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Posterior tibial slope in adults with sequelae of Osgood-Schlatter disease: An MRI study

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MAIN POINTS

- Skeletally mature adults with Osgood–Schlatter disease (OSD) sequelae show no significant differences in medial or lateral posterior tibial slope compared with matched controls on magnetic resonance imaging.
- Contrary to adolescent studies, posterior tibial slope alterations associated with OSD do not appear to persist after skeletal maturity.
- The trivial effect sizes despite adequate statistical power suggest no clinically meaningful biomechanical alteration in adult OSD sequelae.
- These findings highlight the importance of distinguishing adolescent and adult OSD when considering knee biomechanics and anterior cruciate ligament injury risk.

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ABSTRACT

Aim: Magnetic resonance imaging (MRI) assisted evaluation of the lateral and medial posterior tibial slopes in patients with Osgood-Schlatter disease (OSD) sequelae who have reached skeletal maturity.

Materials and Methods: The study population comprised 78 adults with OSD sequelae, while the control group consisted of 78 age-, sex-, and side-matched individuals without osseous, ligamentous, or tendinous pathology. A retrospective analysis of knee MRI scans was performed. The medial and lateral posterior tibial slope (PTS) angles were calculated from the sagittal T1-weighted images.

Results: Demographic variables (age, sex, and side) were statistically similar among the two groups. The medial PTS was 4.01° (95% CI: 3.41–4.61) in the OSD group and 3.90° (95% CI: 3.33–4.47) in the control group ($p = 0.784$; Cohen's $d = 0.04$). The lateral PTS was 4.98° (95% CI: 4.46–5.51) and 4.85° (95% CI: 4.29–5.41) respectively ($p = 0.732$; Cohen's $d = 0.05$). Post-hoc power analysis indicated that, with the current sample size (n = 78 per group), the study had >80% power to detect a medium effect size (Cohen's $d = 0.50$) at $\alpha = 0.05$; however, the observed differences corresponded to trivial effect sizes.

Conclusion: Contrary to findings in adolescents, skeletally mature adults with OSD sequelae did not exhibit statistical variation in medial or lateral PTS compared to matched controls. These results imply that changes in slopes described during growth may be lost after maturity.

Keywords: Osgood-Schlatter disease, Adult, Posterior tibial slope, Magnetic resonance imaging

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INTRODUCTION

Repetitive loading of the tibial tuberosity from quadriceps muscle activity results in Osgood-Schlatter disease (OSD), a form of traction apophysitis. It is typified by activity-related knee pain coupled with swelling and tenderness at the tibial tubercle, and it is exclusively seen in physically active adolescents, particularly boys. The condition typically manifests between ages 8–13 in girls and 10–15 in boys, with bilateral involvement reported in roughly one-quarter of patients. When skeletal growth is complete, OSD typically goes away on its own [1–5]. Ununited ossicles are a common residual finding in adults [6,7].

The shape of the proximal tibial plateau has a significant impact on knee biomechanics, with the posterior tibial slope (PTS) being especially significant [8–10]. In imaging studies, the PTS angle is the standard parameter used to quantify this feature. According to earlier studies, adolescents with OSD frequently have steeper PTS values than their peers in good health [11,12]. There is currently a lack of data on skeletally mature adults who still have OSD-related abnormalities. The aim of this study was to evaluate medial and lateral PTS in skeletally mature adults with OSD sequelae using magnetic resonance imaging (MRI). We hypothesized that there would be no significant difference in medial and lateral PTS values

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between adult patients with OSD sequelae and matched controls.

MATERIALS AND METHODS

This study was approved by the Non-Interventional Research Ethics Committee of Bilkent City Hospital (approval number: 2-24-414). We retrospectively analyzed knee MRI examinations performed between January and December 2022. Exclusion criteria included a history of prior knee surgery or significant trauma (with radiologic evidence of ligament, tendon, or bone injury), the presence of space-occupying lesions within the knee joint, age below 20 years, and poor-quality or motion-degraded MRI scans that precluded accurate evaluation. After the exclusion of the patients that met the exclusion criteria, 78 patients with OSD sequelae were included for analyses in our study. The control group comprised 78 age-matched patients without bone, tendon or ligament disease, as determined by an MRI scan performed for anterior knee pain.

