Acta Scientific Orthopaedics (ISSN: 2581-8635)
Volume 6 Issue 5 May 2023
Research Article

Postoperative Radiographic Control of the Orientation of the Femoral and Tibial Tunnels in Patients Operated on Anterior Cruciate Ligament Reconstruction with Technique all inside

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Received: March 16, 2023
Published: April 17, 2023

Abstract

A cross-sectional, retrospective and observational study was conducted in postoperative patients of anterior cruciate ligament (ACL) reconstruction with all-inside technique; from July 1, 2018 to July 30, 2019 at the Spanish Hospital with 10 patients: 8 men and 2 women in immediate postsurgical radiographs AP and Lateral knee with 30º flexion.

The measurement of the maximum femoral inclination angle was 47.54°, with a minimum of 38.95°. The measurement of the maximum tibial tilt angle was 21.25°, with a minimum of 16.40.

The all-inside technique is an anatomical reconstruction, minimally invasive and highly reproducible, which allows adequate soft tissue management and bone preservation.

An adequate placement by this method of the inclination of the femoral and tibial tunnels was found when measuring the angulation.

Keywords: Postoperative; Radiographic; Anterior Cruciate; Ligament Reconstruction

Introduction

The rupture of the anterior cruciate ligament (ACL), is one of the ligament injuries that cause joint pain and instability most frequently, caused mainly by sports injuries or falls [1].

On average, 150,000 ACL injuries are recorded annually in the U.S. Around 4 million knee arthroscopies are performed each year worldwide for this pathology [1-3].

The ACL is formed by 2 fascicles; the antero-medial (AM) and posterolateral (PL). The AM fasciculus stabilizes the anterior displacement of the tibia on the femur and the external rotation with the knee in flexion between 0° and 90°. The fasciculus PL is tensioned in extension and the AM in flexion [6,7]. When the knee is in flexion, the femoral insertion of the ACL is more horizontal, thus tightening the AM fasciculus and relaxing the PL fibers [6,7]. The restriction of internal rotation is controlled by the PL fasciculus [7]. With the knee in extension the AM and PL fascicles are parallel and rotate on oneself when the knee is flexed.

One of the main risk factors described in the literature for ACL injury is contact sports. Other intrinsic factors include misalignment of the lower extremity shaft, anteroposterior knee laxity, and pronation of the subastragalin joint. Extrinsic factors are also considered as the interaction of the shoe with the terrain, the playing surface and the altered strategies of neuromuscular control [2,3].

The biomechanics of the ACL injury is by shearing through a rotational movement in valgus or forced varus and flexion of the knee when standing. It may present hemarthrosis and limitation in the extension when the lesion is acute [14].

This injury is associated with long-term clinical sequelae including meniscal and chondral lesions and an increased risk of early post-traumatic osteoarthritis [16].

The diagnosis is made with the presence of pain, joint swelling, joint blockage and knee instability in acceleration and deceleration. As diagnostic tests of choice are the anterior drawer, Lachman and pivot shift, the latter with a specificity of 98% and the Lachman test with a sensitivity of 85% [15]. Radiographic studies complement the patient's approach to rule out associated fractures, magnetic resonance imaging is the study of choice.

ACL reconstruction has remained the gold standard for the treatment of these types of injuries, especially in young individuals and athletes seeking to return to high-level sporting activities [16,17].

Over the past decade, substantial effort has been made to make surgical reconstruction more anatomical by altering the traditional tunnel position and introducing the concept of dual-beam reconstruction [16,18,19]. This evolution in ACL reconstruction has resulted in better rotational stability of the joint compared to conventional non-anatomical single-beam reconstruction [19,20].

Lubowitz first described the all-in-house technique for ACL reconstruction [8] in 2001 using a retrograde drill bit coupled within the joint through a small one-centimeter incision, a tibial foramen, and a femoral hole with interference screws for graft fixation [8,9,11].

