THE RELATIONSHIP BETWEEN POSTERIOR TIBIAL SLOPE AND ANTERIOR CRUCIATE LIGAMENT INJURY

UTICAJ NAGIBA ZGLOBNE POVRŠINE GOLENJAČE NA POVREDE PREDNJEG UKRŠTENOG LIGAMENTA

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Summary

Introduction. The aim of this study was to identify an increased posterior tibial slope as a possible risk factor for anterior cruciate ligament injury. Material and Methods. Sixty patients were divided into two groups (with and without anterior cruciate ligament rupture). The posterior tibial slope on the lateral and medial condyles was measured by sagittal magnetic resonance imaging slices by means of computerized method using circles to determine tibial axis. Results. The patients with anterior cruciate ligament rupture had a statistically significantly (p=0.06) greater posterior tibial slope on the lateral tibial condyle than the control group (6.68°:5.64°), and a greater slope on the medial condyle (5.49°:4.67°) in comparison to the patients with the intact anterior cruciate ligament. No significant difference in the average values of angles was observed between males and females with anterior cruciate ligament rupture, the average value being 6.23° in men and 5.84° in women on the lateral condyle, and 4.53° in men and 4.53° in women on the medial condyle. Discussion and Conclusion. A statistically significant difference between the values of posterior tibial slope was observed between the groups with and without anterior cruciate ligament rupture, the sex having no affect on the value of the posterior tibial slope. The method of measuring angles should be unique.

Key words: Anterior Cruciate Ligament; Risk Factors; Magnetic Resonance Imaging; Anterior Cruciate Ligament Reconstruction; Tibia

Sažetak


Ključne reči: Prednji ukršteni ligament; Faktori rizika; Magnetna rezonanca; Rekonstrukcija prednjeg ukrštenog ligamenta; Tibija

Introduction

The number of registered anterior cruciate ligament (ACL) injuries is on constant rise in the world [1, 2] as well as in the Republic of Serbia [3]. Consequently, the number of performed reconstructions of this structure of knee joint has been also rising [1, 4, 5]. The results of reconstructions are excellent in 80-90% of all cases due to the development of diagnostic methods, such as magnetic resonance imaging (MRI), operative techniques and early rehabilitation [4–9]. However, it is illogical to have a situation where the number of studies dealing with the results and complications of operative treatment [4–9] is incomparably higher than those dealing with the prevention of ACL injuries [1, 3].

The situation changed in the last twenty years so that the interest has increased regarding the necessity to define vulnerable groups, risk factors, causes of ACL injuries [1–3] as well as the possibilities to develop effective preventive trainings [10]. In the last few years the anatomy of knee joint was often high-

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lighted as one of risk factors, such as the influence of anterolateral ligament on knee stability [2], size of intercondylar notch or posterior tibial slope (PTS) as potential factors for ACL rupture [1, 11, 12].

The aim of this study was to identify an increased posterior tibial slope as a possible risk factor for anterior cruciate ligament injury.

Material and Methods

We divided our total specimen of 60 patients into two groups. The first group included 30 patients with complete ACL rupture, 24 men and six women, whose average age was 30.41 years (9-59). The second group consisted of 25 men and five women, whose average age was 28.33 years (16-56). This control group did not have ACL rupture on MRI. All of the patients were diagnosed and treated at the Department of Orthopedics and Traumatology of Clinical Centre of Vojvodina in Novi Sad. MRI was performed at the Center for Radiology “VMR” in Novi Sad by a MRI device with 1.0 Tesla magnetic field, manufactured by Philips. All measurements were performed by the same radiologist. The angles of PTS (Figure 1) were measured in the program developed at the Faculty of Technical Sciences in Novi Sad.

The exclusion criteria of this study were partial ACL rupture, chondromalacia grade III or IV, osteophyte formations and previous knee surgery.

The statistical analysis included the average values, standard deviation and range of measurements. The results are shown by figures, graphs and tables further in the text.
Results

The average angle of PTS on the medial tibial condyle in the control group (without ACL rupture) was 4.67°, while on the lateral condyle it was 5.64° (Table 1).

The group with ACL rupture had the average PTS on medial condyle of 5.49° and 6.68° on the lateral one (Table 2). The values of measured angles varied from the maximal 13.2° to the minimal 1.0°.

A statistically significant difference was found between the groups (Table 3), because the patients with ACL rupture had PTS greater by 1.04° on the lateral tibial condyle than the controls, as well as a somewhat greater slope on the medial condyle by 0.82° in comparison with the patients with intact ACL.

