Medial and Lateral Posterior Tibial Slope Are Independent Risk Factors for Noncontact ACL Injury in Both Men and Women

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Background: Higher posterior tibial slope (PTS) is a risk factor for anterior cruciate ligament (ACL) injury in men and women. The individual contribution of the lateral (LPTS) and medial (MPTS) slope has not yet been investigated.

Purpose: To determine whether either the LPTS or the MPTS is an independent risk factor for ACL injury, and to determine sex-specific differences between patients with ACL-deficient and ACL-intact knees.

Study Design: Cohort study; Level of evidence, 3.

Methods: We reviewed knee magnetic resonance (MR) images performed on ACL-deficient and ACL-intact knees between January 2018 and June 2020 at a single institution. Inclusion criteria were isolated ACL injury and noncontact mechanism (ACL-deficient group) and nonspecific knee pain and no history of injury (ACL-intact group). Exclusion criteria for both groups were the following: previous knee surgery; meniscal, collateral ligament, posterior cruciate ligament, or multiligamentous injuries; radiological evidence of osteoarthritis; and chondral damage on the tibia. The MR images were used to establish the posterior bony slope at 25%, 50%, and 75% from the medial and/or lateral border of the tibial plateau with respect to the proximal tibial anatomic axis. One-way analysis of variance (ANOVA) was used to determine differences in PTS at the 25%, 50%, and 75% distances for the medial and lateral tibial plateau between the groups and between the sexes.

Results: Overall, 325 images were included (mean age, 36.1 ± 11.1 years; 142 ACL-deficient images [82 men and 60 women]; 183 ACL-intact images [112 men and 71 women]). MPTS and LPTS were significantly higher at 25%, 50%, and 75% in the ACL-deficient group (range, –2.7° to –5.7°) compared with the ACL-intact group (range, –2.1° to 1.5°; $P = .00001$). Similarly, MPTS and LPTS were significantly different in men versus women ($P = .00001$). ANOVA revealed that there were no significant differences in PTS between men and women for all measures (MPTS, LPTS, ACL-deficient, ACL-intact; $P = .68$).

Conclusion: The study results demonstrated that higher MPTS and LPTS is a potential risk factor for ACL injury in both men and women. However, despite being highly statistically significant, the differences between groups and sexes were small and may not be clinically relevant.

Keywords: posterior tibial slope; anterior cruciate ligament injuries; noncontact; risk factors

Risk factors associated with anterior cruciate ligament (ACL) injuries can be broadly divided into extrinsic and intrinsic.[17] Intrinsic risk factors such as anatomy, bone morphology, and general ligamentous laxity are genetically determined and difficult to modify.[18,27] The posterior tibial slope (PTS) has been identified as 1 possible contributing factor for ACL injury.[11,12] Dejour and Bonnin[6] demonstrated that for every 10° increase in PTS, there was a 6-mm increase in anterior tibial translation in ACL-deficient knees. Giffin et al[9] demonstrated that an increase in the tibial slope causes an anterior shift in the resting position of the tibia, reducing sag in a posterior cruciate ligament–deficient knee; alternatively, decreased slope is protective in an ACL-deficient knee. With large joint compression loads during weightbearing activities, an anterior shear vector forces the tibia anteriorly.[1,8] With a higher PTS, the magnitude of this vector force increases, and if it exceeds the load to failure of the ACL, the ligament will fail.[9,11]

Studies using lateral radiographs have provided conflicting evidence regarding the influence of PTS.[3,5,11,17,24,28] Alternatively, magnetic resonance (MR) images can be used to analyze tibial plateau geometry more precisely[27] and have been used by several research groups.[2,13,21,22] Stijak et al[22] demonstrated a relationship between the lateral tibial plateau slope and ACL injury, and Ristic et al[21] reported a greater PTS for both the medial and the lateral plateau in patients with ACL-injured knees. However, Hudek et al[13] could not demonstrate a link between medial

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or lateral slope and ACL injury. Blanke et al[2] investigated the injury risk in recreational skiers and were unable to confirm a relationship between lateral posterior tibial slope (LPTS) or medial posterior tibial slope (MPTS) and ACL injury. Finally, a recent meta-analysis including both radiographic and MR imaging–based studies concluded that MPTS and LPTS were risk factors for ACL injuries in men but not women.[26]