The all-inside technique consists of making holes instead of wide tunnels; so that the tibial and femoral cortical remain intact. The graft should be between 65 and 90 mm long. Graftlink® is the name given to the graft already prepared with a Tightrope® implant at each end. The implant has a cortical fixation button and a graft hoisting system that locks itself at four points at the end of the procedure. The graft should be prepared in four bands pretensioning it at 40N and marked to establish a femoral depth of 25 mm, intraarticular depth of 25 mm and tibial depth of 20 mm [16,17].

The procedure is started with a diagnostic arthroscopy; Femoral perforation is performed using the femoral guide, which is placed on the medial surface of the lateral condyle of the femur by introducing the femoral guide shirt through a small cutaneous incision on the lateral aspect of the thigh. It is drilled with a Flipcutter® drill bit of the same diameter as the femoral end of the graft; through this perforation a Fiberstick® suture is inserted, and the suture is retrieved through the anteromedial portal. The procedure is repeated with the tibial guide, which is placed in the anatomical imprint of the tibial insertion of the ACL. The graft is introduced through the anteromedial portal and passed through the femoral orifice with the help of the suture previously introduced with the Fiberstick® the procedure is repeated by passing the graft through the tibial perforation, then tightened and the wounds are closed [16,17].

The main consequences of the incorrect position of the tunnels result in inadequate mechanics of the knee; If the femoral tunnel is placed anteriorly, it will tighten in flexion and lose tension in the extension.

If the femoral tunnel is placed posteriorly, it will cause loosening in flexion and increase the tension in extension. An anterior tibial tunnel will cause tension in the flexion and impingement in the extension. The tibial tunnel placed posteriorly will cause tension in the extension and impingement with the posterior cruciate ligament [21,22].

There are several methods for measuring the femoral footprint of native ACL.

The most common methodology known as "quadrant method" was described by Bernard [24]. It is a "grid" rather than a "quadrant" system. It is performed by obtaining a lateral x-ray of the knee with overlapping femoral condyles. A line is drawn along the Blumensaat line; which is a linear condensation located at the base of the femoral condyles corresponding to the intercondylar notch, a line is drawn that continues the bone condensation and projects forward, this must be tangential to the distal pole of the patella [26]. With a parallel line the tangent to the distal lateral femoral condyle is drawn. Perpendicular lines are then drawn along the dorsal and ventral border of the condyle where the proximal line, the extension of the Blumensaat line, crossed the condyles. Measurements from the center of the ACL are made in terms of percentages of the grid described from the posterior condyle and from the Blumensaat line [22-24].

Guo; described a complex parallelogram that allows measurements of the femoral insertion of the ACL on lateral radiography, these are percentages similar to those described by Bernard. Used 16 cadaveric samples where he discovered an average of 2:3 for the distance from the Blumensaat line and 13:7 for the distance from the femoral axis. Divided the ACL footprint evenly into five sections on the X-rays and then measured the angle based on a clock face metric [23,25].

Illingworth determined the longitudinal axis of the femur by drawing a line in the most proximal part of the femoral epicondyles to define the transepicondylar axis (ASD). The most proximal portion of the femur visible on the x-ray is identified, and the width of the shaft parallel to the ASD (line a) is measured. The width of the shaft is also measured at a second location at a distance of half the length of the ASD distally (line b). The midpoints of line *a* and *b* are determined. A "*y*" line is drawn down in the center of the femoral axis through the midpoints of lines a and b, and an additional one in the center of the femoral tunnel. The angle of the femoral tunnel is defined as the angle formed between the femoral tunnel and the line and, as shown in figure 1 [27].