We also analyzed the PTS difference between sexes among the patients with ruptured ACL. The average PTS on the medial tibial condyle in females was 5.84° and 4.78° on the lateral one. The average values of PTS in males were 6.23° and 4.53° on the medial and lateral tibial condyle, respectively (Graph 1). The female patients had smaller PTS on the lateral tibial condyle by 0.39°, but it was greater by 0.25° on the medial condyle than in the male patients.

The statistical analysis showed that there was a significant difference between the values of lateral PTS between the groups with and without ACL rupture (F=3.665 p=0.06). We did not find a significant difference between the same groups concerning medial PTS (F=1.489 p=0.227) although the patients with ACL rupture had greater PTS values.

According to Fisher’s test there was no difference between PTS concerning the age difference between the groups (F=2.108 p=0.152).

Discussion

The incidence of ACL injury has been on constant rise in the last few decades with the resulting necessity to determine risk factors and causes of injury and to develop preventive measures in order to reduce the incidence of injuries. The risk factors are divided to intrinsic and extrinsic, as well as to changeable and unchangeable [13]. The preventive measures are mainly focused on the correction of changeable conditions during non-contact sports ACL injuries [3, 14]. The extrinsic risk factors include environmental conditions such as playing surface, shoe type, weather conditions and type of sport [3, 13, 15]. The intrinsic risk factors may be divided into anatomic, hormonal, neuromuscular and familial [16]. Numerous anatomic variables include intercondylar notch width, in-
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creased body mass index, landing kinematics, female sex, anatomic alignment [13, 14]. Anatomic differences between sexes are Q angle, pelvis width, effects of hormones (primarily of estrogen) on the incidence of injury and ligament strength, neuromuscular and biomechanical factors, former knee injuries and age. All of them may be potential risk factors for ACL injury [16]. Aggressive contraction of quadriceps muscle during moderate knee flexion is also a relevant intrinsic factor for noncontact ACL injuries because it leads to increased anterior translation of tibia [17].

There are many inconsistencies regarding the significance of some risk factors; however, there is no doubt that young athletes are the most vulnerable population. Women have 2–10 times higher risk for injury than men depending on the type of sport [13–16]. In our former study performed on 450 operated patients with ACL rupture [3] we concluded that there was no statistical significance of correlation between ACL lesion and footwear type, body mass index, warm up, previous illnesses, everyday therapy and genetic profile. However, it was proved that ACL lesion correlated with the career length, skill level, competitive level, surface quality, and previous injuries. Most of the injuries occurred in a noncontact way, during landing or sudden change of direction.

Recently, anatomic variations are considered as a risk factor for a primary ACL injury, especially the geometry of the proximal tibia, in particular the PTS [1, 11, 12]. Articular surface of tibia in the knee joint consists of lateral and medial condyles which are in contact with the condyles of femur. With tibial axis, this surface makes an angle (PTS) of 7–10 degrees. A greater PTS with axial loading generates a greater anterior translation of tibia [18]. As the ACL is the main stability structure of this movement, this results in its overthightening. This leads to the increased internal tibial rotation and greater force on ACL [19]. Dejour and Bonnin [18] used lateral radiography and found that for every 10 degrees increase in PTS, there was a 6-mm increase in the anterior tibial translation during a single-legged stance. Fening et al. [20] also registered an increased anterior tibial translation but less ACL tightening after high tibial osteotomy. Similar results have been found in cadaveric and computer modeling studies [21,22].

Many studies found a correlation between the PTS and ACL insufficiency [1, 11, 12, 23–30]. However, authors used different diagnostic methods; some used lateral radiography [12, 18, 29, 30], others computerized tomography [24], while the majority, like us, used MRI slices [11, 23, 25, 26, 28]. A common method for determining tibial axis and the way of measuring tibial slope has not been adopted yet [1, 11, 23, 25]. Even the results are interpreted differently, particularly regarding the dilemma whether the medial or lateral PTS has greater effect on ACL injury [1, 11, 23, 25] and if there is a difference between sexes [12, 29–31]. Authors also disagree about the size of angle that is responsible for risk [1]. Some studies applied the same methods but yielded different results.

Simon et al. [26] used modified Hashemi’s method with 3D reconstruction of tibial articular surface. MRI studies, like ours using methods similar to Hudek or Hashemi [23, 25], had similar results of measuring PTS. The difference between groups with and without ACL rupture ranged from 0.87 to 2.64 degrees [25, 27, 28]. We used MRI slices because some mistakes may occur if profile X-rays are used. One of important advantages of MRI is the possibility for visualization of the articular cartilage that is not visible on lateral radiography [11, 24]. Every patient must be in the same position during MRI diagnostics in order to achieve proper sagittal slices of the knee joint. This is achieved by fixation of the hip and determination of points at the ends of tibia. For the best bone performance, three-dimensional visualization of articular surface of tibia should be used whenever it is possible. The same standard conditions should be provided [24], although every method has its disadvantages [1].

