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The relationship between lateral epicondyle morphology and iliotibial band friction syndrome: A matched case–control study

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ABSTRACT

Background: Iliotibial band friction syndrome (ITBFS) is an overuse injury with pain at the level of the knee lateral epicondyle. We sought to determine whether there is greater knee lateral epicondyle prominence among patients with ITBFS versus matched controls.

Methods: Seventy five patients with ITBFS and 75 age-, height-, and sex-matched controls ($n = 150$ total patients) with knee magnetic resonance imaging from 2015 to 2017 were included. All cases had a diagnosis of ITBFS and a lack of other identified lateral knee injuries on magnetic resonance imaging. Controls had medial knee pain with medial meniscus tear on MRI and no clinical evidence of ITBFS. Lateral knee epicondyle height in millimeters was measured.

Results: Mean patient age was 39.1 years (SD 15.1), 57% were female, and mean height was 170.0 cm (SD 9.3) with no difference between cases and controls. Mean lateral epicondyle height for cases was 13.1 mm (SD 1.6) and for controls was 12.2 (SD 1.4) with a mean difference of 0.9 mm (95% CI 0.4–1.3 mm) between matched pairs ($p < 0.001$). Mean epicondyle height:condylar AP width ratio was 0.211 (SD 0.023) for cases and 0.198 (SD 0.020) for controls with a mean difference of 0.013 (95% CI 0.006–0.020) between matched pairs ($p < 0.001$).

Conclusions: There is a significant association between greater lateral epicondyle prominence and IT band friction syndrome, suggesting another anatomic risk factor for this multifactorial condition.

1. Introduction

Iliotibial (ITB) band friction syndrome (ITBFS), first recognized in 1974 in military recruits, is one of the most common overuse injuries that occurs during activities that involve extensive knee flexion, such as distance running and endurance cycling [1]. While its reported incidence varies between 1.6% and 12% for runners and is as high as 15% to 24% in endurance cyclers, it is thought to be responsible for up to 22% of lower extremity injuries overall [2–7]. Abnormalities in hip adduction, weak hip adductor strength, and excessive knee genu varum have all been suggested as contributors to IT band syndrome from an anatomic perspective [7,8]. Iliotibial band syndrome is believed to occur due to tissue compression of the posterior ITB over the lateral

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femoral epicondyle prominence with the knee in flexion [7,9]. In addition, magnetic resonance imaging (MRI) findings include increased signal intensity and localized fluid collection near the lateral femoral epicondyle in patients with IT band syndrome [10–13]. A case series of patients surgically treated for recalcitrant ITBFS describes excision of the lateral epicondyle prominence as well as windowing of the posterior portion of the IT band overlying the epicondyle at 30° knee flexion [14].

Iliotibial band friction syndrome pain is manifested and reproducible at the lateral condyle [15], and MRI will often show fluid collection and a thickened IT band over the lateral epicondyle in these patients [16]. While the lateral epicondyle's surrounding soft tissue anatomy has been described extensively, little is known about variation in the size of the lateral epicondyle. Distal femoral bony morphology in general is variable across individuals [17] and there are also sex and race specific morphologic differences [18–21]. It has been noted anecdotally that excessive epicondyle prominence may contribute to recalcitrant IT band syndrome symptoms in runners in particular [14], though a small study comparing radiographs of patients with symptomatic ITBFS versus asymptomatic controls found no difference in epicondyle size [1].

Our research group recently conducted an anatomy study characterizing individual variability in lateral epicondyle prominence (unpublished data). Using a sample of 165 human skeletons with known demographic information at death (81 female, 84 male; 85 black, 80 white, age 28.7 years SD 7.6), we demonstrated individual variability in epicondyle prominence (mean prominence 7.9 mm SD 1.1, range 5.5–11.0 mm) and found taller individuals to have more prominent epicondyles. Test–retest and inter-rater reliability for epicondyle prominence using laser scanned images in this pilot study was high (intra-class correlation coefficient (ICC) = 0.94 and 0.91, respectively). This pilot laboratory study has provided a rationale for examining the role of epicondyle prominence in ITBFS symptoms as we have demonstrated individual variability in lateral epicondyle prominence and the feasibility of measuring the prominence of this structure on three-dimensional imaging. The purpose of the current study is to determine whether there is greater knee lateral epicondyle prominence among patients with ITBFS versus sex, height and age matched controls.

