https://doi.org/10.23934/2223-9022-2020-9-4-580-585

Method for Determining the Isometricity of the Location of the Femoral and Tibial Tunnels Before Their Formation in The Anterior Cruciate Ligament Plasty

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RELEVANCE One of the key points in plasty of the anterior cruciate ligament (ACL) is the isometric position of the graft, in which its tension remains the same during flexion and extension of the knee joint. However, no method has been described today for the intraoperative determination of the isometricity of the location of the femoral and tibial tunnels (for placing the graft) before their formation.

PURPOSE OF THE STUDY

To develop a method for intraoperative determination of the isometricity of the location of the femoral and tibial tunnels before their formation during ACL plasty and to study its effectiveness.

MATERIAL AND METHODS The study included 30 patients who underwent ACL repair. For a preliminary intraoperative assessment of the isometric areas of graft fixation on the femur and tibia, the proposed original method with the use of two knot pushers and a thread passing through them. Isometry was assessed by the degree of displacement of this thread. After determining the isometric areas of fixation, the femoral and tibial tunnels were formed, and the isometric position of the graft before its fixation in the tibia was checked by the degree of displacement of the threads with which the graft was sutured relative to the aperture of the tibial tunnel.

RESULTS The average displacement of the thread relative to the pusher of the knot in the preliminary determination of the isometric areas of fixation according to the proposed method corresponded to the displacement of the threads with which the distal end of the graft was sewn relative to the outer aperture of the tibial tunnel (this value did not exceed 2 mm on average) until the final fixation of the graft in the tibial tunnel..

CONCLUSION The developed method makes it possible to determine the isometric location of the femoral and tibial tunnels during arthroscopic plasty of the anterior cruciate ligament before their formation. If the location of the fixation points on the femur and tibia is determined non-isometric, it is possible to correct their position.

Keywords: anterior cruciate ligament plastic, isometry, tunneling, knee arthroscopy

For citation Slastinin VV, Yarygin NV, Parshikov MV, Fain AM, Sychevsky MV. Method for Determining the Isometricity of the Location of the Femoral and Tibial Tunnels Before Their Formation in The Anterior Cruciate Ligament Plasty. *Russian Sklifosovsky Journal of Emergency Medical Care.* 2020;9(4):580–585. DOI: 10.23934/2223-9022-2020-9-4-580-585 (in Rus.)

Conflict of interest Authors declare lack of conflicts of interest.

Acknowledgments, sponsorship The study has no sponsorship

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ACL - anterior cruciate ligament

INTRODUCTION

In the early days of the development of reconstructive surgery of the knee joint, the most popular technique for forming a femoral tunnel for placing a graft in ACL plasty was the transtibial technique. But it did not bear the test of time, since the formation of a vertically oriented femoral tunnel in the area of the roof of the intercondylar space leads to disruption of the kinematics of the knee joint and either loss of flexion in the knee joint or relapse of instability [1].

In 2013, already 68% of US surgeons used the technology of independent formation of the tibial and femoral tunnels [2]. But simply changing the transtibial technique of forming the femoral tunnel to an independent one could not solve the problem of graft failure after ACL plasty. Thus, in the study by E.L. Jr. Cain et al. [1] was noted: after the transition of surgeons from the technique of transtibial formation of the femoral tunnel to the independent, frequency of instability relapses increased from 3.2% to 5.16%, which is associated with the nonisometric of the tunnels formation. The authors concluded that a too low position of the femoral tunnel and a too posterior position of the tibial tunnel lead to a non-isometric position of the graft.

In ACL plastic, the key point is the isometric position of the graft [1, 3, 4]. If the distance between the intra-articular apertures of the femoral and tibial tunnels increases during flexion or extension of the knee joint, this leads to excessive tension on the graft and either limits the range of motion or leads to rupture of the graft [5]. The ideal anatomical location of the bone tunnels is a prerequisite for achieving a physiological stress on the graft, which allows to avoid excessive stretching of the graft and ensures good integration at the bone-graft interface [6].