Since we achieved positive statistical correlations, it can be concluded that there was a significant difference in values of measured angles between the group with ACL rupture and group with intact ACL. Our method relied only on MRI of knee joint, without slices of complete tibia, using circles in tibia for determination of axis. Some authors think that the best method is MRI containing slices of proximal tibia (10-15 cm) or complete tibia [1]. Others believe that the method with circles is a good choice if MRI of complete tibia is not available [23, 25].

A group of Chinese authors [1] applied the meta analysis to systemize the results of 12 studies on PTS and concluded that both lateral and medial PTS were significantly increased in ACL injured groups compared to the controls, the difference being greater in the lateral tibial plateau slope (1.8°) than in the medial slope (1.1°). Our results are similar but with smaller difference (1.04°: 0.82°). In contrast, some Serbian authors [11] think that the patients with greater PTS on lateral condyle but at the same time with lesser PTS on medial condyle are at higher risk for ACL rupture than the controls.

Webb et al. [12] proved that operated patients with increased PTS (of 9.9° on average) more frequently have reruptures of graft and ACL ruptures of contralateral knee in comparison to common PTS (8.5°) in operated patients without the above complications. Since the highest number of ACL reruptures was recorded in the patients having the slope over 12°, it can be concluded that the risk for rerupture is proportional to the increase in the slope angle. Those patients who have the slope over 12° (only 12% of specimen) are at five times
higher risk of further ACL injuries than those having the slope less than 9°.

The average age of our patients was 29 years. This is similar to other studies where the most ACL injured population were in the third decade of life [3, 5–9, 13–16]. The different results may be influenced by different choice of patients [1], because some study samples consisted only of female patients, other samples included only noncontact injuries or patients under 18 years of age [1, 23, 25, 29, 30]. Exclusion criteria may also have influence. Our groups were uniform because there were no statistical differences among our groups considering age and sex structure. Webb et al. as well as Bourke et al. [12, 31] have found that men have greater PTS, while Brandon et al. as well as Todd et al. [29, 30] have observed that PTS is increased in women. They also mentioned that corrective osteotomy should be taken into consideration to reduce the risk of (re)injuries [29, 30]. We did not find a statistically significant difference between sexes so causes for epidemiology of ACL ruptures among women athletes lie in anatomic differences between sexes. Women have increased Q angle and knee valgus, smaller intercondylar notch, wider pelvic ring, influence of hormone (estrogen) on ligament strength and different contraction time of anterior and posterior muscles groups of thigh [16]. Bearing the above in mind, some Swedish authors [10] achieved a significant reduction in ACL injuries in female soccer players: by 15-minute neuromuscular warm-up program, twice a week during the period of three years. It consisted of one-legged and two-legged knee squats, pelvic lifts, the bench, lunges, jumps and proper landings. This program reduced the ACL rate by nearly two-thirds.

The fact that our study was performed on a relatively small sample consisting of only 60 patients and MRI slices of the whole tibia were not available gives the basis to consider our research limited. MRI slices of the whole tibia are necessary for precise determination of tibial axis and for minimizing mistakes during measuring angles, but they are more expensive. Further studies should consider those facts as well as finding new, better and unique methods for visualization of PTS. New studies should create proper standards for connection between PTS and ACL injury as well as to find new prevention methods by neuromuscular trainings.

The question whether corrective osteotomy would reduce the incidence of ACL ruptures and re-ruptures is still open, as well as the dilemma whether the preventive programs focused on strengthening posterior thigh muscles of athletes with increased PTS can reduce anterior tibial translation.

**Conclusion**

We found a statistically significant difference in the values of posterior tibial slope between the group with and without anterior cruciate ligament rupture.

The slope on the lateral condyle is greater than on the medial one and it is a more significant parameter.

Sex does not influence values of posterior tibial slope either in the group with ruptured anterior cruciate ligament or in the control group.

Method of measuring angles by magnetic resonance imaging diagnostics should be unique to avoid mistake.

Posterior tibial slope cannot be assumed as an isolated risk factor.

Conditions for prevention of anterior cruciate ligament ruptures can be achieved by knowing risk factors, causes and mechanisms of its injuries.

**References**


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