Comparison of Clinical Results of Anteromedial and Transtibial Femoral Tunnel Drilling in ACL Reconstruction

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Abstract

Background: This study compares long term results of femoral tunnel drilling between anteromedial (AM) and transtibial (TT) techniques in reconstruction of anterior cruciate ligament (ACL). Methods: 300 patients with ACL reconstructions were chosen to this study from previously collected data of ACL reconstructions.They were divided into two groups: 150 patients with AM and 150 with TT drilling. In the AM group the reconstructions were performed using semitendinosus graft with Tape Locking Screw (TLS™) technique (n=87) or Retrobutton™ femoral and BioScrew™ tibial fixation with a semitendinosus-gracilis graft (n=63). In the TT group the fixation method used was Rigidfix™ femoral and Intrafix tibial fixation with a semitendinosus-gracilis graft. The evaluation methods were clinical examination, knee scores (Lysholm, Tegner, IKDC) and instrumented laxity measurements (KT-2000™). Our aim was to evaluate if there is a better rotational stability and therefore better clinical resultswhen using AM drilling compared to TT drilling. Results: Revision procedures were excluded from the study. There were 132 patients in the AM group and 133 in the TT group for evaluation. In the two year follow-up there were 60 patients in the AM group (45,5 %) and 58 in the TT group (43,6 %). There were no statistically significant differences found between the groups. Conclusion: Both drilling techniques resulted in improved patient performance and patient satisfaction. We found no data supporting the hypothesis that AM drilling technique provides better rotational stability to the knee. Trial registration: ISRCTN registry with study ID ISRCTN16407730.

Keywords: Anterior cruciate ligament reconstruction; clinicaloutcome; anteromedial; transtibial

1. Background

Arthroscopic assisted ACL reconstruction has become a standard procedure to control anterior-posterior and rotational stability after ACL injury. In Finland there were 3100 ACL reconstructions in 2013, incidence of 57 per 100,000 person-years [1].

TT technique has been used in ACL reconstruction for decades [2, 3]. The risk of blow-out fractures of the posterior cortex of femur is minimal. Griffin et al and Fu et al have presented good and excellent results in 80-95 % of cases [4, 5]. Regardless of these good results there is criticism about this technique. The question is, can TT technique target the original ACL femoral insertion. Unanatomically positioned graft worsens the function of the knee [6, 7].

Different fixation methods and approaches have been developed to create the bony tunnels. There are two commonly used drilling techniques for the femoral tunnel. In transtibial drilling technique the tibial tunnel is drilled first. A drill guide is used and positioned intra-articularly at the tibial ACL footprint and the second quadrant anterior to posterior is targeted. Femoral tunnel is drilled through the tibial tunnel and aimed at the posterior fourth quadrant of the femoral condyle in the sagittal plane and 10:30-o´clock position in the right and 1:30-o´clock position in the left knee in the frontal plane. Anteromedial drilling is done from a low anteromedial portal and it has been said to provide better rotational stability to the knee, by creating a more oblique femoral tunnel positioning [8]. This drilling technique is thought to mimic the anatomical femoral insertion of the anterior cruciate ligament better.

A survey done in 2010 among the members of the American Orthopaedic Society for Sports Medicine disclosed that 70-85% use TT technique of drilling the femoral tunnel through the tibial tunnel [9, 10].

In this study some patients were athletes, some were participating in recreational sports, also middle aged physically active citizens were included in our study. 26% of injuries were not connected with any sport. Most sports related injuries in this study took place in downhill skiing (21.3%), indoor ballgames (19%), and football (16.3%). Median age of the patients was 34 years (12-64 years). No statistical difference in the activity level of the patients was found.

The purpose of this study was to find out if there are differences in clinical results after an ACL reconstruction performed by anteromedial drilling or transtibial drilling technique. Our hypothesis was that anteromedial drilling technique gives better rotational stability and clinical results because the graft placement is more anatomical.

2. Methods

Patients

300 patients with anterior cruciate ligament injuries were treated with an arthroscopic reconstruction of ACL. Sixty of the patients were from a previous RCT comparing fixation methods [11].

The patients were 12 to 64 years in the AM group (mean 35 years) and 13 to 59 years in TT group (mean 34 years). Median time from the injury to surgery was 2 months in the AM group (1 to 42 months) and 3,5 months in the TT group (1 to 366 months). With respect to gender ($p = 0.2$) there was no difference between the two groups.

