Radiometric factors associated with functional prognosis after anterior cruciate ligament reconstruction

Article *in* International Journal of Advanced Joint Reconstruction · September 2017

Gustavo Armando Tafoya-Arreguin
Hospital Civil de Guadalajara

ORIGINAL

Radiometric factors associated with functional prognosis after anterior cruciate ligament reconstruction

Gustavo A. Tafoya-Arreguín[1,2], José J Martínez-Ruíz [1], Sergio Sánchez-Enriquez [3,4].

1 Servicio de Traumatología y Ortopedia. Antiguo Hospital Civil de Guadalajara "Fray Antonio Alcalde".
2 Instituto de Reconstrucción Articular y Medicina Deportiva de Occidente (IRAMDO)
3 Departamento de clínicas, Centro Universitario de los Altos, Universidad de Guadalajara.
4 Departamento de Biología Molecular y Genómica, Centro Universitario de Ciencias de la Salud, Universidad de Guadalajara.

Abstract

The prevalence of anterior cruciate ligament (ACL) injury is around 1 in 3000 people and approximately 250,000 new injuries occur annually. It is estimated that 100,000 ACL surgeries are performed annually. Some patients become incapacitated for sports activity and others only suffer minimal damage. So far, there is no studies analyzing the correlation between the radiometric and functional results after the PLCA. Therefore, the objective of our study is to correlate the functional and radiometric results in post-surgical ACL patients.

In an analytical cross-sectional study, 84 postoperative PLCA patients were divided into two groups, which were evaluated clinically and radiographically, making descriptive and inferential statistics in order to compare radiometric factors that could predict the evolution in our patients. There were no differences in the demographics, and we found that there are radiometric variables associated with the functional prognosis.

Keywords

ACL, Radiometrics mesures, knee function.

Introduction

Injury to the anterior cruciate ligament (ACL) is one of the most frequent lesions of the knee. In United State of America, prevalence of ACL injury is about 1 in 3000 people and approximately 250,000 new injuries occur annually (1).

It is estimated that 100,000 reconstructions of the anterior cruciate ligament are performed per year (1). Sports activity is the usual context of most ACL injuries, since there are mechanisms of deceleration, trimming, twisting and jumping (2). The mechanisms that cause ACL injury including: excessive force in valgus and external rotation, while the knee is in full extension or hyperextension (3).

The frequency of instability of the knee secondary to the anterior cruciate ligament injury is 16 to 100% (4-8). This instability causes femorotibial subluxation (9,10), which conduces to meniscal injuries and joint damage in 50 and 70% of cases, respectively (11).

To date, there is no literature to support the correlation between radiometric factors and functional results of the knee joint after ACL reconstruction. Therefore, the objective of our study was to correlate the functional results of the knee with radiometric variables in post-surgical ACL reconstruction patients.

Patients and Methods

Study Design and ethical considerations

An analytical cross-sectional study was performed in patients from the Traumatology and Orthopedics Service of the Guadalajara Civil Hospital, Fray Antonio Alcalde. The study was approved by the bioethics committee and in accordance with the international regulations established for this type of studies.

Selection criteria

Patients older than 18 years, with BMI <30 kg/m2, diagnosis of isolated ACL injury with less of 18 months of evolution, treated with hamstrings autograft with femoral button fixation technique and tibial interferential and, signed informed consent, were included. Patients in whom it was difficult to obtain the antero-posterior and lateral radiographs of the knee, those who showed no adherence to physiotherapy or had changes in their training habits, were excluded.

Functional evaluation of the knee

To evaluate the functionality of the knee, we applied the Lysholm functional scale (12-16) to all our patients, taking it as our outcome variable. We dichotomize the scale to obtain two groups: A) good results (≥ 84 points) and b) poor results (<84 points).

Table 1. Description and abbreviation of the radiometric variables evaluated in patients with ACL reconstruction.

