | 1.68 ± 0.42 | 1.44 ± 0.43 | 1.22 ± 0.31 |
| Female (n = 200) | 7.08 ± 2.37 | 4.06 ± 1.31 | 6.08 ± 2.37 | 31.3 ± 3.9 | 1.81 ± 0.51 | 1.54 ± 0.57 | 1.23 ± 0.31 |
| *P* value | <0.001 | <0.001 | <0.001 | <0.001 | 0.015 | 0.044 | 0.528 |
| Side | | | | | | | |
| Right (n = 224) | 7.55 ± 2.33 | 4.53 ± 1.59 | 6.41 ± 2.40 | 33.0 ± 4.7 | 1.74 ± 0.47 | 1.46 ± 0.44 | 1.24 ± 0.32 |
| Left (n = 178) | 7.49 ± 1.90 | 4.52 ± 1.47 | 6.54 ± 2.05 | 33.0 ± 4.4 | 1.75 ± 0.47 | 1.53 ± 0.58 | 1.20 ± 0.30 |
| *P* value | 0.781 | 0.972 | 0.336 | 0.956 | 0.856 | 0.395 | 0.367 |
| Articulating groove | | | | | | | |
| Yes (n = 179) | 8.68 ± 1.85 | 5.44 ± 1.41 | 7.36 ± 2.12 | 32.8 ± 4.6 | 1.67 ± 0.44 | 1.39 ± 0.37 | 1.24 ± 0.30 |
| No (n = 223) | 6.59 ± 1.92 | 3.79 ± 1.21 | 5.75 ± 2.09 | 33.2 ± 4.5 | 1.81 ± 0.48 | 1.58 ± 0.58 | 1.21 ± 0.32 |
| *P* value | <0.001 | <0.001 | <0.001 | 0.349 | <0.001 | <0.001 | 0.381 |
| MM tear | | | | | | | |
| Yes (n = 122) | 8.22 ± 2.36 | 4.38 ± 1.45 | 7.11 ± 2.37 | 32.6 ± 4.3 | 1.97 ± 0.50 | 1.70 ± 0.60 | 1.21 ± 0.33 |
| No (n = 280) | 7.21 ± 1.98 | 4.59 ± 1.58 | 6.19 ± 2.14 | 33.2 ± 4.7 | 1.65 ± 0.42 | 1.40 ± 0.43 | 1.23 ± 0.30 |
| *P* value | <0.001 | 0.294 | 0.001 | 0.314 | <0.001 | <0.001 | 0.408 |
| Age group[b] | | | | | | | |
| ≤20 (n = 19) | 7.79 ± 2.18 | 5.29 ± 1.42 | 6.64 ± 1.59 | 33.5 ± 5.8 | 1.49 ± 0.29 | 1.33 ± 0.40 | 1.20 ± 0.32 |
| 21-30 (n = 54) | 7.17 ± 1.97 | 5.08 ± 1.76 | 6.42 ± 2.15 | 34.0 ± 4.8 | 1.47 ± 0.33 | 1.32 ± 0.39 | 1.16 ± 0.27 |
| 31-40 (n = 91) | 6.92 ± 1.77 | 4.61 ± 1.58 | 6.07 ± 2.06 | 33.4 ± 4.3 | 1.56 ± 0.32 | 1.35 ± 0.36 | 1.20 ± 0.29 |
| 41-50 (n = 82) | 7.02 ± 1.83 | 4.29 ± 1.48 | 6.09 ± 2.32 | 33.6 ± 5.0 | 1.71 ± 0.37 | 1.43 ± 0.44 | 1.23 ± 0.30 |
| 51-60 (n = 57) | 7.63 ± 2.10 | 4.33 ± 1.43 | 6.65 ± 2.28 | 32.6 ± 4.4 | 1.86 ± 0.52 | 1.61 ± 0.55 | 1.21 ± 0.32 |
| ≥61 (n = 99) | 8.55 ± 2.45 | 4.30 ± 1.40 | 7.03 ± 2.47 | 31.8 ± 4.0 | 2.07 ± 0.52 | 1.71 ± 0.65 | 1.28 ± 0.35 |
| *P* value | <0.001 | 0.011 | 0.078 | 0.115 | <0.001 | <0.001 | 0.417 |

| Fabellar parameter | Length, mm | Thickness, mm | Width, mm | DFI, mm | Length/Thickness | Width/Thickness | Length/Width |
|---|---|---|---|---|---|---|---|
| Overall (n = 402) | 7.52 ± 2.15 | 4.53 ± 1.54 | 6,47 ± 2.25 | 33.0 ± 4.6 | 1.75 ± 0.47 | 1.49 ± 0.51 | 1.22 ± 0.31 |

[a]Values are presented as mean ± standard deviation mm. *P* values refer to independent samples t test, Mann-Whitney U test or Kruskal-Wallis H test for pooled values. *DFI* distance between the fabella and the insertion of the lateral head of the gastrocnemius onto the femur, *MM* medial meniscus.

