

## Original Research Article

# Tibial tunnel positioning on lateral radiographs in anterior cruciate ligament reconstruction: a single surgeon experience

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## ABSTRACT

**Background:** Accurate tunnel positioning in anterior cruciate ligament reconstruction surgery is one of the cornerstones for its success. However, it is still controversial and target of disagreement within the orthopedic literature. Therefore, it was aimed to evaluate the tibial tunnel placement in anterior cruciate ligament reconstruction surgeries of a single orthopedic surgeon.

**Methods:** The postoperative knee sagittal radiographs of anterior cruciate ligament reconstructed knees from a single surgeon were retrospectively collected. To assess the tunnel positions was used predefined criteria (in percentage and in millimeters) within the intervals found in the literature (41-43 percent and 21-23 millimeters).

**Results:** There were no significant differences between the number of results (% and mm), within and without the intervals that were considered acceptable for this measure ( $P > 0.05$ ). It was found significant differences in the absolute deviation (%) throughout non-consecutive years ( $P < 0.05$ ). There was no correlation between the absolute deviations and the years of experience ( $r = -0.080$ ,  $P = 0.663$ ).

**Conclusions:** Significant differences were found in the absolute deviation (%) throughout non-consecutive years, suggesting variations in the tunnel position throughout the years.

**Keywords:** Anterior cruciate ligament, Tunnel placement, Rauching, Surgical accuracy

## INTRODUCTION

Correct tunnel positioning in anterior cruciate ligament (ACL) reconstruction surgery is one of the keystones for success and is still an important question among orthopedic surgeons. However, the correct location of the femoral and tibial tunnels is still controversial and target of disagreement within the scientific literature. The known problems include femoral notch impingement and graft versus posterior cruciate ligament (PCL) impingement. Fortunately, tibial tunnel placement error has less negative impact in graft function than the femoral tunnel and probably, by this reason, the impact in the literature regarding this subject is less common.<sup>1</sup> To achieve optimal surgical performance the surgeon

requires practice and continuous execution of the surgical procedure.<sup>2</sup> Therefore, it was decided to study the tibial tunnel placement in ACL reconstruction surgeries of a single surgeon in his first 32 cases during a 6 years period in order to identify a correlation between the number of cases performed by year and the correct placement of the tunnel, as well as, the evolution along the years on the positioning.

## METHODS

It was retrospectively analyzed the radiographs of 32 patients submitted to ACL reconstruction surgery by a single senior surgeon (LC) between 2009 and 2015 (these were the first cases performed by the surgeon with

accessory portal for the placement of the femoral tunnel, once the surgeon, in the previous years, performed the transtibial technique). Table 1 described the socio-demographic characteristics of the included sample, comprising 31 males and 1 female with an average age of 27 years and the right leg constituted 21 of the cases (68%). An autograft was used in all the cases and the hamstrings was the graft of choice in 30 cases and bone-patellar-bone graft was used in 2 cases.

**Table 1: Demographic characteristics of the included sample.**

| Variable                     | Sample    | p*    |
|------------------------------|-----------|-------|
| <b>Gender</b>                |           |       |
| Female, n (%)                | 1 (3.1)   | 0.000 |
| Male, n (%)                  | 31 (96.9) |       |
| Age (in years),              | 27.0±8.3  |       |
| Years of the study (min-max) | 2009-2015 |       |
| <b>Lower limb</b>            |           |       |
| Right, n (%)                 | 21 (65.6) | 0.077 |
| Left, n (%)                  | 11 (34.4) |       |

\* Chi square

The criteria assessed was the measurement (in percentage, %) of the center of the tibial tunnel to the

anterior margin of the tibia, in sagittal knee radiographs, according to Rauschnig and Staubli, and the measurement (in millimeters, mm) from the center of the tibial tunnel to the anterior tibial margin as shown in Figure 1.<sup>3</sup> The measurement endpoint goal was determined by a specific interval and not by a specific measurement due to the conflicting data reported in the scientific literature, and the intervals used were: 41-43 % and 21-23 mm.<sup>3-6</sup>

**Statistical analysis**

The statistical analysis was performed using the Statistical Package for Social Sciences version 24.0® (SPSS, Inc., Chicago, Illinois). Categorical variables were expressed as counts and percentages; and continuous variables as mean (± standard deviation) due to gaussian behavior. Also due to normally distributed variables, continuous variables have been compared using one sample t-test, independent t-test or one-way ANOVA, depending on the number of compared groups. The difference or association between categorical variables has been assessed by the Chi-square test or the Fisher's exact test (when criteria for using the chi-square test were not fulfilled). To measure the linear dependence between two variables Pearson's correlation was used. All reported probability values are two-tailed, and p <0.05 have been considered statistically significant.