	Variable	Acronym	Measurement
1	Anterior tibial tunnel length	ATTL	Milimeters
2	Anterior femoral tunnel length	AFTL	Milimeters
3	Anterior tibial tunnel width	ATTW	Milimeters
4	Anterior femoral tunnel width	AFTW	Milimeters
5	Anterior tibial tunnel angle	ATTA	Grades
6	Anterior femoral tunnel angle	AFTA	Grades
7	Anterior femoro-tibial tunnel intersection	AFTTI	Grades
8	Lateral tibial tunnel length	LTTL	Milimeters
9	Lateral femoral tunnel length	LFTL	Milimeters
10	Lateral tibial tunnel width	LTTW	Milimeters
11	Lateral femoral tunnel width	LFTW	Milimeters
12	Lateral tibial tunnel angle	LTTA	Grades
13	Lateral femoral tunnel angle	LFTA	Grades
14	Lateral femoro-tibial tunnel intersection	LFTTI	Grades

Radiometric evaluation of the knee

Two radiographic projections (anteroposterior and lateral) were obtained, in monopodal support, with the same technique in all cases:

1. Patient in standing position,

2. At a 1 meter of distance between the focus and the film,

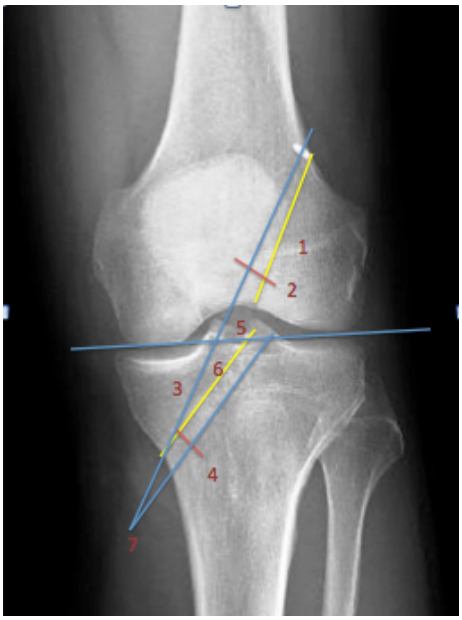

Figure 1. Measurement chart in anteroposterior X-ray projection. 1.Anterior femoral tunnel length (AFTL), 2. Anterior femoral tunnel width (AFTW), 3. Anterior tibial tunnel length (ATTL), 4. Anterior tibial tunnel width (ATTW), 5. Anterior femoral tunnel angle (AFTA), 6. Anterior tibial tunnel angle (ATTA) and, 7. Anterior femoro-tibial tunnel intersection (AFTTI).

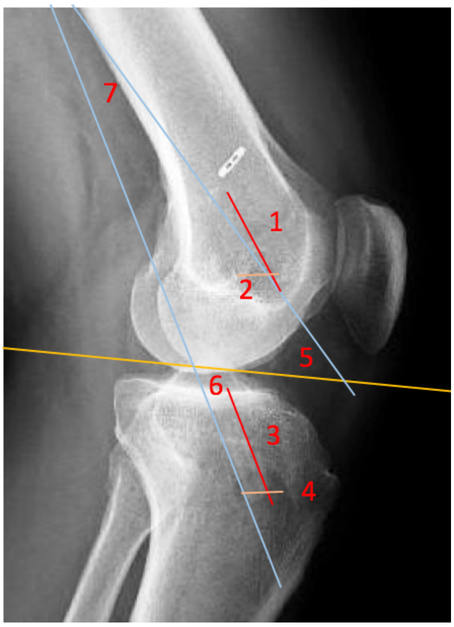

Figure 2. Measurement chart in lateral X-ray projection. 1. Lateral femoral tunnel length (LFTL), 2. Lateral femoral tunnel width (LFTW), 3. Lateral tibial tunnel Length (LTTL), 4. Lateral tibial tunnel width (LTTW), 5. Lateral femoral tunnel angle (LFTA), 6. Lateral tibial tunnel angle (LTTA) and, 7. Lateral femoro-tibial tunnel intersection (LFTTI).

3. Anteroposterior projection of the x-ray with 0º of extension with focus at 10º in the caudal direction,

4. Lateral projection of the x-ray with flexion 20º in monopodal support, and

5. Free technique to 65KVP and 50MAS.

These two radiographic projections were used to access the angulations, lengths, and, widths of the femoral and tibial tunnels. As well as, the anterior and lateral femorotibial intersection tunnel angles, to obtain a total of 14 dependent variables, see table 1 and figures 1 and 2.

Statistical analysis

Descriptive statistics were performed taking central tendency measures (mean, median, and, mode) and dispersion measures (maximum and minimum standard deviation, standard error, variance, and range). In qualitative variables percentages were used.

Also, inferential statistics was performed for quantitative variables averages are compared with the Student t test. Pearson correlation was performed for quantitative variables besides odds ratio and linear regression analysis, using the statistical package SPSS v22.0. A p value <0.05 was considered significant.

Table 2. Demographic characteristics according to study groups.