In a study by Y.K. Kim et al. [2] special attention was paid to the relationship between the isometry and the anatomical location of the ACL graft, as well as the assessment of isometry during anatomical reconstruction of the ACL in vivo. The concept of "isometric" location of the ACL graft was defined by the authors as a change in its length with full extension and flexion of the knee joint by less than 2 mm. They studied the isometric location of the graft after its installation before fixation in the tibial tunnel according to the magnitude of the longitudinal movement of the graft part protruding from the tibial tunnel.

To objectively assess the correct location of the femoral tunnel, the Bernard quadrant method is often used, which requires radiography or computed tomography. In the lateral projection, the Blumensaat line is marked, which connects the most anterior and most posterior parts of the roof of the intercondylar space. The lower border of the rectangle is drawn strictly parallel to the Blumensaat line and tangentially to the most distal point of the lateral condyle of the femur. Then the two remaining edges of the rectangle are completed [7]. The correct location of the femoral tunnel is calculated by calculating the distance from the Blumensaat line in the proximal-distal direction and the distance from the most posteriad part of the lateral condyle of the femur in the dorsal-ventral direction [8]. For an objective assessment of the tibial tunnel location, the Amis and Jakob lines are used - the distance between the anterior edge of the tibial plateau to the center of the tunnel, expressed as a percentage of the anteroposterior size of its proximal section [9]. Both of these methods require the use of radiography, are guided by the model of the average knee joint and are usually not used in daily practice.

There are attempts to determine isometry on cadaveric material using specialized navigation devices (in particular, Orthopilot). It shows the advantage of using navigation in comparison with traditional methods of bone tunnel formation [10]. There are domestic works on the use of navigation computer systems for isometric reconstruction of the ACL, the authors of which recommend the introduction of navigation into the "gold standard" in the reconstruction of the ACL. But, unfortunately, the high cost of this system, combined with the impossibility, even when using it, to exclude the human factor makes this technique unsuitable for wide practical application [11].

Thus, today there is no clear criteria for the formation of isometric tunnels for ACL plasty, as well as there is no way of intraoperative determination of isometry before the formation of bone tunnels. With all this, there are only general recommendations about the "higher" formation of the femoral tunnel [12], or about the "more anterior" location of the tibial tunnel [13].

Moreover, a 2019 study by Y. Tanabe et al. [14], in which isometric assessment was carried out at different positions of the femoral and tibial tunnels, confirms the impossibility of general specific recommendations for isometric formation of tunnels.

Purpose of the study: to develop a method for intraoperative determination of the isometricity of the femoral location and tibial tunnels before their formation during ACL plasty and to study its effectiveness.

MATERIALS AND METHODS

From 2018 to 2019, the study included 30 patients (8 women and 22 men). Their ages ranged from 18 to 33 years old. The criterion for the inclusion in the study was a clinically diagnosed and confirmed by magnetic resonance imaging data, ACL rupture in one knee joint. The exclusion criterion was any operative intervention on the same knee joint in the history.

DESCRIPTION OF THE PROCEDURE

After performing diagnostic arthroscopy of the knee joint through the standard anterior superior lateral port and the formation of the anteromedial port, the character of ACL rupture was determined. A four-bundle graft was formed for its plasty from the semitendinosus tendon, and its diameter and length were measured. Previously, prior to the formation of the tibial and femoral tunnels, the isometric arrangement of the apertures was determined. First, the centers of the intra-articular apertures of the tunnels were marked with an arthroscopic monopolar coagulator in the form of a ball (Fig. 1).

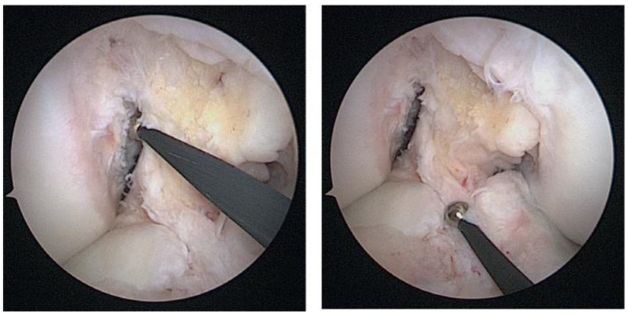

Fig. 1. Marking the centers of intra-articular apertures of the femoral (left) and tibial (right) tunnels with an arthroscopic monopolar coagulator in the form of a ball (endoscopic photo)