There are two main methods for defining the maximum anteroposterior length (AP) of the tibia. Stäubli and Rauschning [29], described the total AP diameter of the tibia as perpendicular to the tibial axis, and the Amis and Jakob line [30], passing through the pos-

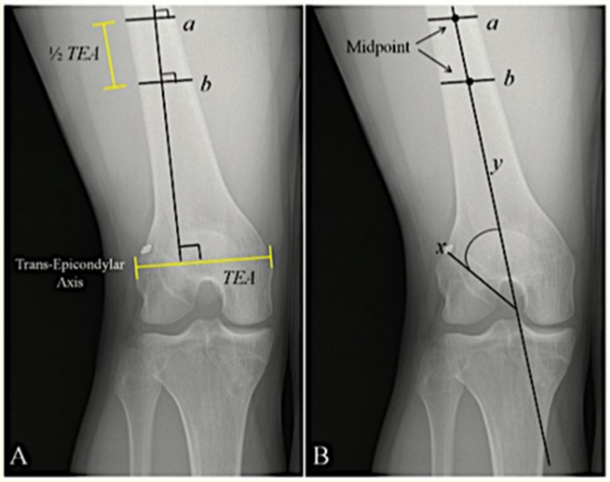

Figure 1: Method for determining the angle of the femoral tunnel on anterio r to posterior radiography. (A) Two proximal (line a and line b) of the femoral shaft are measured parallel to the transepicondylar axis (ASD), as described above. (B) The midpoints of line a and line b are determined to drawan estimate of the longitudinal axis of the femur (line y). A line dividing from the femoral tunnel, line X; and line Y are used for the angle of the femoral tunnel [27].

terior corner of the tibial plateau and parallel to the surface of the medial tibial joint [29-31]. The center of the tibial tunnel in the lateral view was determined in relation to the maximum diameter of the tibial condyle in an anteroposterior direction and was given as a percentage. A target value of 43% was assumed and a tolerance of ± 4% [32] was accepted. Finally, the angle between the center of the tibial tunnel and a line perpendicular to the tibial plateau is measured.

Methodology

A cross-sectional, retrospective and observational study was conducted in postoperative patients of anterior cruciate ligament reconstruction with all-inside technique in a period of time from July 1, 2018 to July 30, 2019 at the Spanish Hospital.

The measurements were made in immediate postoperative radiographs AP and lateral knee with 30º of flexion.

In the AP knee projection, the orientation of the tibial tunnel angle was taken in relation to the tibial cymbals according to Behrend and Stutz [32]. (Figure 2) The technique used by Illingworth [27]. (Figure 3) described above was used to measure femoral tunnel inclination in the PA radiographic projection of the knee.

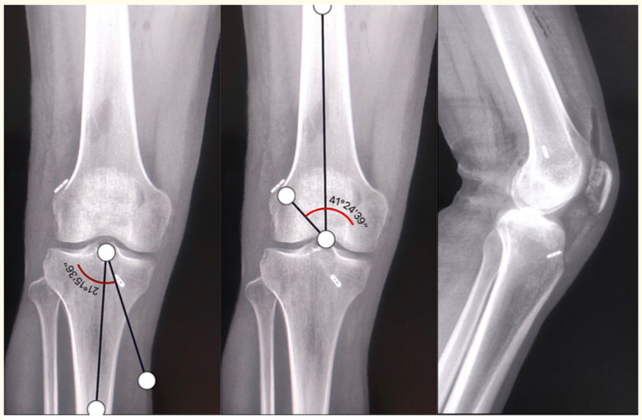

Figure 2,3 and 4: (9) orientation measurement of the angle of the tibial tunnel in relation to the tibial plates according to Behrend and Stutz. [32] (10) measurement of femoral tunnel inclination in the AP radiographic projection of knee will take into account the technique used by Illingworth [27] (11) Lateral radiography of knee with 30 degrees of flexion.

The measurement of the radiographs was performed the program: Horos 2K v2.01.1para Maquintosh. Statistical analysis was performed with SPSS 21.0 for Macintosh.

Inclusion criteria: Patients of both sexes who agreed to participate in the study, diagnosis of complete rupture of clinical and imaging (MRI), age < 60 years, study period from July 1, 2018 to July 31, 2019, complete clinical and radiological record. Exclusion criteria: Patient with recent ACL revision surgery (less than 6 months), radiographic projections with poor technique or where the placement of the tibial and femoral tunnels is not clearly observed. Elimination criteria: Patient who wishes to leave the study.

