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Diagnosis, treatment and statistic of anterior cruciate ligament injuries

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Abstract

One of the most frequently damaged structures of knee is the ACL. Among risk factors for ACL injury, particular attention is paid to anatomic ones-structural, hormonal, genetic, biomechanical, neuromuscular and environmental disorders. Correctly performed diagnostics and rehabilitation after knee injury determine the effectiveness of treatment. The diagnostic methods includes: subject examination, physical examination, imaging diagnostics and arthrometry. The overarching goal after ACL injury is regain knee joint stability and return to full mobility thus surgical methods to restore passive joint stability are recommended. Regular physical activity appears to be essential in maintaining good physical condition as opposed to a prevalently sedentary lifestyle. A properly selected form of movement and intensity convey improvement of our health, better body shape, improvement of ability and physical activity as well as improvement of well-being. Excessive loads on the musculoskeletal system and incorrect posture during exercise are not recommend, because these can lead to injury.

Keywords

anterior cruciate ligament, ACL injuries, ACL reconstruction, diagnostics, treatment strategy

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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INTRODUCTION

The popularization of amateur physical and sports activity along with increasing levels of physical activity in society have resulted in an increase in the number of injuries in the knee joint [1]. One of the most frequently damaged structures of this joint is the Anterior Cruciate Ligament (ACL), whose rupture causes significant changes immediately and in the long term. The estimated annual number of ACL injures in Poland is about 1/1000 citizens [1], the vast majority of which occur among individuals with a sports background. Of all sports injuries, only about 25% of cases involve competitive athletes, with the others resulting from participation in amateur sports [2]. With regard to gender, the incidence of ACL injuries in women is almost 9 times higher [3], this is particularly evident when comparing males and females in the same sport discipline [4]. The data collected in the Norwegian National Registry of Knee Ligaments indicate that the highest risk of ACL injury is for people 16-39 years old. In this group the risk increases from 34 to 85 cases in conversion per 100,000 people, compared to all other age groups. This institute also identified that the most frequent ACL injury accidents involve girls aged 15–19 [5].

Among the most frequently mentioned risk factors for ACL injury, particular attention is paid to anatomic ones-structural, hormonal, genetic, biomechanical, neuromuscular and environmental disorders [6, 7]. Risk factors also include: a valgus knee tendency (especially for adolescent girls practicing team and contact sports, i.e. football, handball, basketball, gymnastics, martial arts, skiing) and an inappropriate level of motor preparation to achieve specific training goals (this applies mainly to amateur athletes inspired by a particular trend or fashion of practicing a given sports discipline) [8–12]. In the professional athlete group, especially among men, the correlation of ACL injury with reduced mobility of the hip joints, especially in terms of internal rotation of the joints and weakening of the buttock muscle function, is noteworthy. These dysfunctions translate into an impaired manner of central stabilization [13]. Due to the anatomical structure of the ACL, the damage may involve one or two bundles; it means that injury may be partial or complete [14]. The most common indicator of injury is a characteristic "crack" at the time of ligament rupture and joint swelling due to intra-articular hematoma. In addition, there is also a limitation of both passive and active mobility, contusion of the subchondral bone of the tibial and femoral condyles and especially the limitation of full extension [15, 16]. Often, as a result of the connection between lower limb valgus and the rotation mechanism, the adjacent structures are damaged, i.e.: menisci, cartilage and other ligaments, especially the tibial collateral ligament, anterolateral ligament and posterior cruciate ligament [15, 17–19].

DIAGNOSTICS

Correctly performed diagnostics after knee injury determine the effectiveness of treatment and rehabilitation. The diagnostic algorithm includes:

1. Subject examination – an interview during which the circumstances and mechanism of injury are established in addition to the level of discomfort. It is important to collect information about the history of surgical procedures, medications taken and comorbidities [20].
2. Physical examination - functional examination, which depends on the time elapsed since the injury. The early period will hinder the examination due to pain, swelling and hematoma in the joint. However, early diagnostics and knee stability tests are recomended, provided it is possible [21–23]. It is also necessary to take into account the functions of adjacent joints (hip and ankle).