2. Methods

All patients were enrolled from a single academic medical center from 10/2015 to 04/2017 to 2018. Based on a prior pilot study (unpublished work), mean lateral epicondyle prominence of skeletal specimens free of soft tissue was 7.9 mm with a standard deviation of 1.1. An a-priori power analysis determined that the current study sample size (n = 75 per group) is adequate to detect a difference in mean epicondyle prominence of 0.6 mm, assuming similar standard deviations as the pilot study, at 80% power and alpha = 0.05. All potential cases were evaluated for iliotibial band friction syndrome at the knee and several inclusion criteria were applied (Table 1). All cases had knee pain localized to the distal iliotibial band at the level of the lateral condyle and had a knee MRI obtained as part of their clinical care. No cases had evidence of concomitant lateral compartment pathology on MRI. Controls were obtained from patients within the same timeframe that were matched by gender as well as age within five years and height within five centimeters. All control patients had a knee MRI obtained for medial knee pain with a diagnosis of medial meniscus tear. Medial meniscus tears were selected as control injuries as they are very common (thus limiting the number of patient records needed to identify controls well matched to cases), they involve contralateral side of the knee and are caused by a mechanism distinct from ITBFS.

All lateral epicondyle measurements were performed with MRI using a T2-weighted axial sequence (Figure 1) and were performed by two independent evaluators (JH and JCK). To measure lateral epicondyle height and lateral condylar anterior–posterior (AP) width, the axial image at which the lateral epicondyle is the most prominent is utilized. Lateral condylar AP width was determined by lateral margin of the anterior and posterior articular surface of the lateral condyle; the length of this line represents the lateral condylar AP width. A second line is then drawn perpendicular to the first line toward the lateral-most point on the lateral epicondyle; this second line represents the lateral epicondylar height.

2.1. Statistical analysis

Statistical analyses were performed with a standard software package (STATA 13.0, College Station, TX). Descriptive data were generated with stratification by case or control status. The relationship between epicondyle height and matching characteristics (sex, height, and age) was assessed via unpaired t-test and simple linear regression, respectively. Epicondyle height versus lateral condyle AP width was assessed via simple linear regression. Paired Student's t-tests were utilized to compare differences in demographics and knee morphologic measurements between matched cases and controls. Test–retest and inter-rater reliability was assessed with the intra-class correlation (ICC) statistic.

Table 1
Study inclusion and exclusion criteria.

Inclusion criteria
Age 13–70, no gender or height restrictions
No prior history of knee surgery
Cases: clinical presentation and physical examination consistent with IT band friction syndrome
Controls: physical examination and clinical imaging consistent with medial meniscus tear
Cases and controls: knee MRI study available and without evidence of concomitant lateral knee cartilage, meniscus or ligamentous pathology

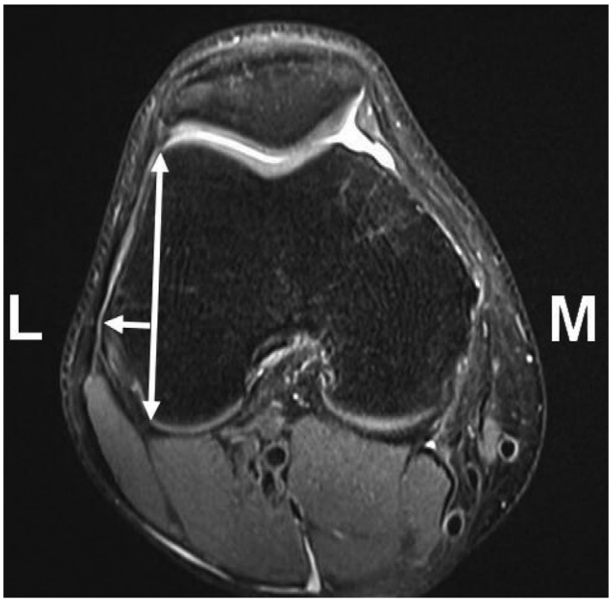

Figure 1. Axial T2-weighted MRI of a right knee (M: medial; L: lateral) and method of measuring lateral condylar anterior–posterior (AP) width and lateral epicondylar height. The axial image at which the lateral epicondyle is the most prominent is utilized. A line is first drawn connecting the lateral margin of the anterior and posterior articular surface of the lateral condyle; the length of this line represents the lateral condylar AP width. A second line is then drawn perpendicular to the first line toward the lateral-most point on the lateral epicondyle; this second line represents the lateral epicondylar height.