**Figure 1: Sagittal radiograph of the knee with tibial tunnel placement measurements.**

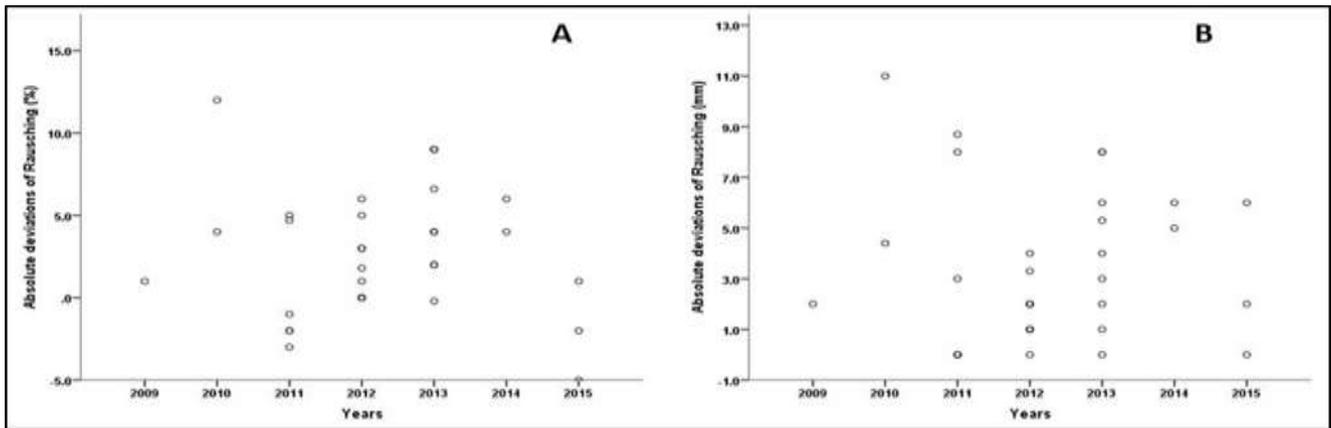
**RESULTS**

There were no significant differences between the number of Rausching results (% and mm), within and without the intervals that were considered acceptable for this measure, throughout 2009 to 2015 as given in Table 2. Table 3 displays the absolute deviations throughout the years of the intended interval limits for Rausching (% and mm) interval. The absolute deviation of Rausching were statistically different in percentage (P =0.01), but not when considered in mm (P =0.198). In this sense, it was found statistical differences in the absolute deviations of

Rausching between the years 2010 and 2012 (P =0.027), 2011 and 2013 (P =0.024), 2012 and 2015 (P =0.025), and 2013 and 2015 (P =0.011). However, no significant differences were found in the absolute deviations of Rausching (%) for the years 2009 and 2010 (P =0.497), 2010 and 2011 (P =0.057), 2011 and 2012 (P =0.222), 2012 and 2013 (P =0.056), 2013 and 2014 (P =0.987) and 2014 and 2015 (P =0.059). In addition, there were significant differences in the Rausching deviations (in % and mm) for the years 2012 and 2013 in relation to the interval limits.

When correlating the Rausching interval and the studied years, no correlation was found between the absolute

deviations of Rausching (%) and the years of experience ( $r = -0.080$ ,  $P = 0.663$ ; as presented in Figure 2.



**Figure 2: Correlation between absolute deviations of Rausching and years. A) Rauching in percentage; B) Rauching in mm.**

**Table 2: Number and percentage of cases of the Rausching interval (% and mm), throughout the years.**

| Rausching (% and mm)                | Year       | Year    |         |         |          |          |         |          | p*    |
|-------------------------------------|------------|---------|---------|---------|----------|----------|---------|----------|-------|
|                                     |            | 2009    | 2010    | 2011    | 2012     | 2013     | 2014    | 2015     |       |
| <b>Within the interval: 41-44%</b>  | No, n (%)  | 1 (100) | 2 (100) | 6 (100) | 6 (66.7) | 9 (100)  | 2 (100) | 3 (100)  | 0.206 |
|                                     | Yes, n (%) | 0 (0)   | 0 (0)   | 0 (0)   | 3 (33.3) | 0 (0)    | 0 (0)   | 0 (0)    |       |
| <b>Within the interval: 21-23mm</b> | No, n (%)  | 1 (100) | 2 (100) | 3 (50)  | 8 (88.9) | 8 (88.9) | 2 (100) | 2 (66.7) | 0.411 |
|                                     | Yes, n (%) | 0 (0)   | 0 (0)   | 3 (50)  | 1 (11.1) | 1 (11.1) | 0 (0)   | 1 (33.3) |       |