3. Imaging diagnostics and arthrometry, which allow you to confirm the subjective and physical examination diagnosis, and also very importantly, provide information on the extent of the injury and anatomical disorders resulting from it [24–26].

The Lachman test is the standard test in orthopedic examination, which confirms anterior instability resulting from ACL injury. It is a test of excessive anterior and asymmetrical displacement of the tibia in the position of incomplete knee extension in relation to the opposite limb. This test is conducted manually by the researcher [22]. One of the most important diagnostic tests to confirm the rotational component of anterior instability is the Pivot-Shift test. This test is based on rotating the tibial lateral condyle forward in relation to the femur. When the test is positive, it indicates an injury of the anterior cruciate ligament [23]. One symptom associated with ACL rupture, whose credibility is currently being called into question, is determined using the drawer test, i.e. the frontal translation of the tibia in the knee flexion at an angle of 90 degrees [22]. One basic imaging test is the classic radiological examination in the antero-posterior (AP) and lateral projection to diagnose possible bone damage associated with knee sprain, e.g. fracture of the tibial lateral condyle – the so-called Segond fracture and presence of free post traumatic bone-cartilage particles [27].

In explicit cases of ACL damage, X-ray photos can be omitted in favor of magnetic resonance imaging (MRI), which is considered the gold standard in the diagnosis of tendon and ligament injuries. MRI is a modern and widely available tool that accurately and in many projections shows the extent of intra- and periarticular damage [25]. A less useful diagnostic method is computed tomography, necessary for the precise diagnosis of bone damage [28]. Imaging diagnostics tests, in addition to ultrasound, are static and it is recommended to combine them with dynamic assessment of anterior and rotational stability of the joint, using arthrometry [29]. Among diagnostic tests, an ultrasound examination is used as a supportive study for the evaluation of soft tissues, the results of which are reliable only in the hands of an experienced radiologist [24].

Arthrometry is a fast and relatively simple test which quite clearly allows for the confirmation of knee ligament damage. This study is similar to the Lachman test in which a motion sensor can help measure the tibial tuberosity shift relative to the femur with a high degree of accuracy [30]. Among the various types of arthrometers, a very precise GNRB Rotab arthrometer is used at the Galen Rehabilitation center. This device, in addition to accurate assessment (accuracy up to 0.1 mm) of anterior stability, also allows for examinaion of rotational instability resulting from damage to the anterolateral ligament of the knee. Other advantages of GNB Rotab are: the ability to control the force exerted on the patella, precise control of the force exerted on the lower leg at a time point, and more accurate measurement of tibial displacement. In addition, it is possible to perform the examination after ACL reconstruction (4 weeks past surgery) in order to evaluate the result of the procedure. The difference of tibia movement between legs can be determined using this test. In the event that the difference is from 1.5 to 3 mm as a result of the applied force, partial failure of ACL (tear) is suspected and displacement above 3 mm is treated as a total failure of the ligament, which may indicate that it is ruptured [31–33].

In the algorithm of diagnostic procedure, it is important to have the knee joint examined by a specialist in orthopedics and traumatology of the musculoskeletal

system and to choose the right diagnostic tools. Comparison of the results and the analysis should be the basis for making decisions regarding the type and time of further treatment.

TREATMENT

It is recommended that conservative treatment be introduced as soon as possible after the injury, preferably according to the universal RICE principle (R - rest: rest and relief of the limb, I - ice: cooling compresses, C - compression: application of a compression dressing, E - elevation: limb elevation). Although this principle is widely propagated, excessive tissue cooling is questioned, which can lead to ischemia and disruption of the natural regenerative response. Implementation of pharmacological agents in the form of non-steroidal anti-inflammatory drugs that relieve pain and reduce inflammation as well as anticoagulants that improve blood circulation is also suggested [34].

