

# Femoral Tunnels in Anatomical ACL Reconstruction: Techniques Inside Out X Outside In

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## Abstract

**Objective:** To observe the accuracy and the advantages and disadvantages of the femoral tunnels made by the two techniques. **Materials and Methods:** We randomly summoned nineteen patients undergoing anatomic ACL reconstruction in a single band technique by the same surgeon: Ten by group II (GII) and nine by Group I (GI). GI: drilling in the technical in-out. GII: drilling the technique out-in. The patients underwent a CT scan with three-dimensional reconstruction of the distal femur. Was applied the technique of quadrants described by Bernard and Hertel and optimized for position by Forsythe and observed in the femoral tunnel: the accuracy of the joint entry; posterior cortical thickness in that point; emergency lateral distance to the lateral epicondyle and the overall length. **Results:** The coordinates of the distances obtained average was very close, with no statistical difference comparable to that obtained by Bernard and Hertel and Forsythe. The distance from the tunnel exit to the lateral epicondyle obtained average 1.46 cm in GI and 0.47 cm in GII, with a significant statistical difference. The thickness of the posterior cortex was 3.9 mm in GI and 5.4 mm in GII, with no statistical difference. The length averaged was 3.07 cm in GI and GII in 2.94 cm, with no statistical difference. **Conclusions:** Both techniques allow well placed tunnels, with no statistical difference. In the technique in-out the tunnel exit is closer to the lateral epicondyle. The thickness of the posterior cortex is similar. The length of the femoral tunnel is similar and around 3 cm.

## Keywords

ACL Reconstruction, Knee, ACL Surgery

## 1. Introduction

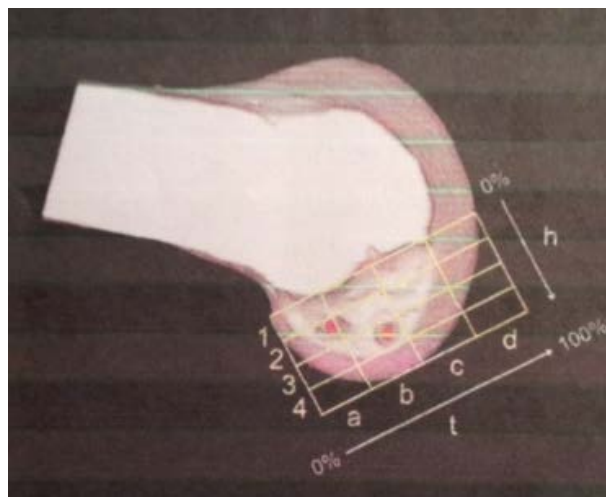
The demand for greater stability and precision in the anterior cruciate ligament (ACL) reconstruction has increasingly used the technique called anatómica [1]-[6]. This technique returns after decades of dominance isometric transtibial technique, which usually results in a higher tunnel entrance and with a more vertical position of the graft in the sagittal and coronal aspects, reducing rotational [7] [8] stability. On the anatomical technique, the femoral tunnel can be made in two main ways: through the anteromedial portal or in the outside-in way (two incisions).

Freddie Fu popularized the anatomic ACL reconstruction with preparation of the femoral tunnel with the drill from the arthroscopic anteromedial portal [9] [10]. Chambat popularized the technique of the femoral drill on from the outside in way, with an additional lateral incision [11].

Bernard and Hertel [12] developed the quadrant method to analyze the profile of the RX tunnel entrance precision in the lateral femoral condyle. Later, Forsythe [13] in cadaver study adapted this method to the study with computed tomography with a three-dimensional reconstruction, as in **Figure 1**. Albuquerque [14] also in an experimental study in cadaver, makes measurements of the thickness of the posterior cortex in the tunnel entrance and the distance from the emergence of the guide wire to the lateral epicondyle, analyzing the safety of tunnels on the possibility of breaking its back wall and injury of the lateral ligaments.

## 2. Objective

To observe the accuracy and the possible advantages and disadvantages of femoral



**Figure 1.** quadrant method: in this case showing the centers of the openings of the femoral tunnels for the anteromedial and posterolateral bundles that is studied in a check-board grid guided along the anterior edge of the c intercondyle roof. t = line parallel to the Blumensaat line and h = line perpendicular to the Blumensaat line. The square limits are the cortical ends of the lateral femoral condyle.

tunnels made by the two techniques, with reference to the work of the above authors.

### 3. Materials and Methods

Were randomly summoned nineteen patients undergoing anatomic ACL reconstruction in a single band technique by the same surgeon made for at least 2 years, ten by the technique of the group I and nine by the group II. After completing the consent form, patients underwent computed tomography with three-dimensional reconstruction of the distal femur.