The geometry of the tibial plateau is complex and asymmetric. The medial tibial plateau has a concave shape with a subchondral bone cavity ranging from 1.4 to 4.2 mm.[5] The lateral tibial plateau has a convex shape, although the convexity is not large enough for meaningful measurements.[5] Depending on the anatomic location, these differences may result in different PTS measures and cause measurement bias. Previous studies have either used radiographs or MR imaging and relied on a single midline-plateau slope measure. Given the shape asymmetry of both the medial and the lateral tibial plateau, these measures may therefore not represent bone geometry accurately and could result in systematic error, either under- or overestimating the relevance of the PTS on the risk of ACL injury.[5,21]

The purpose of this study was therefore to determine whether increased posterior slope of either the lateral or medial tibial plateau using 3 different locations is a risk factor for noncontact ACL injury. The secondary purpose was to further investigate potential sex-based differences in PTS between patients with noncontact ACL-deficient and ACL-intact knees.

METHODS

This study received ethics committee approval and complied with all the requirements set out in the South African National Health Act 63 of 2003. The Department of Radiology database at a tertiary subspecialty hospital for orthopaedic surgery was searched for all knee MR images from patients with ACL-deficient and ACL-intact knees that were performed between January 2018 and June 2020. The following inclusion criteria were applied: patients aged 16 to 60 years; skeletal maturity; intact menisci in all planes and sequences; and either no history of previous knee surgery or injury (ACL-intact group) or history of reconstruction within the previous 12 months or radiologic evidence of ACL injury (ACL-deficient group). Patients were excluded if there was radiological evidence of osteoarthritis or chondral defects, if there was evidence of ACL reinjury after ACL reconstruction (ACLR); previous ACLR; prior fractures; multiligamentous injuries; medial collateral, lateral collateral, posterior cruciate, or posterolateral corner injuries; or patellofemoral instability including radiological evidence of trochlear hypoplasia. For all MR images that were initially included, the medical records were cross-checked as to whether any of the exclusion criteria applied, and these images were then excluded.

The medical records were reviewed to ensure that only patients with noncontact injuries were included. Noncontact injury was defined as one in which there was no physical contact with an opponent or stationary object at the time of injury, with no large external force applied directly to the knee but including rotational, hyperextension, valgus/varus, and combinations of these uniplanar forces. If the mechanism of injury could not be established, the image was excluded from the analysis.

A total of 831 MR images were performed from January 2018 to June 2020. Meniscal injuries were observed on 329 images and were excluded. There were 93 patients younger than 16 years and 19 patients older than 60 years, and these were also excluded. Chondral defects and degenerative changes were identified on 42 images, and 23 images had evidence of multiligamentous injuries. These 506 image sets were excluded, and the total number of included images was therefore 325.

PTS Measurements

The annotation tools of the IMPAX (AGFA Healthcare) picture archiving and communication system were used to carry out all measures. Proton density images were used for all measures. On a split screen, the coronal, sagittal, and axial images were displayed, and the scout line and localizer mode were used to scroll through all 3 planes simultaneously. The center of the tibial plateau was established, and the corresponding intermediate vertical line on the coronal image was defined as the reference image dividing the coronal tibial plateau into a medial and lateral half (Figure 1A). Similarly, the intermediate vertical line on the sagittal image was defined on the reference image dividing the tibial plateau into an anterior and posterior half

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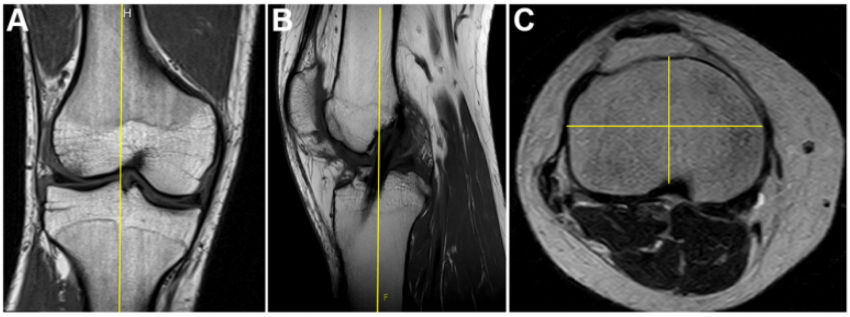

Figure 1. The annotation tools of the IMPAX picture archiving and communication system were used to establish the center of the tibial plateau (yellow lines) on (A) coronal, (B) sagittal, and (C) axial magnetic resonance images. The tools allow simultaneous shifting of the reference line in all 3 images. The coronal image was defined as the reference image, and the vertical intermediate line defined the center of the knee, dividing the tibial plateau into a medial and lateral half.