Regardless of the decision made about further treatment (surgical or conservative treatment), it is advisable to introduce rehabilitation exercises to the patient to improve central stabilization and to learn correct movement patterns. This is important not only due to the improvement in the state of tissue morphology, but it also takes into account the psychological aspect, reducing the stress of the treated person and allows the risk of similar injuries in the future to be minimized [35]. Statistically better results of surgical treatment in patients who underwent preoperative rehabilitation are emerging from the research [36]. Similar conclusions were also made by Shaarani [37], who indicated in his research that a significant improvement in knee function in patients undergoing 6 weeks of preoperative rehabilitation, and a significant improvement in relation to the control group was maintained up to 12 weeks after surgery [37].

SURGERY TREATMENT

Surgical methods to restore passive joint stability (ligament reconstruction or reinsertion) are recomended by most doctors. Using the Internal Bracing method, it is possible to attach the ligament in the cases of fresh injuries (up to 6 weeks after the injury) and in cases in which the ligament has detached at the place of its attachment to the thigh bone [38]. This procedure involves sewing a detached ligament to the place of its attachment to the bone. Compared to classical reconstruction, this method is characterized as being less invasive, preserving the natural biomechanics and proprioception of the operated joint [38,39]. Statistically significant shortening of recovery time has been demonstrated after Internal Bracing [38,40,41]. Ligament anchoring at the site of the original ACL attachment has an undoubted advantage over the classical method; however, the possibility of carrying it out is limited. The injured ligament should show excellent tissue quality and sufficient length to allow the fragment to reach the location of its attachment [14]. Unfortunately, the vast majority of operations involve damage in which the type of injury does not allow the use of the said method. Furthermore, if the time between damage and surgery is too long, then the classic method of ACL reconstruction is used [42]. The material used for reconstruction is most often autogenous grafts taken from the tendons of the semitendinosus muscle, gracilis muscle, straight thigh muscle and middle part of the patellar ligament. Allogeneic, xenogeneic and synthetic transplants are less common, although recently there has been an increasing tendency towards the former, because they enable significantly reduced surgery times and do not require interference with healthy tissues to prepare the transplant [43].

The absence of surgical intervention in the tendons surrounding the knee joint allows for the maintenance of the functional efficiency of the flexor and extensors of this joint, which allows for more intensive rehabilitation and significantly shortens the time of recovery [43]. The disadvantages associated with sterilization and storage conditions to which allogenic transplantation is subjected should be mentioned in addition to the advantages. Sterilization with ionizing radiation and storage at low temperature (-80°C) can worsen tissue properties, which may result in diminished healing [44–46]. There is a difference of opinion among the authors of numerous publications regarding the advantages of using allogenic transplants. Smith et al. [47] and Kuhn and Ross [48] show the superiority of allogenic transplant over autogenous transplant, while Barrett et al. [49] and Chen et al. [50] do not confirm this thesis. Due to the structure and properties that differ from human tissues, most researchers believe that xenografts do not give satisfactory therapeutic effects and for a long time were not widely used as material for transplants [51–53]. However, researchers showed promising effects from the use of allografts in a recent study [54], which should be confirmed in a larger group of patients. Synthetic materials (made e.g. of polytetrafluoroethylene) have different properties in relation to human tissue, but they are often used as a supporting and strengthening material during the regeneration of a damaged ligament. Synthetic materials are used among others in the abovementioned Internal Bracing method [38] and in the Ligament Augmentation and Reconstruction System (LARS), using artificial ligaments as a scaffolding to regenerate those which have been damaged [55]. The LARS method, despite good therapeutic effects and a relatively small percentage of side effects, is rarely used and thus the number of publications on it is small. This method requires that the injured ligament is in great condition (good blood supply) and a short (up to several months) period between rupture and surgery. A quick return to physical activity and the possibility of walking without crutches (not recommended) even a day after surgery are the advantages of this method. Due to the small amount of data on long-term effects of treatment, the LARS method remains unweighted compared to other treatment methods [56]. In addition to the type of transplant used, the location of bone tunnels has an impact on the course of treatment and stability of the operated joint. There are two techniques for positioning these tunnels: the first from anteromedial portal and the second from the transtibial portal. The analyzed literature shows that the technique with anteromedial access determines the location to fix the graft in an anatomically-similar position and provides greater stability [57, 58]. Positive effects of treatment, i.e. a subjective improvement in knee rotation control and a lower likelihood of subsequent ligament rupture are observed in people who underwent reconstruction of the Anterolateral Ligament (ALL) during ACL reconstruction. Periarticular procedures strengthening the reconstructed ACL, including the lateral tenodesis of the ilio-tibial band, enable a significant reduction of forces acting on the ACL. A very clear pivot-shift symptom, previous transplant rupture and training at a high level of sports with dynamic changes of directions and rotations are the major criterions to qualify for lateral tenodesis [59].