Two knot pushers were used. One was a standard size used in shoulder arthroscopy and one was a small. Small Knot Pusher (Arthrex), as well as a 2/0 braided suture. One of the ends of the thread was threaded into the lug of the small knot pusher, then both free ends were threaded into the lug of the standard knot pusher and the threads were fixed, pressing them to the body of the standard knot pusher in a taut state. An improvised meter was formed, shown in Fig. 2.

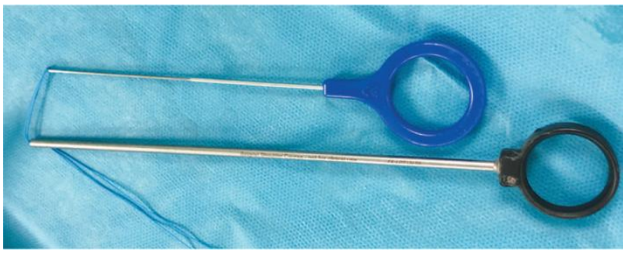

Fig. 2. View of an improvised measuring device

The ends of both knot pushers were inserted into the knee joint through the anteromedial port. The pusher end of the small assembly was positioned in the area of the mark provided by the coagulator to mark the center of the proposed femoral tunnel. The end of the standard assembly pusher is in the area of the mark provided by the coagulator to mark the center of the tibial tunnel. The ends of both knot pushers were mounted on the bone structures. Then, both ends of the thread were pulled outside the joint and the thread was pressed tightly to the body of a standard knot pusher. The assistant controlled the position of the arthroscopic chamber and helped to flex and extend the knee joint (Fig. 3).

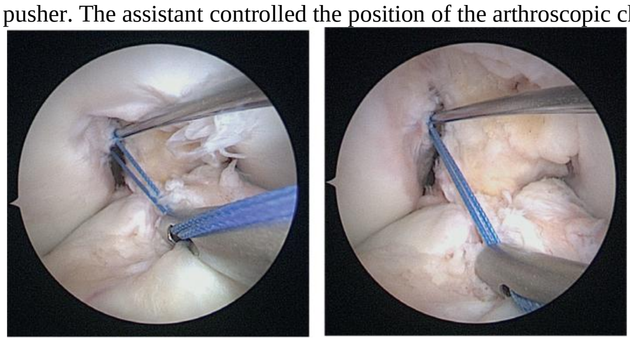

Fig. 3. Arthroscopic picture of the location of the ends of the knot pushers during extension (left) and flexion (right) in the knee joint (endoscopic photo)

With a non-isometric arrangement of the centers of the planned tunnels during flexion and extension in the knee joint, the distance between the ends of the knot pushers changed, which was fixed by the displacement of the ends of the threads relative to the body of the standard knot pusher. If it was necessary to quantify the degree of non-isometricity, marks were placed on the thread and the body of the knot pusher (at the same level) with a surgical marker and the amount of displacement in millimeters was determined by the amount of displacement of marks on the instrument and thread during flexion and extension in the knee joint. When non-isometricity was established, the position of the ends of the knot pushers was corrected and the cycle of flexion and extension in the knee joint was repeated until isometric fixation points were determined.

After determining the isometric points of the femoral and tibial tunnels, they were formed when the guide pins were located in the centers of the isometric view. Further, tunnels were formed along the pins according to the standard technique using capitate drills - a stepped tunnel in the femur and a through tunnel in the tibia in accordance with the diameter of the graft. The graft was placed and fixed on the femur with a TightRope RT cortical fixator (Arthrex Inc., Naples, Florida, USA) (Fig. 4).