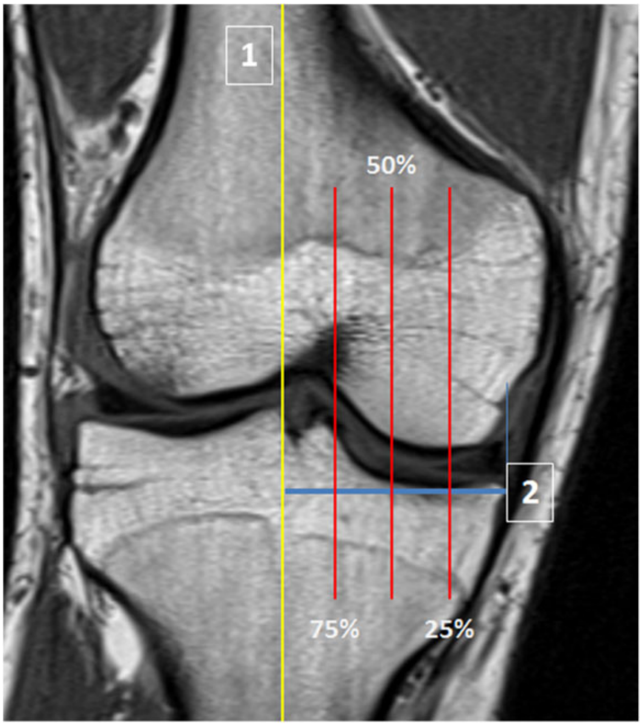

Figure 2. The most medial and lateral aspects of the joint line were marked with a vertical line (line 1, yellow). A line was then drawn from the joint line (line 2, blue) to the center of the tibial plateau passing through the most inferior aspect of the plateau, and 3 parallel lines were drawn at 25%, 50%, and 75% from the joint line (red lines).

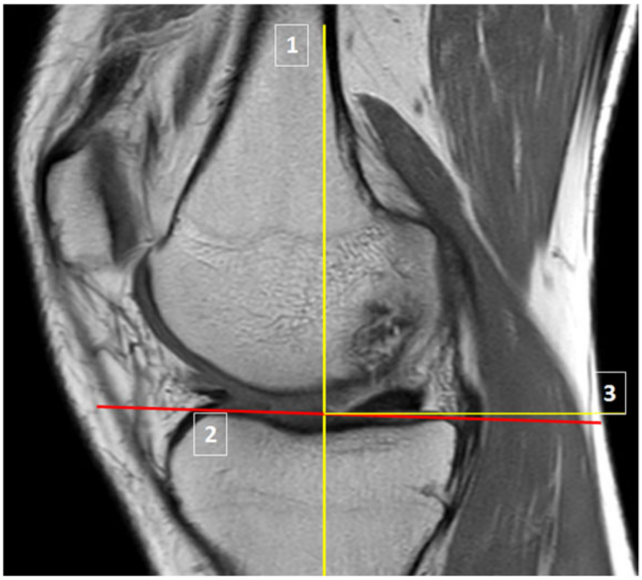

Figure 3. The PTAA was established by superimposing the previously drawn sagittal reference line from Figure 1 (line 1, yellow). The tibial plateau was defined as a line drawn from the most anterior to the most posterior point of the joint line (line 2, red). An additional line perpendicular to the PTAA (line 3) was drawn from the point where the tibial plateau line met the PTAA. The angle between this line (line 3) and the tibial plateau line (line 2) was defined as the posterior tibial slope. The slope was defined as posterior (–) if the plateau line was inferior to the perpendicular line, and anterior (+) if the plateau line was proximal to the perpendicular line. PTAA, proximal tibial anatomic axis.

(Figure 1B). Both intermediate lines passed through the center of the axial image (Figure 1C).