Conservative treatment

The improvement of active stabilization without ligament apparatus reconstruction and without passive stabilization concerns patients with partial ACL damage and those who do not want or cannot undergo surgery due to general or local health and/or age reasons. These patients have limited mobility,

especially in the dynamic aspect and should voluntarily act as directed by a doctor. The ischial-shin muscle group and the quadriceps muscle are major muscles responsible for the movement and stabilization of the knee [60]. The goal of improving active stability is to rebuild and improve the functioning of these muscles [61]. It was also noticed that people who have suffered ACL damage have a considerable gluteal muscle strength deficit, particularly in the gluteus medius. This muscle is responsible for the stabilization of the pelvis and lower limb. Attention should be paid to the position and stability of the pelvis, because disorders in these aspects significantly affect the mechanics of the knee joint. It is important that while striving to improve knee stability, core stabilization is not forgotten. Ankle instability, torso instability and weak gluteus muscles predispose individuals to knee instability, which can lead to various injuries, including ACL tear or rupture. Therefore, exercises to improve sensation and stabilization of the whole body are very important and should be included in post-traumatic rehabilitation protocol [62–64].

QUALITY OF LIFE IMPROVEMENT

The overarching goal after ACL injury is regain knee joint stability and return to full mobility. Both amateurs and professional athletes want to return to their pre-injury activities as soon as possible [65]. The correct movement patterns and deep sensation and body stability improvement will certainly translate into improved functioning during everyday tasks [66]. Despite the continuous improvement of rehabilitation protocols related to conservative treatment, nearly 2/3 of patients originally treated in this way do not feel adequately satisfied and ultimately decide to have surgical treatment [67, 68]. ACL reconstruction restores knee joint stability, prevents incorrect distribution of forces acting on the articular surfaces of the tibia and femur and reduces the risk of secondary sprains. The instability and frequent secondary sprains are considered a cause of premature degenerative changes that can be avoided by undergoing an ACL reconstruction surgery. Unfortunately, literature data do not confirm that reconstruction reduces the risk of cartilage degeneration [68–72]. ACL reconstruction is currently recognized as the gold standard of treatment and it is recommended for all patients, provided there are no contraindications to it [73].