[b]r = 0.463, P<0.001 for length/thickness ratio, r=0.303, P<0.001 for width/thickness ratio; Spearman nonparametric correlation test.

**Table 3 Multivariate Odds Ratios of Risk Factors for Medial Meniscal Tear [a]**

| | Coefficient | Standard Error | df | *P* value | Odds Ratio Multivariate | 95% Confidence Interval |
|---|---|---|---|---|---|---|
| Fabellar presence | | | | | | |
| Yes vs No | 0.989 | 0.190 | 1 | <0.001 | 2.690 | 1.853-3.903 |
| Age | 0.074 | 0.007 | 1 | <0.001 | 1.077 | 1.063-1.091 |
| Intercept | -5.468 | 0.364 | 1 | <0.001 | 0.004 | n/a |

[a]Factors with an increased unvariate odds ratios of risk were included in the logistic regression model. *n/a* not applicable.

**Table 4 Diagnostic Performance Among Age and Fabellar Parameters [a]**

| | Length | Width | Length/Thickness | Width/Thickness | Age | Combination[b] |
|---|---|---|---|---|---|---|
| Sensitivity | 0.664 | 0.418 | 0.648 | 0.705 | 0.779 | 0.730 |
| Specificity | 0.536 | 0.739 | 0.704 | 0.641 | 0.707 | 0.746 |
| Accuracy | 0.559 | 0.681 | 0.694 | 0.653 | 0.748 | 0.741 |
| DOR | 2.280 | 2.037 | 4.361 | 4.507 | 8.496 | 7.939 |
| AUC | 0.619 | 0.604 | 0.706 | 0.688 | 0.766 | 0.791 |
| AUC: 95% CI | 0.559-0.679 | 0.544-0.664 | 0.649-0.763 | 0.633-0.744 | 0.716-0.816 | 0.744-0.837 |
| *P* for AUC = 0.5[c] | 0.001 | 0.012 | <0.001 | <0.001 | <0.001 | <0.001 |
| *P* for AUC = Combination[d] | <0.001 | <0.001 | 0.024 | 0.005 | 0.473 | n/a |

[a] *DFI* distance between the fabella and the insertion of the lateral head of the gastrocnemius onto the femur, *DOR* diagnostic odds ratio, *AUC* area under curve, *CI* confidence interval, *n/a* not applicable.

[b]Combination = Width + Length/Thickness + Age, Logistic regression: Backward.

[c] $P$ value of each AUC tested against 0.5; binomial $z$ test.

[d] $P$ value of each AUC tested against the AUC of combination; binomial $z$ test.