3. Results

3.1. Patient demographics and lateral epicondyle height

A total of 75 ITBFS cases and 75 medial meniscus tear controls were enrolled. The mean age of cases was 39.6 years (SD 15.4), 57% were female, and the mean patient height was 170.2 cm (SD 10.1); there were no differences in age, gender, or height between cases and matched controls (Table 2). Patient age was not correlated with epicondyle height ($R = 0.1$, $p = 0.21$); however, patient height was positively correlated with lateral epicondyle height ($R = 0.36$, $p < 0.001$) with an average 0.6 mm increase in epicondyle height for every 10 cm increase in patient height (Figure 2). There was a difference in epicondyle height between men (13.1 mm SD 1.4) and women (12.2 mm SD 1.5) ($p < 0.001$).

3.2. Difference in lateral epicondyle height

Lateral epicondyle height was 0.9 mm larger on average for cases (13.1 mm SD 1.6) compared to matched controls (12.2 SD 1.4) ($p < 0.001$) (Table 2) (Table 3). The lateral condyle AP width was similar between cases and controls ($p = 0.57$), though lateral condyle AP width was moderately correlated with lateral epicondyle height for both cases ($R = 0.44$; $p < 0.001$) as well as controls ($R = 0.51$; $p < 0.001$). The ratio of epicondyle height to lateral condyle AP width was significantly higher among cases (mean ratio 0.211 SD 0.023) compared to controls (0.198 SD 0.02) with a mean difference of 0.013 between case–control pairs ($p < 0.001$) (Table 2) (Table 3), indicating a relatively large lateral epicondyle relative to the size of the distal lateral femur.

Table 2
Demographics and distal femur measurements.

	Cases (n = 75)	Controls (n = 75)	p-Value[a]
Age	39.6 SD 15.4	39.4 SD 14.6	0.80
Male	43%	43%	N/A[b]
Female	57%	57%	
Height (cm)	170.2 SD 10.1	169.8 SD 9.1	0.28
Lateral condyle AP width (mm)	62.0 SD 3.9 Range: 54.9–71.1	61.7 SD 4.1 Range: 51.6–69.3	0.57
Lateral epicondyle height (mm)	13.1 SD 1.6 Range: 8.5–16.8	12.2 SD 1.4 Range: 9.8–15.4	<0.001
Epicondyle height:lateral condyle AP width ratio	0.211 SD 0.023 Range: 0.144–0.258	0.198 SD 0.020 Range: 0.159–0.260	<0.001

[a] Paired Student's t-test.
[b] All cases and controls were matched exactly according to gender.

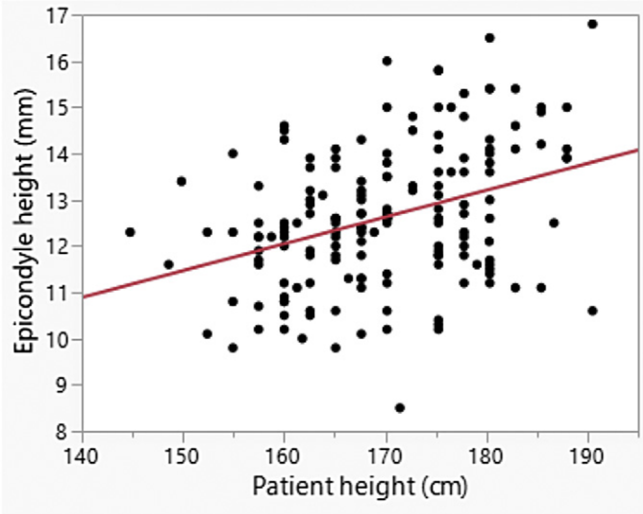

Figure 2. Association between patient height and lateral epicondyle height. There is a linear association between patient height and lateral epicondyle height. According to the best fit line (Pearson R = 0.36, $p < 0.001$), epicondyle height increases on average 0.6 mm for every 10 cm increase in patient height.

3.3. Measurement reliability

Test–retest reliability was good to excellent for all knee measurements including lateral condyle AP width (ICC 0.86), lateral epicondyle height (ICC 0.81), and the epicondyle height:condyle AP width ratio (ICC 0.73) (Table 4). Inter-rater reliability was similarly good to excellent for lateral condyle AP width (ICC 0.84), lateral epicondyle height (ICC 0.82), and the epicondyle height to lateral condyle AP width ratio (ICC 0.79) (Table 4).