MRI acquisition

All imaging was conducted using a specialized extremity coil on a 1.5 Tesla Optima scanner (GE Medical Systems, Milwaukee, WI, USA). The knee was kept fully extended while the patients were in a supine position for the purpose of examination. The standard knee MRI protocol encompassed sagittal T1-weighted fast spin echo sequences, axial fat-suppressed PD FSE sequences, sagittal and coronal fat-suppressed PD FSE sequences, and sagittal 3D T2-weighted Cube FSE acquisitions. Slice thickness was 4.4 mm for 2D sequences with an interslice gap of 0.5 mm, while the sagittal 3D T2-weighted Cube sequence had a slice thickness of 2.15 mm with no interslice gap.

Definition of OSD sequelae

The sequelae of OSD, defined as an enlarged bony prominence in the tibial tuberosity or non-united bony fragmentation in the patellar tendon [6]. Diagnosis was based on MRI findings, and clinical history was reviewed when available to confirm consistency with prior OSD. No radiographic criteria outside MRI were required for inclusion.

Measurement of PTS

The lateral and medial PTS angles were measured using a method previously described [13]. Lateral and medial PTS were measured on the central sagittal slice, identified at the level of the posterior cruciate ligament and intercondylar eminence. The tibial axis was defined by fitting circles to the tibial cortices, and PTS was calculated relative to a perpendicular line through this axis (Figure 1A-C). All measurements were performed independently by two radiologists: one with a 20 years of experience in musculoskeletal imaging and the other with six years of experience in radiology. Inter- and intra-observer reliability were evaluated using the intraclass correlation coefficient (ICC).

Statistical analysis

SPSS software, version 20.0 (Armonk, NY: IBM Corp.) was used to conduct statistical analyses. The homogeneity of variances was confirmed using Levene's test, and the distribution of variables was examined using the Kolmogorov–Smirnov test. Independent samples t-test for continuous data and Chi-square tests for categorical data were used to compare groups. Correlation between age and PTS values was assessed using Pearson correlation analysis, as the data demon-strated normal distribution. A post-hoc power analysis was performed to evaluate the achieved statistical power using the observed effect sizes. Inter- and intra-observer reliability were assessed using the intraclass correlation coefficient (ICC). A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1 displays the demographic characteristics of the participants. The demographic variables were similar among the OSD sequelae and control groups, with mean age (35.94 ± 12.26 vs. 35.23 ± 10.80 years, p = 0.599), sex distribution (male/female: 69/9 in both groups, p = 1.000), and side of the knee evaluated (right/left: 32/46 in both groups, p = 1.000) being highly comparable across groups. Continuous variables showed normal distribution as illustrated in Supplementary Figure 1.

Correlation analysis between age and medial/lateral PTS values did not show any significant associations (all p>0.05). Post-hoc power analysis indicated that with the current sample size (n = 78 per group), the study had >80% power to detect a medium effect size (Cohen's d = 0.50) at $\alpha = 0.05$, whereas the observed group differences corresponded to trivial effect sizes (Cohen's d < 0.10). Medial and lateral PTS values are summarized in Table 2. The mean medial PTS was 4.01° (95% CI: 3.41–4.61) in patients with OSD sequelae and 3.90° (95% CI: 3.33–4.47) in the control group (p = 0.732; Cohen's d = 0.055, 95% CI: −0.261 to 0.371). The mean

Table 1. Demographic and clinical characteristics of participants.

Variable	OSD sequelae group (n = 78)	Control group (n = 78)	P value
Gender (male/female)	69 / 9	69 / 9	1.000
Age (years, mean ± SD)	35.94 ± 12.26	35.23 ± 10.80	0.599
Side (right/left)	32 / 46	32 / 46	1.000

OSD: Osgood-Schlatter Disease; SD: Standard deviation.

Table 2. Medial and lateral posterior tibial slope (PTS) measurements in adults with OSD sequelae versus the controls.

Variable	OSD sequelae group (n = 78) (mean; 95% CI)	Control group (n = 78) (mean; 95% CI)	P value
Medial PTS (°)	4.01 (3.41--4.61)	3.90 (3.33--4.47)	0.784
Lateral PTS (°)	4.99 (4.46--5.51)	4.85 (4.29--5.41)	0.732

OSD: Osgood-Schlatter Disease; PTS: Posterior tibial slope.