On the coronal reference image, a line was drawn passing through the most inferior aspects of both the medial and the lateral tibial plateau, extending from the medial to the lateral border. The annotation tools were then used to determine parallel lines 25%, 50%, and 75% of the distance between the medial and lateral borders of the tibial plateau (Figure 2).

The corresponding sagittal images at each of these 3 points were then used to measure the PTS of both the medial and the lateral plateau. To do so, the previously drawn sagittal reference line (Figure 3, line 1) was superimposed onto these images to define the proximal tibial anatomic axis. A final line was then drawn from the most anterior to the most posterior point of the tibial plateau (Figure 3, line 2). The slope was measured as the angle between the tibial plateau and a line perpendicular to the proximal tibial anatomic axis (Figure 3, line 3). If the slope was directed posterior it was defined as posterior or negative (–), and if the slope was directed anterior it was defined as anterior or positive (+).

All measurements were performed 3 times. If deviations of >5% were observed for any of the measures, they were repeated 5 times and the 2 outliers were removed. The results of these 3 measurements were then averaged.

Statistical Analysis

Descriptive statistics were applied to all measures. The mean PTS angles, standard deviation, range, and 95% CIs were calculated. Normality of the data distribution was assessed with the Shapiro-Wilk test. One-way analysis of variance (ANOVA) was used to determine differences between the PTS at the 25%, 50%, and 75% distances for the medial and lateral tibial plateau, with comparisons between the ACL-deficient and ACL-intact groups and between men and women in both groups. A level of significance of $P < .05$ was selected in all analyses. In the event of a significant main effect or interaction, post hoc comparisons were conducted using the least significant differences test. An a priori sample size analysis was performed using G*Power 3.1.9.2 and the following variables: Cohen effect size $q \geq 0.3$; $P = .05$; power of 0.9; critical $t = -1.98$; β error 0.2; 2-tailed. The sample size calculation based on these parameters indicated that a minimum of 119 measures were needed to provide a statistical power of 90%.

The intra- and interrater reliability for all drawings and angles was established by repeating the measures in 10 randomly selected MR images. Three independent research associates drew all lines and measured all angles on 2 consecutive days. The images were presented in random order to reduce recognition. Reliability was determined with the intraclass correlation coefficient (ICC), and the algorithm of Landis and Koch was used to interpret the values: ICC >0.80 represented excellent agreement, 0.62 to 0.79 good agreement, 0.41 to 0.61 moderate agreement, and <0.4 fair to poor agreement.[16] All analyses were conducted using STATA SE Version 12.0 (StataCorp) for Windows.

RESULTS

The 325 images consisted of 183 images of ACL-intact knees with a mean patient age of 36.1 ± 11.1 years and 142 images of ACL-deficient knees with a mean patient age of 34.9 ± 9.5 years. In the ACL-intact group, there were 112 men (mean age, 36.4 ± 10.5 years) and 71 women (mean age, 35.4 ± 12.5 years). In the ACL-deficient group, there were 82 men (mean age, 35.9 ± 10.5 years) and 60 women (mean age, 34.1 ± 9.1 years) (Table 1).

The ICCs for the 3 raters were as follows: for the vertical intermediate line and 25%, 50%, and 75% lines, they ranged from 0.95 to 0.98 for interrater reliability and 0.94 to 0.99 for intrarater reliability; for the proximal tibial anatomic axis and tibial plateau slope lines they ranged from 0.89 to 0.93 for interrater reliability and 0.92 to 0.96 for intrarater reliability; and for the PTS they ranged from 0.91 to 0.94 for interrater reliability and 0.94 to 0.97 for intrarater reliability. Given the consistently higher ICCs for intrarater reliability, all measurements used comprised those performed by the first author (E.H.) only.

TABLE 1
Demographics of the ACL-Intact and ACL-Deficient Groups[a]

	ACL-Intact Group	ACL-Deficient Group
All patients	183	142
Age, y	36.1 ± 11.1	34.9 ± 9.5
Age range, y	16-60	16-60
Men	112	82
Age, y	36.4 ± 10.5	35.9 ± 10.5
Age range, y	16-60	16-60
Women	71	60
Age, y	35.4 ± 12.5	34.1 ± 9.1
Age range, y	16-60	16-60

[a]Data are reported as n or mean ± SD. ACL, anterior cruciate ligament.