Results

We analyzed 10 patients of which 8 were men and 2 were women, with laterality of the lesion of 6 right knees and 4 left knees. The measurement of the maximum femoral inclination angle was 47.54°, with a minimum of 38.95°, a mean of 41.82° and a standard deviation of 2.68. The measurement of the maximum tibial tilt angle was 21.25°, with a minimum of 16.40, a mean of 18.91 and a standard deviation of 1.68.

The Mann-Whitney U test was performed to find if there was a relationship between the inclination of the femoral angle and the male or female sex with one ($p = 0.533$) and the relationship be-

Patient	Age	Sex	Date of Injury	Date of surgery	Femoral angle	Angulo tibial	Rodilla D/I
1	29	M	10.09.2018	14.09.2018	42.02°	20.16°	D
2	36	M	24.02.2019	02.04.2019	47.54°	19.21°	I
3	23	M	11.02.2019	22.02.2019	41.87°	17.20°	I
4	51	M	27.02.2019	04.04.2019	43.10°	20.54°	I
5	39	M	27.06.2019	17.07.2019	39.62°	19.55°	D
6	32	M	18.06.2019	02.07.2019	39.02°	16.40°	D
7	45	M	10.07.2019	16.07.2019	40.35°	18.69°	D
8	38	F	14.04.2019	16.05.2019	41.24°	21.15°	D
9	27	F	06.05.2019	08.05.2019	44.51°	16.55°	I
10	30	M	07.11.2019	21.11.2019	38.95°	19.57°	D

Table 1: Results of the 10 patients analyzed by age, sex, date of injury, date of surgery, femoral angle, tibial angle and laterality of the lesion.

tween the inclination of the tibial angle and the male or female sex with one (p = 889) finding that the distribution of the femoral and tibial angle is the same in both sexes.

The mean waiting time between injury date and anterior cruciate ligament reconstruction surgery was 17.60 days, with a maximum wait of 37 days and a minimum of 2 days, with a standard deviation of 13.16.

A total of 7 patients were operated before 30 days of the date of injury and 3 patients were operated after 30 days of the date of injury, the relationship between the waiting time of surgery and the inclination of the angles was analyzed with the Mann-Whitney U test, finding that the distribution of the inclination of the femoral angle is the same in patients who underwent anterior cruciate ligament reconstruction surgery before 30 days from the date of injury and those who underwent surgery 30 days after the date of injury finding one (p = 0.183). It was also found that the distribution of tibial angle inclination is the same in patients who underwent surgery before 30 days and those who underwent surgery 30 days after their injury date with one (p = 0.117).

Because the all-inside technique the femoral and tibial tunnels are done independently, a direct relationship between the two angles cannot be found.

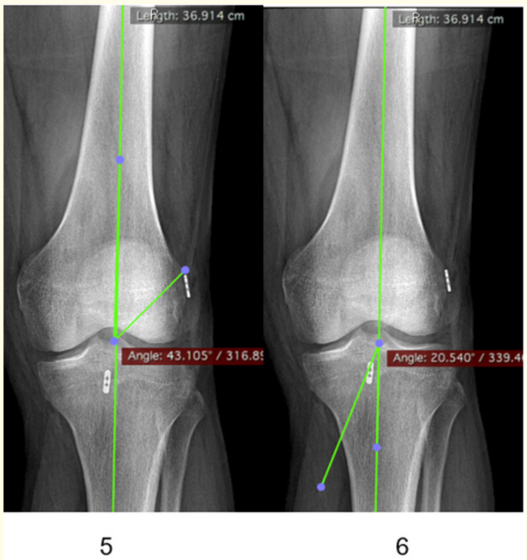

Figure 5 and 6: Radiographs of patient number2 with The orientation measurement of the angle of the tibial tunnel in relation to the tibial plates according to Behrend and Stutz. And measurement of femoral tunnel inclination in Illingworth knee AP radiographic projection [27].