	Group A Good results	Group B Bad results	Significance
N	42	42	-
Male/female proportion	24/18	29/13	.258*
Age, years (min-max)	29 (18-44)	28 (19-44)	0.951**
Affected limb -right n(%) -left n(%)	 26 (62%) 16 (38%)	 19 (41%) 23 (59%)	 .126*
Dominant limb n(%)	26 (62%)	21 (50%)	.272*
Lysholm scale (mean)	92.6	71	0.000**

*=Chi-Squared test. **= Student-t test.

Table 3. Comparison of radiometric variables between study groups

X-RAY ANTEROPOSTERIOR PROJECTION	GROUP A Good results	GROUP B Bad results	*P value**	CI 95%
Femoral tunnel length (mm)	40.31	36.95	**0.000**	1.6/5
Tibial tunnel lenght (mm)	58.79	36.95	**0.000**	4.5/12.6
Femoral tunnel width (mm)	9.98	9.71	0.311	-.249/.773
Tibial tunnel width (mm)	8.71	8.43	0.217	-.171/.743
Femoral tunnel angle (grades)	49.74	30.24	**0.000**	16.5/22.4
Tibial tunnel angle (grades)	69.95	65.71	**0.000**	2.5/5.9
Femoro-tibial intersection angle (grades)	27.81	39.38	**0.000**	-13.8/-9.3
X-RAY LATERAL PROJECTION				
Femoral tunnel length (mm)	34.38	26.43	**0.000**	5.8/10
Tibial tunnel lenght (mm)	61.29	50.55	**0.000**	8/13.4
Femoral tunnel width (mm)	9.95	8.98	**0.000**	.445/1.5
Tibial tunnel width (mm)	7.79	7.88	0.663	-.528/.337
Femoral tunnel angle (grades)	51.76	64.00	**0.000**	-16.5/-7.9
Tibial tunnel angle (grades)	63.88	81.43	**0.000**	-21.9/13.1
Femoro-tibial intersection angle (grades)	61.86	33.33	**0.000**	24.9/32

* *Student-t* test.

Table 4. Radiometric variables correlations in the group A.

VARIABLE	AFTL	AFTTI	LFTL	LTTL	LFTW	LFTA	LFTTI
AFTL			.424	.425		.516	-.512
LFTA	.516	-.364	.339		-.254		

AFTL= anterior femoral tunnel length; **AFTTI=** anterior femoro-tibial tunnel intersection; **LFTL=** lateral femoral tunnel length; **LTTL=** lateral tibial tunnel Length; **LFTW=** lateral femoral tunnel width; **LFTA=** lateral femoral tunnel angle; **LFTTI=** lateral femoro-tibial tunnel intersection.

Results

We included 84 patients in two groups (n=42 each), divided according to the outcome of the Lysholm functional scale.

Group A

In group A, classified as poor functional outcome, a mean age of 28 years (range 19-44 years) was obtained. The gender distribution was 13 female patients and 29 male. In 50% of cases the affected limb was the dominant one. The left side was affected more frequently than the right side (54%). The mean score on the Lysholm scale was 71.55 (60-80). No differences were found between pre-operative and postsurgical physical activity ($p = 0.624$ CI 6.3-8.7).

Group B

In group B, classified as good functional results, we found an average age of 29 years (range 18-44 years). The gender distribution was 18 female patients and 24 male. In 62% of cases the affected limb was the dominant one. The right side was affected more frequently than the left side (62%). The mean score on the Lysholm scale was 92.64 (87-100). A difference between preoperative and postoperative physical activity was found. Patients decreased activity weekend from 86% to 35% ($p = 0.002$ CI 17 to 29), see Table 2.

The Kolmogorov-Smirnov test yielded data with normal distribution, so the Student-t test was used to compare the means between groups. We found statistical significance in eleven variables, all of them with $p = 0.000$ (Table 3).

Correlations

In group A (good results), the lateral tibial tunnel angle (LTTA) had no correlation with any of the radiometric variables. While the anterior femoral tunnel length (AFTA) and lateral femoral tunnel angle (LFTA) were the most correlated. Table 4.

In group B (bad results), Correlation was obtained between all variables, being the ones with the highest correlation femoral angulations in anteroposterior and lateral x-ray projections. As well as, lateral tibial angulation, table 5.