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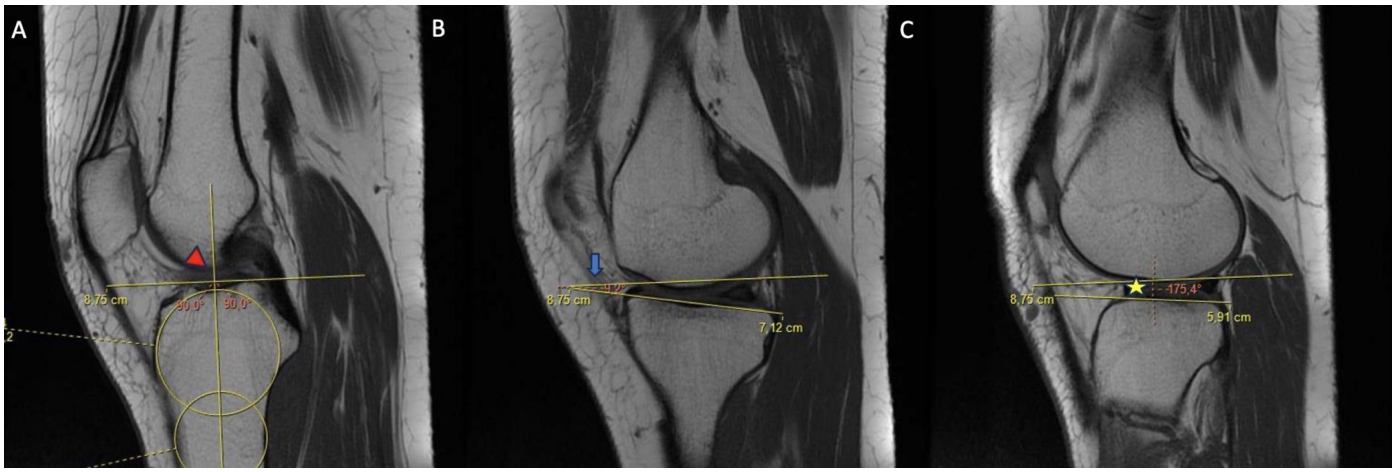

Figure 1. Central sagittal MR images of the knee. (A) Determination of the longitudinal tibial axis using two reference circles placed at the proximal tibial shaft (red arrowhead). (B) Measurement of the medial posterior tibial slope on the central sagittal plane of the medial tibial plateau (blue arrow). (C) Measurement of the lateral posterior tibial slope on the central sagittal plane of the lateral tibi-al plateau (yellow star).

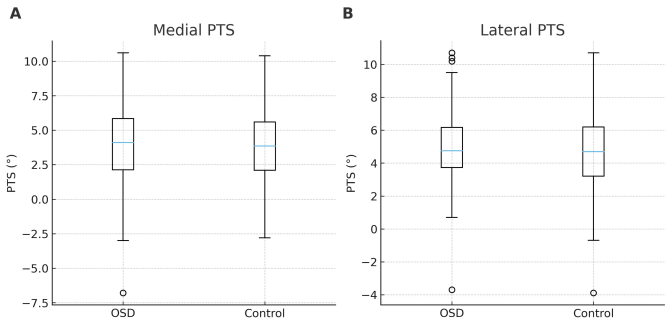

Figure 2. Boxplots depicting the distribution of medial (A) and lateral (B) posterior tibial slope values in OSD and control groups (n = 78 per group).

lateral PTS values were 4.99° (95% CI: 4.46–5.51) and 4.85° (95% CI: 4.29–5.41), respectively (p = 0.784; Cohen's d = 0.044, 95% CI: −0.272 to 0.360). Group distributions are illustrated in Figure 2.

Interobserver agreement was good to excellent, with intraclass correlation coefficients of 0.89 for medial PTS and 0.91 for lateral PTS. Intra-observer agreement was similarly excellent, with ICC values of 0.92 for medial PTS and 0.94 for lateral PTS.

Differences in medial and lateral PTS measures were statistically non-significant (p>0.05 for both). Effect size calculations confirmed the absence of clinically relevant differences, with Cohen's d values < 0.20 for both medial and lateral slopes. This suggests that, unlike in adolescents, adults with OSD sequelae do not have altered posterior tibial slope values compared to matched controls.

DISCUSSION

In this study, we investigated PTS in adults with sequelae of OSD and observed statistically non-significant differences compared with controls. Specifically, the lateral and medial PTS values were similar between the groups, suggesting that alterations in tibial plateau geometry reported in adolescents with OSD may not persist into adulthood.