Posterior Tibial Slope

The results for the PTS are summarized in Table 2. For the medial bone slope, patients with ACL-deficient knees had a significantly higher slope at 25%, 50%, and 75% (range, –4.47° to –5.66°) compared with patients with ACL-intact knees (range, 1.50° to –2.13°; $P = .00001$). Similarly, the lateral slope was significantly higher in the ACL-deficient group (range, –2.66° to –3.96°) compared with the ACL-intact group (range, –0.27° to –1.24°; $P = .00001$).

In men, the medial bone slope in the ACL-deficient group was significantly higher at 25%, 50%, and 75% (range, –4.49° to –5.52°) compared with those in the ACL-intact group (range, –1.54° to –1.98°; $P = .00001$). Similarly, the lateral slope was significantly higher in the patients in the ACL-deficient group (range, –2.87° to –4.09°) compared with the patients in the ACL-intact group (range, –0.22° to –0.49°). In women, the medial bone slope in patients in the ACL-deficient group was significantly higher at 25%, 50%, and 75% (range, –4.33° to –5.84°) compared with patients in the ACL-intact group (range, –1.19° to –2.36°; $P = .00001$). Similarly, the lateral slope was significantly higher in patients in the ACL-deficient group (range, –2.38° to –4.54°) compared with patients in the ACL-intact group (range, –0.17° to –0.27°). Results of the ANOVA revealed that there were no significant differences in PTS between women and men for comparisons between either the lateral or medial compartment slope measures, in patients in both the ACL-deficient and ACL-intact groups ($P = .68$).

DISCUSSION

The findings from this study demonstrated statistically significant differences between patients in the ACL-deficient

TABLE 2
PTS (in degrees) of the ACL-Intact and ACL-Deficient Groups[a]

	Mean ± SD	95% CI	Mean ± SD	95% CI	*P* Value
All patients	ACL-Intact Group (n = 183)		ACL-Deficient Group (n = 142)		
Medial PTS 25%	1.50 ± 2.24	1.17 to 1.83	–4.58 ± 3.45	–4.01 to –5.16	.00001
Medial PTS 50%	–1.49 ± 2.26	–1.16 to –1.82	–4.47 ± 3.16	–3.95 to –5.0	.00001
Medial PTS 75%	–2.13 ± 2.60	–1.75 to –2.51	–5.66 ± 3.61	–5.06 to –6.26	.00001
Lateral PTS 25%	–1.24 ± 1.48	–1.17 to –2.07	–3.63 ± 3.03	–3.12 to –4.13	.00001
Lateral PTS 50%	–0.27 ± 1.48	–0.01 to –0.67	–2.66 ± 2.28	–2.28 to –3.04	.00001
Lateral PTS 75%	–0.37 ± 1.53	–0.06 to –0.74	–3.96 ± 3.11	–3.44 to –4.47	.00001
Men	ACL-Intact Group (n = 112)		ACL-Deficient Group (n = 82)		
Medial PTS 25%	–1.70 ± 2.49	–1.23 to –2.16	–4.77 ± 2.99	–4.11 to –5.42	.00001
Medial PTS 50%	–1.54 ± 2.39	–1.09 to –1.99	–4.49 ± 2.86	–3.86 to –5.12	.00001
Medial PTS 75%	–1.98 ± 2.81	–1.45 to –2.50	–5.52 ± 3.65	–4.72 to –6.32	.00001
Lateral PTS 25%	–0.22 ± 1.58	–0.07 to –0.26	–4.09 ± 2.79	–3.48 to –4.71	.00001
Lateral PTS 50%	–0.35 ± 1.94	–0.90 to 0.20	–2.87 ± 2.27	–2.37 to –3.67	.00001
Lateral PTS 75%	–0.49 ± 1.7	–0.10 to 1.70	–3.53 ± 3.0	–2.87 to –4.18	.00001
Women	ACL-Intact Group (n = 71)		ACL-Deficient Group (n = 60)		
Medial PTS 25%	–1.19 ± 1.75	–0.78 to –1.6	–4.33 ± 4.0	–3.29 to –5.36	.00001
Medial PTS 50%	–1.41 ± 2.05	–0.93 to –1.89	–4.44 ± 3.54	–3.53 to –5.36	.00001
Medial PTS 75%	–2.36 ± 2.25	–1.83 to –2.81	–5.84 ± 3.59	–4.91 to –6.77	.00001
Lateral PTS 25%	–0.27 ± 1.3	–0.18 to –082	–3.00 ± 3.2	–2.16 to –3.83	.00001
Lateral PTS 50%	–0.17 ± 1.14	–0.07 to –0.33	–2.38 ± 2.29	–1.79 to –2.96	.00001
Lateral PTS 75%	–0.18 ± 1.19	–0.07 to –0.32	–4.54 ± 3.18	–3.72 to –5.37	.00001