4. Discussion

The purpose of the current study was to determine the difference in lateral epicondyle height between patients with symptomatic IT band syndrome (ITBS) and those without ITBS. The current study found that there was a mean difference of 0.9 mm (95% confidence interval (95% CI): 0.4–1.3, $p < 0.001$) in lateral epicondyle height between patients with ITBS and case–controls, confirming that a more prominent lateral epicondyle is typically present in the setting of ITBS. This difference persisted even after adjustment for the size of the entire lateral condyle (AP width) (Table 3), indicating that ITBS patients have large lateral epicondyles relative to the size of the distal lateral femur. The anatomic space deep to the distal IT band may be effectively 'overstuffed' with a prominent lateral epicondyle with resulting predisposition to bursitis and subsequent ITBFS symptoms.

Due to the multifaceted nature of ITBS, it is important to elucidate the different exacerbating factors, and thereby improve treatment options available to patients. The current study helps to further parse out the different aspects of ITBS by determining anatomical differences between patients with ITBS and matched controls. Since there is an overall difference in lateral epicondyle prominence between patients with and without ITBS, it is likely a factor in IT band syndrome. However, lateral epicondyle height is not likely to be a sole cause of ITBS as a large variation in epicondyle height was observed in both cases and control. This further emphasizes the multifactorial nature of IT band syndrome, and lateral epicondyle prominence may have a cumulative effect to other primary causes of ITBS, such as IT band tightness or hip abductor weakness [3,4].

Lateral epicondyle height seems to be a factor in ITBS, and therefore a potential area of treatment. Currently, stretching and strengthening through physical therapy paired with anti-inflammatory medications is the primary mode of treatment for IT band syndrome. The current study findings suggest that there may be alternative options for treatment of the IT band through treatment at the lateral epicondyle, particularly in recalcitrant cases with confirmation of a large epicondyle and the absence of lateral compartment intraarticular pathology on imaging. Decompressing the area through lateral epicondyle osteoplasty with

Table 3
Mean difference in MRI measurements between matched pairs.

	Mean difference (case–control)	95% confidence interval	p-Value[a]
Distal femur AP width	0.2 mm	−1.1–0.6 mm	0.57
Lateral epicondyle height	0.9 mm	0.4–1.3 mm	<0.001
Epicondyle height:lateral condyle AP width ratio	0.013	0.006–0.020	<0.001

[a] Paired Student's t-test.

Table 4
Test–retest and inter-rater reliability.

	Test–retest reliability (ICC and 95% CI)	Inter-rater reliability (ICC and 95% CI)
Lateral condyle AP width	0.86 (0.67–0.94)	0.84 (0.62–0.94)
Lateral epicondyle height	0.81 (0.59–0.92)	0.82 (0.58–0.93)
Epicondyle height:lateral condyle AP width ratio	0.73 (0.44–0.88)	0.79 (0.52–0.91)

ICC: intraclass correlation coefficient.
95% CI: 95% confidence interval.

or without ITB lengthening or windowing may serve to decrease the friction generated at the lateral epicondyle and provide relief when paired with other modalities. This could serve particularly for correcting and improving recalcitrant ITBS and improve the effectiveness for the other modalities such as anti-inflammatories and physical therapy.

Although the purposes of the study were realized, there are limitations in the clinical applicability of these results. A main area of further evaluation would be to determine the efficacy of potential treatments for ITBS that affect the lateral epicondyle. Also, the current study is limited because of the inability to prospectively determine a lateral epicondyle height that would lead to IT band syndrome. This means that we are unable to determine whether lateral epicondyle height is the main cause of ITBS, if it is a secondary factor, or if it is a side-effect of the other causes of ITBS, such as IT band tightness. Regardless, the results of the current study do help to expand upon the existing knowledge of the biomechanical and anatomical causes of ITBS, and thereby potentially improving treatment options for this patient population.

5. Conclusion

There is a significant association between greater lateral epicondyle prominence and IT band friction syndrome, suggesting another anatomic risk factor for this multifactorial condition.

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Ethical review statement

This study was approved by the Biomedical Institutional Review Board of The Ohio State University.

Declaration of Competing Interest

Dr. David Flanigan is a consultant for Vericel, Smith & Nephew, Depuy Mitek, Inc., MTF-Conmed, Ceterix, and Zimmer. The other authors declare no conflict of interest. No funding was received for this study.

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