ACL RECONSTRUCTION IN GALEN-ORTHOPAEDICS CENTER

In the Galen-Orthopaedics center in the years 2014-2018 the number of ACL reconstructions performed grew from 111 to 213 cases, an 18% (± 4.7) average increase per year. 54 women (25%) and 159 men (75%), aged 15 to 61 years, were subjected to ACL reconstruction (Tab. 1) in the period from 01/01/2018 to 12/31/2018. The average age was 31.9 years for women and 30.6 years for men. Secondary reconstructions within the same knee joint were perfomed for 3 men and 1 woman. 161 (75.6%) cases of ACL injury occurred while practicing various forms of sport activity. The most injuries were recorded during football matches and training (30%); the second largest group comprised skiers (29%), mainly amateurs. Some of the other groups of injured patients comprised handball players (9%), basketball players (7%), volleyball players (5%) and people doing martial arts (5%). The right lower limb ACL reconstruction was statistically more often found, both among men and women (Tab. 2). A correlation of ACL injury with the phenomenon of lateralization of the right upper and lower limb was observed in most people [74]. In reconstructions carried out in 2018, a combination of autogenous fragments of the semi-tendon

and gracile tendons fragment (41.8%; 34 reconstructions in women and 55 in men) was most often used by doctors from Galen-Orthopaedics (Tab. 3). In 4 cases, only the semi-tendon fragment (1.9%) was used and in 2 cases only the gracile tendon fragment (0.9%) was used. The quadriceps tendon transplant (33.8%) was the second most popular transplant. Allogenic tendon reconstructions were performed in 34 cases (16%), while 12 patients (5.6%) were operated on using the Internal Bracing method.

Table 1. ACL reconstructions in Galen-Orthopaedics in 2018

Lower extremity	Woman	Man
Left leg	24	66
Right leg	30	93
Both	54	159

Table 2. Sport competition practiced at the ACL injury time

Competition	Number	Percent (%)
Football	48	29.82
Skiing	46	28.57
Handball	14	8.7
Voleball	11	6.83
Basketball	8	4.97
Martial arts	8	4.97
Other	26	16.15

Table 3. Material and method used in tendon reconstruction

Surgical technique	Woman	Man
Polycarpus muscle tendon (ST) and gracilis muscle tendon (GR)	34	55
GRAFT	11	23
Hamstrings quadriceps	6	66
Internal Bracing	1	11
Polycarpus muscle (ST)	2	2
Gracilis muscle (GR)	0	2

CONCLUSIONS

The current trend of "being fit" leads to increased interest and active participation in sports activities. Widespread popularization and encouragement to take part in various forms of physical activity has promoted an increase in the number of exercising people. Regular physical activity appears to be essential in maintaining good physical condition as opposed to a prevalently sedentary lifestyle. A properly selected form of movement and intensity convey improvement in our health, better body shape, improvement in ability and physical activity as well as improvement in well-being. Some people give in to their competitive impulses and engage in activity exceeding the limits of their strength, which in turn negatively affects their health. An office worker's decision to participate in a marathon after only one month of training will bring more harm than good. This type of scenario is increasingly common, e.g. with visits to the gym or skiing trips, when unprepared people who lead a rather sedentary everyday life suddenly intensify their physical activity. Excessive loads on the musculoskeletal system and/or incorrect posture

during exercise can quickly lead to injury. Correctly performed movement patterns, both during physical activity and daily activities are important elements. Even the right adaptation of the body to physical exertion is not enough if the movements and movement patterns are incorrect, in that the effect is overloading the body, which often leads to serious injury as a result. This is observed especially among high-performance sports athletes who participate in contact sports. These players are more likely to be injured in non-contact situations than contact situations. Correct walking and squating patterns seem to be simple and obvious to perform; however, a large number of people do these incorrectly. Improper ankle positioning and deformation of the knees are the result of posture defects, such as reduced range of hip movement, pelvic rotation, abnormal pelvic anterior and posterior tilt, flat feet, and/or muscle failure - mainly of the gluteus. Movement pattern disorders and excessive musculoskeletal loads lead to the ankle and knee overload accumulations, which often result in knee injury, including ACL injury. Therefore, it is important when undertaking physical activity to do so with caution and select the load accordingly, according to one's level of fitness. The help of instructors and physiotherapists is recommended. They can teach the proper movement patterns and correct mistakes which will significantly reduce the likelihood of injury.

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