[a]ACL, anterior cruciate ligament; PTS, posterior tibial slope.

and ACL-intact groups for PTS in both the medial and lateral compartments, measured at 3 different locations. These differences were not sex specific, and both men and women who had sustained an ACL injury had a significantly higher PTS. The 95% CIs for all measures between ACL-deficient and ACL-intact knees did not overlap, suggesting that the statistical differences were, in fact, technically relevant. However, the differences between the groups and sexes only ranged between 2.5° and 4°, thus these differences may not be clinically relevant.

Other studies have demonstrated an increased PTS is a risk factor for ACL injury, but have also reported relatively small between-group differences.[3,22,24,30] At least 4 separate studies have independently come to the same conclusion, documenting statistically significant differences in PTS between ACL-injured and ACL-intact groups.[3,22,24,30] Brandon et al[3] utilized lateral radiographs and the midtibial axis, measuring a PTS angle of 8.5° in the ACL-intact group and 11.2° in the ACL-deficient group, a mean difference of 2.7° greater slope. In females this mean difference was 3.4°, while the difference was 2.4° in males. Todd et al[24] measured a PTS of 9.4° in ACL-deficient knees and 8.5° in ACL-intact controls, a difference of 0.9°. In females the mean difference was 1.6°, while the difference was 0.6° in males. Ristic et al[21] measured a mean PTS angle of 5.64° in the ACL-intact group and 6.68° in the ACL-deficient control group for the lateral plateau. Similarly, they observed 4.67° PTS in the ACL-intact group and 5.49° in the ACL-deficient group for the medial plateau.[22] Zeng et al[30] reported a mean PTS of 11.5° for patients with ACL-injured knees and 9.4° for their patients with ACL-intact knees, a mean difference of 2.1°. All the above studies reported statistically significant differences between patients with ACL-deficient and ACL-intact knees, identifying an increased PTS as a risk factor for ACL injury.

Recently, several research groups have suggested an increased PTS is associated with subsequent reinjury after ACLR.[4,15,18] Christensen et al[4] compared 58 patients with graft failure with a matched control group and noticed that an increased LPTS was associated with an increased risk of graft failure. The mean slope in the male patients with ACL-injured knees was 8° compared with 6.8° in the control group; the female patients with an ACL-injured knee had a mean slope of 9.1° compared with 5.9° in the control group. The calculated differences were 1.2° in the male group and 3.2° in the female group. Jaecker et al[15] concluded that both the medial and lateral tibial slope were independent risk factors for graft failure. The mean MTPS in the ACL failure group was 10.7° compared with 6.7° and the LTPS was 12.2° compared with 7.3°, indicating differences of 3° for the MTPS and 4.9° for the LTPS. Napier et al[18] demonstrated a mean difference of 1.2° (medial slope) and 1.7° (lateral slope) between patients with an ACLR who sustained a third ACL injury compared with a group who did not sustain a third injury.

In contrast, other studies were not able to establish a relationship between ACL injury and slope and reported very similar between-group differences.[2,23] Blanke et al[2] investigated the risk of ACL injury in recreational alpine skiers and could not demonstrate an association to lateral and medial tibial slope. They reported a mean slope of 7.95° in the lateral and 8.77° in the medial compartment for ACL-injured knees and 7.4° in the lateral and 7.8° in the medial compartment for ACL-intact knees, with between-group differences of 0.54° for the lateral compartment and 0.96° for the medial compartment. Su et al[23] used the anterior and the posterior tibial cortex (ATC and PTC, respectively), and the anatomical axis (CTA) to measure medial tibial slope in ACL-intact and ACL-injured knees and concluded that the medial tibial slope was not associated with either primary or recurrent ACL injury after reconstruction. The differences in slope measures ranged from 1.1° for the ATC, 0.5° for the PTC, and 0.9° for the CTA.