\* Chi square

**Table 3: Absolute deviations concerning the intended interval limits for Rausching (% and mm), throughout the years.**

| Absolute deviations Rausching | Year | Year            |                   |                 |                   |                 |                  | p*    |
|-------------------------------|------|-----------------|-------------------|-----------------|-------------------|-----------------|------------------|-------|
|                               |      | 2009 (n=1)      | 2010 (n=2)        | 2011 (n=6)      | 2012 (n=9)        | 2013 (n=9)      | 2014 (n=2)       |       |
| <b>In %, X±SD (p**)</b>       | 1    | 8.0±5.7 (0.295) | 0.28±3.59 (0.855) | 2.2±2.2 (0.018) | 5.04±3.49 (0.003) | 5.0±1.4 (0.126) | -2.0±3.0 (0.368) | 0.010 |
| <b>In mm, X±SD (p**)</b>      | 2    | 7.7±4.7 (0.258) | 3.3±4.1 (0.107)   | 1.8±1.2 (0.002) | 4.1±2.9 (0.003)   | 5.5±0.7 (0.058) | 2.7±3.1 (0.270)  | 0.198 |

\* ANOVA, \*\* t student test for one sample

**Table 4: Number and percentage of cases within the intended interval of Rausching (%), taking into account the lower limb side.**

| Rausching (% and mm)                 |            | Lower limb |           | p*    |
|--------------------------------------|------------|------------|-----------|-------|
|                                      |            | Left       | Right     |       |
| <b>Whithin the interval: 41-44%</b>  | No, n (%)  | 10 (90.9)  | 19 (90.5) | 1.000 |
|                                      | Yes, n (%) | 1 (9.1)    | 2 (9.5)   |       |
| <b>Within the interval: 21-23 mm</b> | No, n (%)  | 10 (90.9)  | 16 (76.2) | 0.637 |
|                                      | Yes, n (%) | 1 (9.1)    | 5 (23.8)  |       |

\* Fisher test

When considering the intended intervals, there were no significant differences between the number of results

within and without the interval 63-66% ( $P = 1.000$ ) and 21-23 mm ( $P = 0.637$ ), taking into account the lower limb

side as seen in Table 4. Moreover, there were no significant differences between the Rausching deviations (% and mm), taking into account the right and left lower limb ( $P = 0.510$  and  $P = 0.781$ , respectively). Significant deviations in each lower limb were found when studied isolated and compared with a non-deviation scenario as shown in Table 5.

**Table 5: Absolute deviations regarding the intended interval limit for Rausching (% and mm), taking into account the lower limb side.**

| Absolute deviations Rausching | Lower limb                     |                                | p*    |
|-------------------------------|--------------------------------|--------------------------------|-------|
|                               | Left                           | Right                          |       |
| <b>In %, X±SD (p**)</b>       | 3.39±3.33<br>(0.007)<br>(n=11) | 2.41±4.23<br>(0.017)<br>(n=21) | 0.510 |
| <b>In mm, X±SD (p**)</b>      | 3.21±2.57<br>(0.002)<br>(n=11) | 3.53±3.28<br>(0.000)<br>(n=21) | 0.781 |

\* t student test for independent samples, \*\* t student test for one sample

## DISCUSSION

One of the key points in surgical perfection is the knowledge of the surgeon's limitations, which can only be identified by performing rigorous studies with strict criteria. Since good clinical results after ACL reconstruction have been reported in literature, it was decided to study the anatomic tunnel placement using knee sagittal radiographs.<sup>7-10</sup> If an anterior positioning in the sagittal plane is performed, an impingement in the intercondylar roof may occur. Similarly, if the positioning is too posterior in the sagittal plane, it may result in loss of knee flexion and higher tear rate.<sup>10,11</sup>

The evaluation of the correct placement of the tunnel is difficult due to the conflicting data reported in the literature since no method is absolutely unanimous in the current "state of the art".<sup>6</sup>

Some interesting data was found when comparing the absolute deviation (%) according non-consecutive years, 2010 and 2012 ( $P = 0.027$ ), 2011 and 2013 ( $P = 0.024$ ), 2012 and 2015 ( $P = 0.025$ ), and 2013 and 2015 ( $P = 0.011$ ). This suggests that the surgeons tunnel position may vary throughout the years and change according his experience or learning curve.

Although it was tried to establish a correlation between the number of years and the absolute deviation (in %), no linear correlation was found. Moreover, no differences were found regarding the limb submitted to surgery, with the results being similar in both limbs.

Some of the limitations must be acknowledge in this study, including a small number of surgeries performed

in each year and concerning also the total sample, as orthopedic surgical skills require both talent and practice. In this study, it was observed significant differences in the absolute deviation (%) throughout non-consecutive years, suggesting variations in the tunnel position. Due to the steep learning curves, it is important to keep track of the surgeon evolution regarding the multiple aspects important for the success of the surgical procedure in order to optimize results. These studies provide the surgeon the opportunity to identify points that need to be improved which ultimately will benefit the surgical outcome of future surgeries.

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