Lineal regression analysis

Finally, the variables that showed statistically significant correlations were included in a linear regression model, with the following results: 1) Lateral femorotibial tunnel intersection (LFTTI) $p = .008$, B . 527, CI 95% (.329 - .845), 2) Anterior tibial tunnel length (ATTL) $p = .001$, B .903, CI 95% (.854 - .946), 3) Anterior femoral tunnel angle (AFTA) $p = .001$, B . 726, CI 95% (.662 - .832), 4) Lateral femoral tunnel length (LFTL) $p = .001$, B .672, CI 95% (.564 - .801), 5) Lateral tibial tunnel length (LTTL) $p = .001$, B .744, CI 95% (.655 - .849).

What shows us that: 1) for each degree of variability both positively and negatively in the LFTTI variable outside the mean range (61.86 ° ± 4.7º we obtained in relationship between of our typical deviation in good outcomes group.) there will be a 47% chance of poor results ; 2) for each millimeter of variability outside the mean (58.79mm ± 7.5mm) of the ATTL variable there will be a 10% chance of bad results; 3) a 27% chance of poor results for each degree of deviation from the mean

Table 5. Radiometric variables correlations in the group B.

VARIABLE	AFTL	AFTA	ATTA	AFTTI	LFTA	LTTA
AFTA			.391	-.419	.352	-.331
LFTA	-.305	.352	.339			-.327
LTTA		-.331	-.448		-.327	

AFTL= anterior femoral tunnel length; AFTA= anterior femoral tunnel angle; ATTA= anterior tibial tunnel angle; AFTTI= anterior femoro-tibial tunnel intersection; LFTA= lateral femoral tunnel angle; LTTA= lateral tibial tunnel angle.

of the variable AFTA (9.98º ± 0.89º); 4) for each millimeter of deviation of the mean of the LFTL variable increases the risk of poor results (34.38mm ± 5.3mm) by 33% and finally, 5) for each millimeter of deviation of the LTTL variable (61.29 ± 4.8mm), the probability of poor results is increased by 26%.

The out-of-the-way variability found in our study group at the lateral femoro-tibial intersection angle is the most important factor that could lead us to a prediction of good or poor functional outcome. With this study, we can lay the groundwork, since there is no previous description, to consider radiometric measurements of normality or optimal in post-surgical patients to ACL.

Discussion

In our study, it was found that the functional outcomes in patients with ACL reconstruction can be predicted based on radiographic evidence. In our study, the radiometric variable that showed greater predictive power for the patient had a poor functional outcome was LFTTI, followed by LFTL, AFTA and, LTTL, in that order, according to what is described below: 1) for each degree of variability both positively and negatively in the LFTTI variable outside the mean range (61.86 ° ± 4.7 °) there will be a 47% probability of poor results ; 2) for each millimeter of variability outside the mean (58.79mm ± 7.5mm) of the ATTL variable there will be a 10% probability of bad results; 3) a 27% probability of poor results for each degree of deviation from the mean of the variable AFTA (9.98º ± 0.89º); 4) for each millimeter of deviation of the mean of the LFTL variable increases the risk of poor results (34.38mm ± 5.3mm) by 33% and finally, 5) for each millimeter of deviation of the LTTL variable (61.29 ± 4.8mm), the probability of poor results is increased by 26%.

These findings are important for the orthopedic surgeon, because if the postsurgical values in radiometric variables deviate from the average, the surgeon should offer a careful rehabilitation to the patient, to avoid a failure in knee function thereof. On the other hand, knowing these risks forces orthopedic surgeons to be more meticulous when performing the surgical technique and to develop technologies that assist the surgeon for the correct location of the femoral and tibial tunnels.

This is the first study that reports the relationship between radiometric factors and functional outcomes in patients with ACL reconstruction. In the search for information we do not find studies similar to this.

Similarly, in our study we showed that physical activity and especially improve muscle tone quadriceps decreases the sensation of instability and increases the score on the Lysholm functionality scale of knee. This is in agreement with the data reported by Joseph et al. (4)

Conclusions

This is, to our best knowledge, the first study evaluating the relationship between clinical and radiometric outcomes after ACL surgery. The 14 radiometric measures performed in this work have a some degree of significance.

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Conflicts of interest statement

The authors certify that they have no affiliations with or involvement in any organisation or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

Correspondence

Dr. Gustavo Armando Tafoya Arreguín

Av. Empresario # 150 piso 15 Torre Elite, Centro Medico Puerta de Hierro.

Zapopan Jalisco Mexico. C.p: 44100

drgustavotafoya@me.com

How to cite

Tafoya-Arreguín GA, Martínez-Ruíz JJ, Sanchez-Enriquez S. Radiometric Factors Associated with Functional Prognosis after Anterior Cruciate Ligament Reconstruction. Int J Adv Jt Reconstr. 2017; 4(2):46-51.