Discussion

In the literature consulted it is stated that the femoral and tibial tunnels should be anatomically placed as close as possible to the original insertion site of the ACL, otherwise there is greater impact, graft distension and excessive restriction that can limit the arcs of mobility of the knee. If the femoral tunnel is too far from the anterior border, relative shortening of the graft occurs compared to normal ACL and increased stress is applied to the graft, especially during knee flexion [32].

Incorrectly placed grafts remain one of the most common causes of revision after ACL reconstruction [32].

The measurement of the inclination angle of the maximum femoral tunnel was 47.54°, with a minimum of 38.95°, a mean of 41.82° and a standard deviation of 2.68, which ***coincides with the Illingworth article [27]. that measured the inclination angle of native ACL at 49.9° ± 2.8°, with a range of 43° to 57°. Patients who had tunnel positions within an anatomical range had a larger femoral tunnel angle (39.3° ± 4.2°). The measurement of the maximum tibial inclination angle was 21.25°, with a minimum of 16.40°, a mean of 18.91° and a standard deviation of 1.68, which was lower than that reported in the literature by Behrend and Stutz with an average tibial tunnel inclination of 24°, with a maximum of 30° and a minimum of 12°.

A more vertical anatomical femoral tunnel reduces the risk of complications in patients requiring ACL reconstruction, while horizontal femoral tunnels can cause the fination system to rest on the external epicondyle [37].

Taketomi., *et al*. demonstrate the presence of pain due to irritation of the fascia lata from a femoral fjation with EndoBotton near the epicondyle [36].

For this reason it is of great importance to find the relationship of the inclination of the tunnels with the clinical evolution and long-term prognosis of the patient.

Of a total of 10 patients analyzed, 8 were men and 2 women, which coincides with the literature which indicates a greater predisposition of the male sex and patients with high performance sports to have an anterior cruciate ligament injury.

The age range in which the study patients are; It ranges from 23 to 51 years of age. Kennedy., *et al.* found that older patients have more pathologies associated with ACL injury compared to young patients who had the same time of evolution and that these degenerative changes advanced faster, recommend early ACL reconstruction in adults because of the increased risk they have of developing associated lesions more prematurely [34,35].

The laterality of the lesion in this study was greater in the right knee with a total of 6 patients compared to 4 patients with left knee injury, which supports the literature which reports a higher rate of right knee injuries.

The average waiting time reported by this study according to the date of injury and the day of anterior cruciate ligament reconstruction surgery was 17 days, longer than reported in the literature, in which there are several reports that relate the delay in primary repair with the appearance of secondary pathologies.

Lars-Petter Granan., *et al*. found that the probability of presenting cartilage lesions increases 1% for each month from the initial injury to surgery, being 2 times more frequent when patients had associated meniscal lesions. (Level II) [33].

X-rays remain an excellent option for tunnel position assessment in ACL reconstruction, allowing surgeons to assess the position of transsurgical and post-surgical ACL tunnel justifying their use as an easy, simple, low-cost and highly available study.

Conclusion

The surgical technique of anterior cruciate ligament repair with everything inside is an anatomical, minimally invasive and highly reproducible reconstruction, which allows adequate soft tissue management and bone preservation.

Adequate placement by this method of the inclination of the femoral and tibial tunnels was found when measuring the angulation by the Behrend and Stutz method [32] and Illingworth [27].

There are many factors involved that can explain the variation in the femoral and tibial tunnel and angles of inclination, including surgical technique, tunnel placement in the femur, and the patient's variable anatomy. A femoral tunnel in anterior position leads to a smaller angle of the femoral tunnel and a greater angle of inclination, regardless of the surgical technique.

It is necessary to carry out more studies on radiographic measurement in the anatomical technique all in, with comparison of functional scales in the short and long term to monitor the evolution of patients and the rate of recurrence of lesions.

It is necessary to expand the field of research in the area of sports and rehabilitation, since there are few functional tests that evaluate the reincorporation of high-performance athletes after ACL reconstruction with this technique and if the correct inclination of the tunnels is a factor that speeds up their recovery.

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