The evidence in the current study was inconclusive and, despite statistical significance, the observed differences for PTS between ACL injury and patients with an intact ACL were objectively rather small. This leads to the inevitable question of whether an increased PTS is clinically relevant and should be considered to be a risk factor for ACL injury. Based on the current available evidence, this question remains unanswered, and the small differences between patients with ACL-injured and ACL-intact knees suggest instead that a moderate increase in PTS may not be a factor at all. However, it could be argued that even small differences in PTS in the presence of other anatomic, kinematic, and kinetic differences could be a contributing factor resulting in ACL injury.

Furthermore, basic science research does not quite support the above clinical studies. Several biomechanical studies have shown that an increased PTS in isolation may not increase the load on the ACL.[6,9,19,25] Giffin et al[9] increased the tibial slope from 8.8° to 13.2° and demonstrated an anterior shift of the tibial resting position by 3.6 mm but combined anteroposterior (AP) and combined axial compression and AP load did not result in differences in AP translation or increased in situ forces in the cruciate ligaments. Fening et al[8] increased the tibial slope by a mean of 3.5° and 9.6° and was able to demonstrate that anterior tibial translation increased, but the anterior shift had no effect on ACL loading. Nelitz et al[19] investigated ACL strain and knee kinematics at 0°, 5°, 10°, and 15° of PTS; increasing the slope did not increase ACL strain but reduced the extent of tibial rotation during flexion-extension cycles. Voos et al[25] could not demonstrate any significant change in anterior tibial translation of the medial and lateral tibial compartments when decreasing or increasing the tibial slope by 5°. An earlier clinical study investigated the relationship between knee function and tibial slope in patients with ACL-deficient and ACL-reconstructed knees and demonstrated that higher tibial slope was associated with greater knee function.[11] The authors postulated that an increase in slope would lengthen the hamstring muscles, resulting in increased passive muscle tension, which enables greater control of tibial translation after foot strike.

Another clinical study suggested the odds of further ACL injury increases 5-fold if the slope exceeds 12°,[28] and slope-correcting osteotomies have been described to address this deformity.[14] However, the recommended slope correction was 10° using an anterior-based closing wedge osteotomy, substantially higher than what can be achieved through the typical correction with a lateral closing wedge osteotomy.[10,20] In contrast, a biomechanical study by Yamaguchi et al[29] demonstrated the anterior tibial translation reduced when the slope was decreased by 10°, but had no effect when an internal rotation moment was applied. The authors suggested that a slope-reduction osteotomy effectively decreased ACL forces under axial loading, but this effect was negated when internal torque was also applied.

None of these studies have definitively determined whether an increased PTS in isolation poses a clinically relevant risk factor for ACL injury and reinjury. Hence, the question remains as to what degree of tibial slope should be a concern for a subsequent injury, presuming that moderate differences in PTS as reported may not be a major risk factor after all. However, one could argue that there is a threshold value that exposes patients to a higher risk of ACL injury, where corrective slope-reducing osteotomies could be considered. Webb et al[28] have shown that there is a 5 times higher risk of graft rupture after ACLR if the slope exceeds 12°. Similarly, Dejour et al[7] have reported that slope correction for PTS exceeding 12° protects patients undergoing ACL revision surgery. A PTS exceeding 12° could also reasonably be considered as a potential threshold value in patients with intact ACLs.

Limitations

This study has limitations. The height and weight of the participants were not measured, and there might be a correlation between the posterior slope and these demographic variables. Examiner bias cannot be entirely excluded, as the differences between ACL-injured and ACL-intact images were obvious when measurements were performed. It may have been possible that technical challenges identifying the proper image slice could have resulted in measurement error and inconsistencies. However, the ICC results suggest these biases are unlikely. Obviously, radiological assessment of bone morphology only provides a static assessment and does not consider how other potential factors, such as dynamic or neuromuscular adaptations, may compensate, or at least partially compensate, for static anatomic morphology.

CONCLUSION

The results of this study demonstrated that the medial and lateral posterior tibial slope is a potential risk factor for ACL injury in both men and women. However, despite being highly statistically significant, the differences between groups and sexes were small and may not be clinically relevant. The question as to whether PTS is an independent risk factor for ACL injury remains unanswered, and the current evidence should continue to be viewed with caution.

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