# Figures

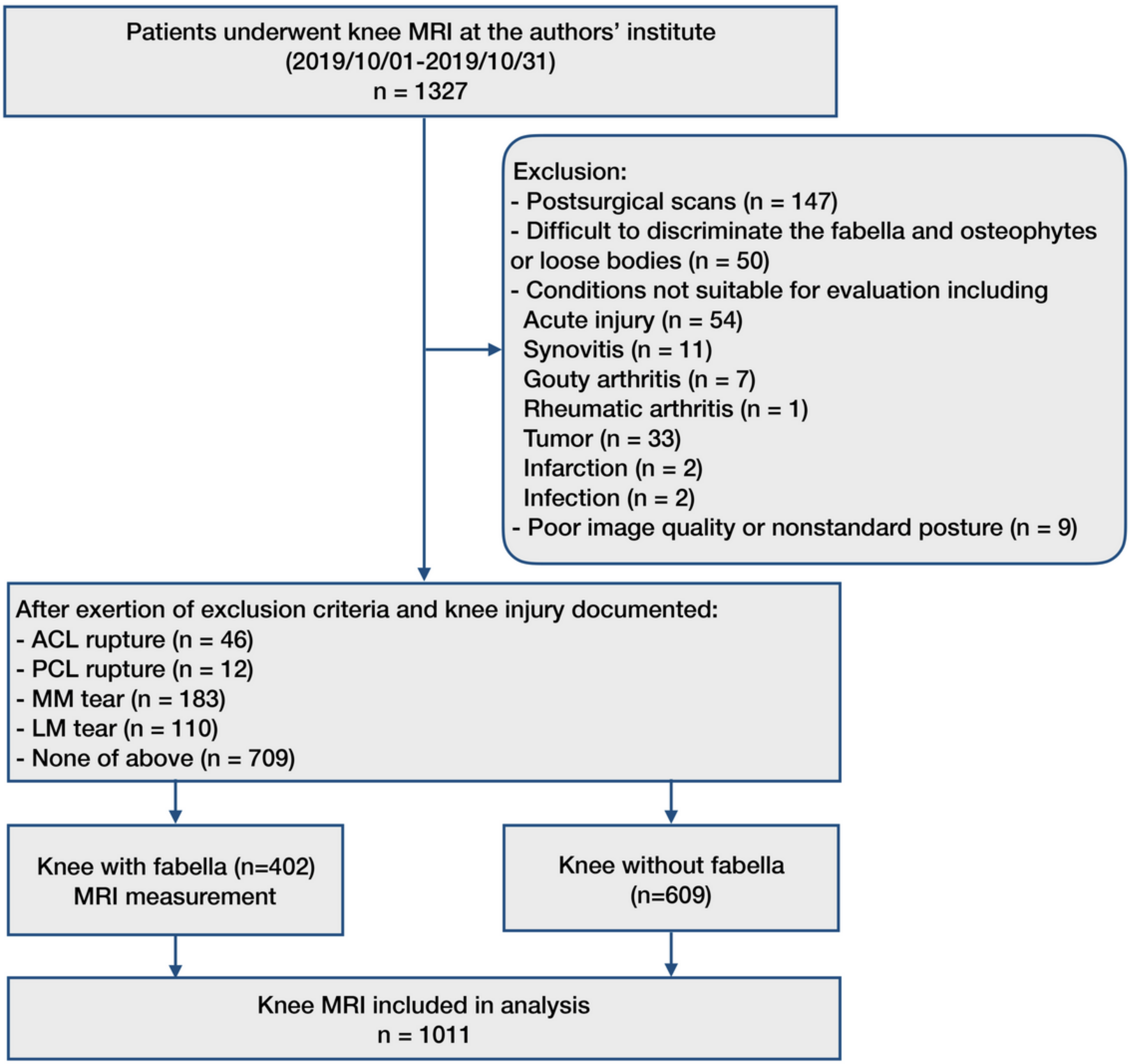


**Figure 1**

Flowchart and eligibility. ACL anterior cruciate ligament, PCL posterior cruciate ligament, MM medial meniscus, LM lateral meniscus, MRI magnetic resonance imaging.