OSD is among the most frequent causes of anterior knee pain in the adolescent population. It is an apophysitis of the tibial tuberosity, where the patellar tendon attaches. It is more prevalent in adolescent boys and usually resolves without treatment [1-5]. In the later stages, the detached fragment may fuse with the tibial tuberosity, giving a normal radiographic appearance, although persistent cases in adults have been described. The typical pathology of adult OSD includes an ununited ossicle and a prominent tibial tubercle [6,7]. MRI plays an important role in these cases by assessing the patellar tendon integrity, excluding other causes of anterior knee pain, and evaluating the positioning of bony fragments.

In this study, the mean age of adults with sequelae of OSD was 35 years. A rate of 88% was recorded for male patients, which was similar to the rate recorded in the Kamel et al. study [6].

In our study, the mean lateral and medial PTS values in adults with OSD sequelae were slightly higher than in the control group (4.01° vs. 3.90° and 4.99° vs. 4.85°, respectively); however, none of these differences reached statistical significance (all p>0.05). This finding indicates that, although adolescents with OSD exhibited significantly augmented PTS, these changes could diminish or become normal after skeletal maturity. Therefore, our results demonstrate that the tibial plateau morphology of adults with OSD is not different to that of adults without OSD.

The posterior tibial slope is generally defined as the angle formed between the tibial long axis and the posterior tilt of the tibial plateau [14]. Previous research has consistently shown that adolescents with OSD present with steeper PTS values than healthy counterparts. Sheppard et al. reported elevated PTS angles in both OSD patients and those with tibial tubercle fractures compared with the control group [12]. Like-

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wise, Green et al. found significantly higher mean PTS values in adolescents with OSD (12.23° ± 3.58°) relative to controls (8.82° ± 2.76°), suggesting that asymmetric loading by the extensor mechanism during growth may contribute to this alteration [11].

Biomechanical and clinical research has emphasized that a steeper posterior tibial slope in the sagittal plane represents an important risk factor for anterior cruciate ligament (ACL) injury during childhood and adolescence [15]. In particular, an increased slope of the lateral tibial plateau has been strongly linked with a higher likelihood of ACL injury in younger patients [15].

A steeper posterior tibial slope increases anterior tibial translation and rotational stress, which may elevate the strain on the ACL. Several studies have supported this association, reporting higher ACL injury risk in patients with increased medial or lateral slope [15–18]. However, other work has shown inconsistent relationships, particularly in adults, leaving the clinical significance of PTS partially controversial [19–22]. In our study, the absence of slope differences between OSD sequelae and controls suggests that this biomechanical risk factor is unlikely to be altered in skeletally mature individuals.

In our study of skeletally mature adults with OSD sequelae, no significant differences in medial or lateral PTS were observed compared with controls. This discrepancy with adolescent studies may reflect the normalization of tibial plateau geometry following skeletal maturity. Future prospective longitudinal studies with clinical and radiologic follow-up are needed to clarify developmental changes in PTS in adults with OSD sequelae.

Although the study was adequately powered to detect medium effect sizes, the observed differences were trivial, supporting the conclusion that no clinically meaningful difference exists.

Limitations

The present study is subject to several limitations. Firstly, the retrospective design of the study, in addition to the relatively modest sample size, may reduce the generalizability of the findings. Second, only symptomatic patients were included, which may introduce selection bias. Third, data on the physical activity levels of the patients and their sports history were not available, preventing assessment of potential associations between activity and PTS measurements. Fourth, the control group consisted of patients undergoing MRI for anterior knee pain, which may not represent fully asymptomatic individuals and introduces potential selection bias.

CONCLUSION

This study found no significant difference in medial or lateral posterior tibial slope between adults with OSD sequelae and age- and sex-matched controls. The increased slope seen during growth may normalize after skeletal maturity, according to these results, which deviate from re-ports in adolescents. Clinically, this emphasizes how crucial it is to differentiate between adult and adolescent OSD when assessing the biomechanical consequences and taking the possibility of ACL damage into account.

Ethics Committee Approval: This study was approved by the Non-Interventional Research Ethics Committee of Bilkent City Hospital (2-24-414) and carried out in accordance with the Helskinki declaration of principles.

Informed Consent: Patient consent was not required because the study was retrospective.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors declare that they have no competing interests.

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