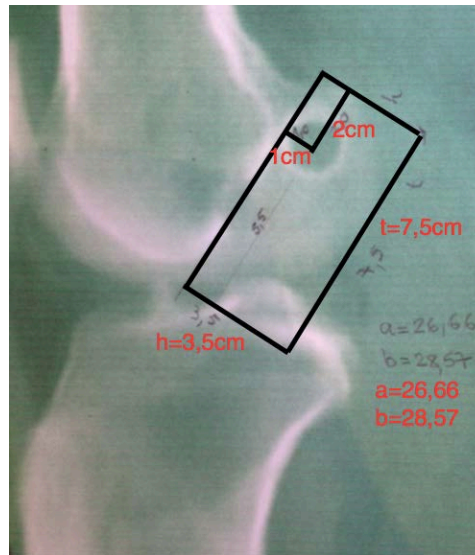
Group I: with optics in traditional anterolateral portal a long anesthesia needle was something more inferior and medial than the traditional anteromedial portal, near the medial meniscus and the medial femoral condyle for a good angle of attack to the anatomical point of insertion anteromedial bundle ACL. Then the portal was made and the arthroscopy started. After the treatment of chondral and meniscal injuries associated when necessary, with an ACL Linvatec 7 mm offset femoral guide and 110 degrees of knee flexion was introduced a guide wire on the anatomical point [9]. Then, with the appropriate drill bit to graft size was made an anatomical femoral tunnel until its output on the cortical femoral side.

Group II: it was made a traditional anteromedial portal slightly increased in size to fit the guide. After treatment of the lesions associated with the use of a MDT out-in guide inserted through the anteromedial portal pattern, with the knee flexed to 90 degrees, the guide wire was passed. After removal of the guide wire was checked its position by optics on the anteromedial portal. After observing proper position was made an initial tunnel with drill 6 mm. With the camera still in the anteromedial portal were past the drills on until the desired size looking to leave the best possible fit according to Chambat [11] technical parameters.

On the CT images the following references were measures and analyzed: was obtained with the tomography image manipulation an oblique sagittal profile where could be seen the medial wall of the lateral femoral condyle (perpendicular to the medial-lateral femoral shaft). It was then drawn and applied to the method of quadrants as described by Bertrand & Hertel [12] and refined to Forsythe and cols [13] for tomography. A tangential line to Blumensaat line and its intersection with the proximal and distal cortical lateral femoral condyle was drawn. On these two points were drawn perpendiculars lines in the posterior and distal direction to its intersection with a line parallel to the starting line that touches the rearmost part of the cortex of the lateral femoral condyle, closing the square (Figure 1).

1) For the Blumensaat line, the central point of the beginning of the femoral tunnel was measured as percentage the t distance, nominated a (Figure 2).

2) The same image, even above the point collected was measured as a percentage of the distance h nominated b (Figure 2).



**Figure 2.** Parameter measurements.  $a = (2.0/7.5) \times 100 = 26.66\%$ ;  $b = (1.0/3.5) \times 100 = 28.57$ .

3) On the axial view, was measured the distance between the lower edge of the emergence of the femoral tunnel in the lateral wall of the lateral femoral condyle to the lateral epicondyle.

4) On the oblique sagittal section was measured the thickness of the posterior cortex in the joint entrance of the lateral femoral tunnel.

5) On the coronal section was measured the size of the femoral tunnel until its emergence in the lateral wall of the lateral femoral condyle.

The statistical t test was applied, considering statistically significant P less than or equal to 0.05.

#### 4. Results

The results are shown in **Table 1**.

**Table 1.** (a) Group I; (b) Group II.

(a)

Age	Sex	Side	sport	Surgery	%t (a)	%h (b)	Distance to the lateral epicondile	Posterior cortical	Tunnel Size	
37	M	Right	soccer	ACL reconstruction	22.91	27.8	1.37	0.29	3.05	In-out
31	F	Left	Volleyball	ACL reconstruction	24.54	34.35	1.89	0.15	3.41	In-out
36	M	left	soccer	ACL reconstruction	26.82	39.38	2.42	0.23	2.61	In-out
40	F	left	Volleyball	ACL reconstruction	26.68	35.39	1.28	0.36	2.9	In-out
38	M	left	soccer	ACL reconstruction	23.28	40.62	0.81	0.4	2.36	In-out
55	M	right	soccer	ACL reconstruction	25	25	1.22	0.63	3.1	In-out
33	M	right	motocycle fall	ACL, Med. Meniscal suture	33.33	21.21	2.55	0.44	3.36	In-out

## Continued

53	M	right	soccer	ACL reconstruction	22.3	32.14	0.6	0.43	3	In-out
28	M	right	soccer	ACL, Partial meniscectomy	25	38.46	1.65	0.57	3.64	In-out
22	M	right	soccer	ACL reconstruction	23.21	34.48	0.85	0.43	3.24	In-out
37.3					25.307	32.883	1.464	0.393	3.067	Average
					3.207862043	6.402709583	0.663562774	0.145223965	0.38067338	Side D.