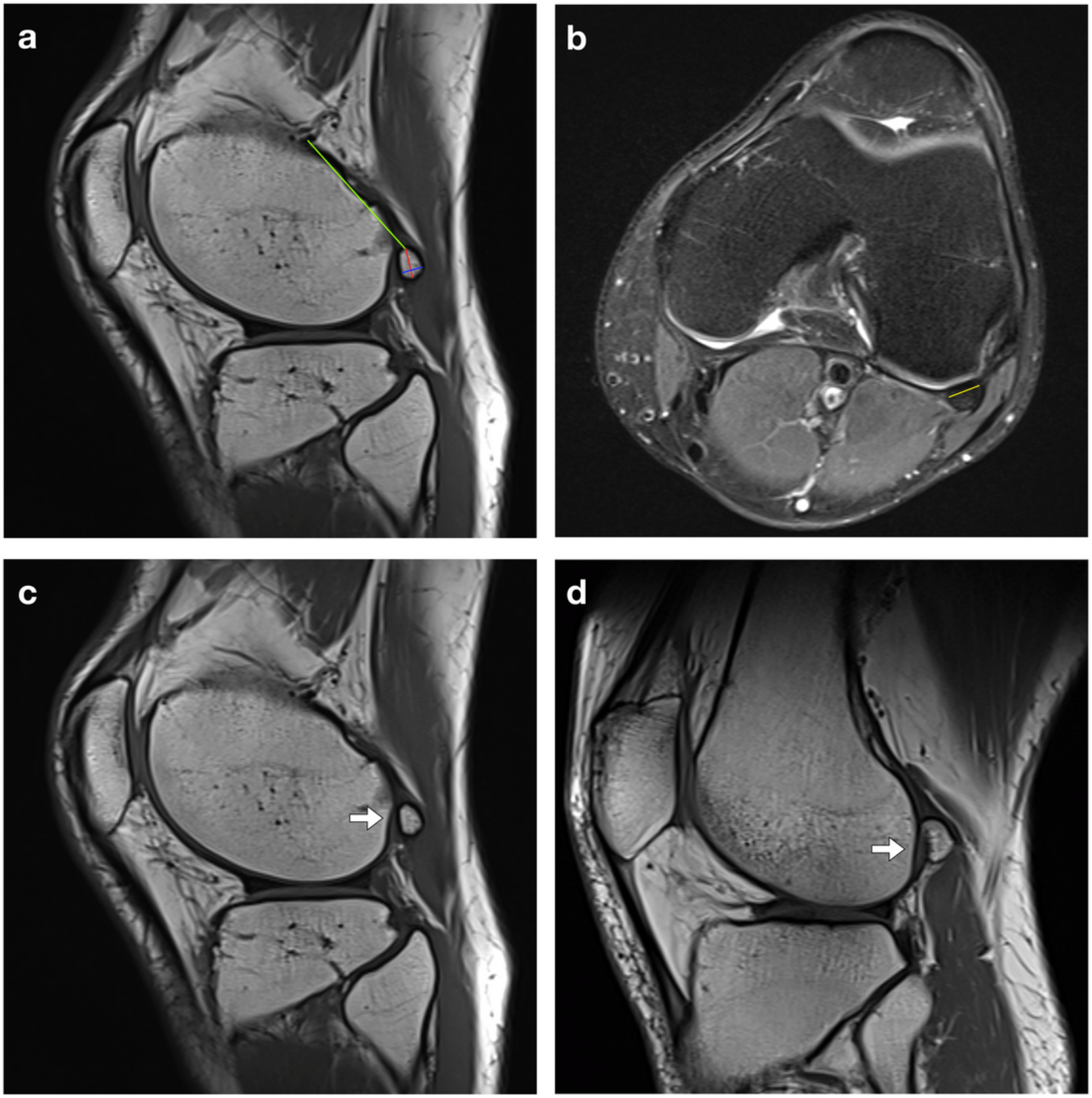


**Figure 2**

Magnetic resonance imaging (MRI) measurement and articulating facet. (a) Sagittal MRI of the knee shows the measurement of the maximum length (red line), thickness (blue line) of fabella, and the distance between the fabella and the insertion of the lateral head of the gastrocnemius onto the femur (green line); (b) Axial MRI of the knee shows the measurement of the maximum width of the fabella (yellow line); MRI of the knee show (c) concave and (d) flat contours of the articulating facet of the lateral femoral condyle of the femur (arrow).

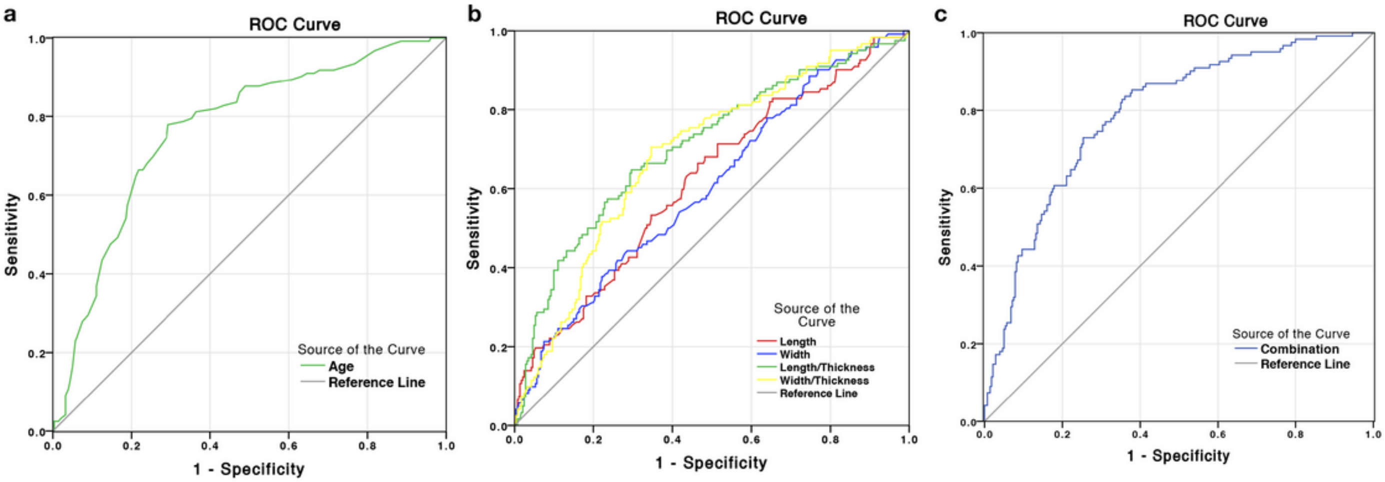


**Figure 3**

Receiver operator characteristic curve analysis. (a) Age yielded an area under the curve (AUC) of 0.766; (b) Fabellar parameters whose AUC differed significantly from 0.5 were showed. Length (red line, AUC = 0.609), width (blue line, AUC = 0.604), length/thickness ratio (green line, AUC = 0.706), width/thickness ratio (yellow line, AUC = 0.688). (c) Combination = width + length/thickness + age (AUC = 0.791). Reference line (grey line): AUC = 0.5.

# Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AppendixTables210517.docx