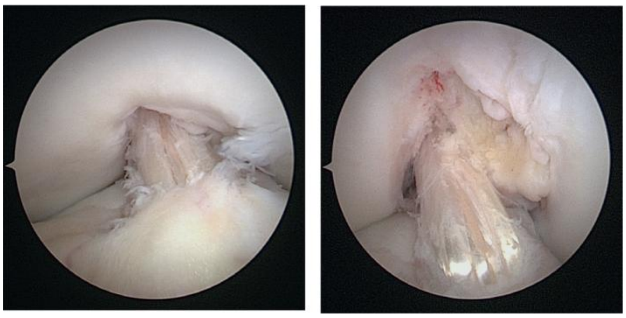

Fig. 4. Arthroscopic picture of the graft position during extension (left) and flexion (right) in the knee joint (endoscopic photo)

Before fixing the graft to the tibia during traction by the threads which was sewed the tibial end of the graft, the isometry of its installation was determined by the magnitude of the displacement of the threads relative to the external aperture of the tibial tunnel. The threads were marked with a surgical marker in the position of maximum extension of the knee joint at the level of their exit from the bone tunnel. Then, making flexion in the knee joint, the displacement of the marks on the threads relative to the outer aperture of the tibial tunnel was determined in millimeters.

EVALUATION OF RESULTS

Evaluation of the effectiveness of the proposed method for determining the isometricity of the location of the femoral and tibial tunnels in ACL plastics was carried out by comparing the displacement amount of the threads relative to the pusher of the node (with preliminary determination of the isometric fixation points) with the displacement amount of the threads with which the graft was stitched after its installation. At the same time, the maximum displacement amplitude of the filaments was noted at full extension and flexion in the knee joint.

RESULTS

The average value of the threads displacement relative to the pusher assembly in the preliminary determination of the isometric fixation points according to the proposed method was 1.8 ± 0.4 mm. The magnitude of the threads displacement with which the distal end of the graft is stitched relative to the outer aperture of the tibial tunnel reached 2.0 ± 0.4 mm. In 3 patients (women) with a small intercondylar notch, it was not possible to preliminarily determine isometric fixation points at the knee extension angles of more than 20 degrees, which was associated with a lack of space between the intercondylar notch of the thigh and the tibial plateau, which is necessary for the insertion of the knot pushers.

DISCUSSION

In the literature, there are repeated references to the importance of the isometric location of the ACL graft during its plasty. Nevertheless, only anatomical and radiological landmarks are given for the correct location of the femoral and tibial tunnels, and the definition of isometry itself is reduced to the degree of the graft displacement after its installation, when it is no longer possible to change the location of the tunnels [2].

The previously mentioned Bernard quadrant method for determining the correct location of the femoral tunnel and determining the correct location of the tibial tunnel using the Amis and Jakob lines are static methods that do not take into account the individual anatomical characteristics of the patient.

The proposed method makes it possible to determine the isometric location of the femoral and tibial tunnels during ACL plasty before their formation. If the non-isometric location of the fixation points on the femur and tibia is determined, it is possible to correct their position.

The disadvantage of this method is the impossibility of controlling isometry in the position of full extension or hyperextension in the knee joint in some patients with a small intercondylar notch, since in this situation there is no space between the intercondylar notch of the thigh and the tibial plateau, which is necessary for the insertion of the knot pushers. But in our study in these patients, the degree of isometric control from full flexion to an angle of flexion in the knee joint of 20 ° was sufficient for the correct location of the tunnels, which was reflected in the isometric position of the graft after the formation of tunnels according to the placed landmarks.

OUTPUT

The developed method makes it possible to determine the isometric location of the femoral and tibial tunnels during arthroscopic plasty of the anterior cruciate ligament before their formation. If the location of the fixation points on the femur and tibia is determined to be non-isometric, it is possible to correct their position.