(b)

Age	Sex	Side	sport	Surgery	%t (a)	%h (b)	Distance to the lateral epicondile	Posterior cortical	Tunnel Size	
55	M	right	soccer	ACL reconstruction	19.95	39.9	0.97	0.4	2.44	Out-In
39	M	left	karate	ACL reconstruction	36.02	33.02	0.58	0.72	2.89	Out-In
27	M	left	soccer	ACL, med. meniscus suture	31.36	38.93	0.8	0.85	2.79	Out-In
39	M	right	soccer	ACL, parcial med. meniscectomy	18.18	6	0.48	0.21	3	Out-In
26	M	right	soccer	ACL reconstruction	26.66	28.57	0.33	0.69	3.5	Out-In
13	F	left	soccer	ACL reconstruction	24.28	37.5	0	0.65	2.97	Out-In
28	F	right	judo	ACL reconstruction	25.97	23.68	0.2	0.64	2.71	Out-In
21	M	right	soccer	ACL, parcial lat. meniscectomy	14.5	29	0.58	0.14	3	Out-In
21	M	Left	soccer	ACL reconstruction	23.81	30.36	0.31	0.58	3.2	Out-In
29.88888889					24.52555556	29.66222222	0.47222222	0.54222222	2.94444444	Average
					6.593178503	10.3755443	0.300448738	0.240612644	0.752704952	Side D.
					0.752704952	0.435972572	0.000948868	0.130628665	0.444123529	t test

## 5. Discussion

The distance was very close to average in the 2 groups, respectively 25.3% and 24.5%, with no significant difference. However, there was a higher standard deviation in group II showing greater uniformity in I group. This may be due to the fact that the group I the tunnel was made starting at inside and in outside in group 2 and the emergence usually is less accurate. Also, the progressive extension of the tunnel was done in this case guided by direct visualization, with a guide wire in an even larger tunnel, which increases the possibility of variability.

The same was found in the distance b, with averages of 32.6% and 29.6% and higher standard deviation in group II, with no statistical difference by applying the same observations above.

Group 1 approached more with the results obtained for Forsythe [13], which was originally made for the two bands ACL but in the case of single band, the reconstruction is considered rebuilding the anteromedial ACL bundle. Forsythe results to the distance a was an average of 21.7%, ranging from 18.9% to 25.7% in experimental environment and going straight in the insertion of still intact

ACL in his original trial. Our means were a little bit anterior (25.3% and 23.8%), but outside of the experimental variation range of Forsythe was only 1 case of the group 1 and 2 cases of group II.

Regarding the distance b, Forsythe found average of 33.2% and range from 24.4% to 42.1%. We also obtained very similar averages (32.8% and 29.6%) and out of your range we had one case in group 1 and 2 patients in group II.

Compared with the studies of Bernard and Hertel [12], the distance is still very similar because they found an average of 24.8%. The distance b is a little less similar, they obtained 28.5%.

In the distance from the tunnel exit to the lateral epicondyle, we obtained average 1.46cm in the group 1 and 0.47 cm in group II, with very significant difference. Although in only one case there was contact between the edge of the femoral tunnel to the lateral epicondyle without prejudice to the ligaments, we think that in the group II the ligaments and knee stabilization structures attached to the lateral epicondyle are at an increased risk.

The thickness of the posterior cortex showed average of 3.9 mm in the group I and 5.4 mm in group II, with no statistical difference. This thickness is greater than the desired 2 mm expected in the isometric technique, which were obtained by Albuquerque [14], with the out-in width greater. This may be due to different guide angle on the femoral anatomical reconstruction in-out, taking the condyle in less precise fit posterior area. In the out-in there is a reversal of the drilling direction, which does not leave the tunnel to closer to the posterior cortex, in addition to final adjustment be under direct vision and without a guide, which makes the parameter of the posterior cortex less priority. Another variable is measured by tomography, which can bring less precision in measuring the exiting point of the tunnel in the posterior cortex, unlike Albuquerque [14] that made directly on anatomical specimens dissected with a caliper rule.

In the group II, the greater thickness of the posterior cortex and the screw placed inwardly theoretically tolerate higher interference screws of diameters with less danger of breaking up the walls. In fact in our cases in Group I, was used absorbable interference screw thick on average 2 mm below the tunnel diameter and II group of 1 mm above the tunnel diameter. The use of larger diameter screws beyond the tunnel entrance angle to the ACL reconstructed be higher in group II should lead to a lower chance of graft loosening after surgery.

The size of the femoral tunnel averaged 3.07 cm in group 1 and 2.94 cm in group II, nearly equal, with no statistical difference, but with higher standard deviation in group II. Greater than 25 mm interference screws protrude may be internal or external, may primarily in the II group, cause friction on the external structures such as the lateral collateral ligament, for example. The type fastening systems with tie buttons which require some free tunnel space for the system, grafting may not leave enough for successful integration because of lack of long tunnel, and in group II, can cause the same type of the lateral ligaments friction, as mentioned above.

## 6. Conclusions

1) The two techniques allow well-placed tunnels, with no statistical differences, but with greater variability in out-in technique.

2) In the technique out-in the tunnel entrance is closest to the lateral epicondyle, exposing more to injury the structures located in that region.

3) The thickness of the posterior cortex is something greater in the out-in technique which, combined with the fixing from outside to inside, allows greater security to not break the tunnel in the use of interference screws.

4) The length of the femoral tunnel is similarly obtained and about 3 cm, making it less desirable to use interference screws larger than 25 mm and limiting the use of other fastening systems.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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