REFERENCES

1. Cain EL Jr, Biggers MD, Beason DP, Emblom BA, Dugas JR. Comparison of Anterior Cruciate Ligament Graft Isometry between Paired Femoral and Tibial Tunnels. *J Knee Surg*. 2017;30(9):960–964. https://doi.org/10.1055/s-0037-1599251
2. Kim YK, Yoo JD, Kim SW, Park SH, Cho JH, Lim HM. Intraoperative Graft Isometry in Anatomic Single-Bundle Anterior Cruciate Ligament Reconstruction. *Knee Surg Relat Res*. 2018;30(2):115–120. https://doi.org/10.5792/ksrr.16.077
3. Abebe ES, Utturkar GM, Taylor DC, Spritzer CE, Kim J P, Moorman CT, et al. The effects of femoral graft placement on in vivo knee kinematics after anterior cruciate ligament reconstruction. *J Biomech*. 2011;44(5):924–929. https://doi.org/10.1016/j.jbiomech.2010.11.028
4. Yasuda K, van Eck CF, Hoshino Y, Fu FH, Tashman S. Anatomic single- and double-bundle anterior cruciate ligament reconstruction, part 1: Basic science. *Am J Sports Med*. 2011;39(8):1789–1799. https://doi.org/10.1177/0363546511402659
5. Kernkamp WA, Varady NH, Li JS, Asnis PD, van Arkel ERA, Nelissen RGHH, et al. The effect of ACL deficiency on the end-to-end distances of the tibiofemoral ACL attachment during in vivo dynamic activity. *Knee*. 2018;25(5):738–745. https://doi.org/10.1016/j.knee.2018.07.013
6. Slastinin VV, Fain AM, Vaza AY. Bone Tunnel Widening After Anterior Cruciate Ligament Autoplasty With Hamstrings (Literature Review). *Russian Sklifosovsky Journal Emergency Medical Care*. 2017;6(3):233–237. (In Russ.). https://doi.org/10.23934/2223-9022-2017-6-3-233-237
7. Bernard M, Hertel P, Hornung H, Cierpinski T. Femoral insertion of the ACL. Radiographic quadrant method. *Am J Knee Surg*. 1997;10(1):14–22.
8. Mochizuki Y, Kaneko T, Kawahara K, Toyoda S, Kono N, Hada, et al. The quadrant method measuring four points is as a reliable and accurate as the quadrant method in the evaluation after anatomical double-bundle ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2018;26(8):2389–2394. https://doi.org/10.1007/s00167-017-4797-y
9. Amis AA, Jakob RP. Anterior cruciate ligament graft positioning, tensioning and twisting. *Knee Surg Sports Traumatol Arthrosc*. 1998;6 Suppl 1:S2–12. https://doi.org/10.1007/s001670050215
10. Angelini FJ, Albuquerque RF, Sasaki SU, Camanho GL, Hernandez AJ. Comparative study on anterior cruciate ligament reconstruction: determination of isometric points with and without navigation. *Clinics (Sao Paulo)*. 2010;65(7):683–688. https://doi.org/10.1590/S1807-59322010000700006
11. Lisitsyn MP, Lisitsyna EM. Computer Navigation During Arthroscopic Anterior Crucial Ligament of Knee Reconstruction. Philosophy and Technique. *Endoscopic surgery*. 2010;(4):34–37. (In Russ.)
12. Nawabi DH, Tucker S, Schafer KA, Zuiderbaan HA, Nguyen JT, Wickiewicz TL, et al. ACL Fibers Near the Lateral Intercondylar Ridge Are the Most Load Bearing During Stability Examinations and Isometric Through Passive Flexion. *Am J Sports Med*. 2016;44(10):2563–2571. https://doi.org/10.1177/0363546516652876
13. Lee JS, Kim TH, Kang SY, Lee SH, Jung YB, Koo S, et al. How isometric are the anatomic femoral tunnel and the anterior tibial tunnel for anterior cruciate ligament reconstruction? *Arthroscopy*. 2012;28(10):1504–1512.e15122. https://doi.org/10.1016/j.arthro.2012.03.010
14. Tanabe Y, Yasuda K, Kondo E, Kawaguchi Y, Akita K, Yagi T. Comparison of Graft Length Changes During Knee Motion Among 5 Different Anatomic Single-Bundle Anterior Cruciate Ligament Reconstruction Approaches: A Biomechanical Study. *Orthop J Sports Med*. 2019;7(3):2325967119834933. https://doi.org/:10.1177/2325967119834933

Received on 12.02.2020

Review completed on 15.09.2020

Accepted on 29.09.2020