Patients for this study were chosen retrospectively. We picked 300 consecutive ACL reconstruction patients from our database at Orton Orthopaedic Hospital, Helsinki Finland. The reconstructions took place from January 2006 to August 2011. At first we used TT drilling technique, and after a change in practice of the clinic, AM drilling technique was used. According to the drilling technique the patients were divided into two groups: 150 ACL reconstructions using AM and 150 reconstructions using TT drilling technique. Side-to-side laxity measurements were excluded from the patients who had a bilateral ACL tear, whether operated or not. Revision ACL reconstruction was performed in 18 patients in the AM group and in 17 in the TT group. These patients were excluded from the final evaluation, leaving 132 patients in the AM group and 133 patients in the TT group. Ninety patients (68,2 %) in the AM group and 86 (64,7 %) patients in the TT group attended the one year follow-up. In the two year follow-up there were 60 (45,5 %) and 58 (43,6 %) patients, respectively.

Surgery

In the AM group the reconstructions were done using either TLS™ technique and a semitendinosus graft (n=87) or Retrobutton™ in femoral tunnel and BioScrew™ in tibial tunnel with a semitendinosus-gracilis graft (n=63). In the TT group the fixation method used was Rigidfix™ in femoral tunnel and Intrafix™ in tibial tunnel. The graft used was a semitendinosus-gracilis graft. The two different fixation methods in the AM group were not compared between each other. All the reconstructions were performed by two experienced orthopedic surgeons (AH, JS).

Postoperative care

Postoperative care was identical in both groups. Immediate mobilization was allowed and no knee braces were used. Partial weight bearing was allowed immediately and full weight bearing at 2 weeks. Light motion including exercise bicycle was allowed at 3 weeks. At 6 weeks active knee extension, deep-water running, proprioceptive exercises and weight training started with physiotherapists. At 3 months jumping and jogging was allowed and actively trained. From 6 to 12 months after surgery a gradual return to sports was allowed. After 1 year there were no restrictions.

Evaluation methods

To evaluate the results the subjective International Knee Documentation Committee (IKDC) score (0-100), Lysholm knee score (0-100) and Tegner activity level (0-10) were used. The clinical tests were Lachman test and the anterior drawer test to determine anterior laxity, and pivot shift to determine rotatory stability. Lachman, anterior drawer test and pivot shift were graded negative, slightly positive, and clearly positive. The anterior-posterior laxity was measured (side-to-side difference with manual maximum force; KT-2000 arthrometer, MEDmetric Corporation, San Diego California) comparing the injured knee to the control one. These tests and scores were collected before the operation and during the 1- and 2-year follow-ups. Patients also evaluated their activity level before the trauma (Tegner).

TLS™ reconstruction technique was described by Collette and Cassard [12]. Normally it is sufficient to use only semitendinosus tendon as a graft. 10-15 mm deep bone sockets are made with a hand-powered retrodrill through a 4,5 mm drill tunnel transtibially and from outside to inside transfemorally in to the intra-articular space of the knee. Bone sockets are created doing 360 degree turns pulling the retrodrill outwards. The graft is pulled inside the knee, the tapes slipped through the tunnels and the graft is pulled to the right tension. A 10 mm titanium screw is inserted to lock the tapes, the length of the screw is 20 mm in femur and 25 mm in tibia.

When using Retrobutton™, the tunnel diameter is the same as the graft. Retrobutton™ loop and implant are attached to the graft and the graft-implant complex is pulled in to the femoral tunnel. The Retrobutton™ plate is flipped outside the femoral cortex and the graft is tightened and followed with the tibial fixation by BioScrew™ of 30 mm. The diameter of the screw is equal to the graft. The screw is inserted eccentrically compressing the graft against the bony tunnel wall.

The graft in Rigidfix^{TM} fixation is constructed according to the manufacturer´s instruction with whipstiches of No. 1 Vicryl (Ethicon Inc, Johnson et Johnson, Somerville, New Jersey) to join the doubled limbs of the semitendinosus and gracilis tendons together. Using drill guides, the depth of the transtibially drilled femoral tunnel is 30 – 40 mm. With Rigidfix^{TM} instrumentation, 2 transverse drill tunnels are drilled for the fixation devices. After the graft is passed in to the femoral tunnel, 2 Rigidfix^{TM} implants are tapped through the drill guide sleeves transfixing the graft. For the Intrafix^{TM} tibial fixation, No. 1 absorbable whipstitch in the graft ends is used, and the graft is spread in to 4 quadrants between the sleeve and the drill tunnel. After cycling the knee 10 to 15 times, the graft is tightened, and the expansion sleeve and the screw are introduced concentrically to compress the 4 limbs between the bony tunnel and the device. Three different screw sizes are used: graft size up to 8 mm a 6-8 mm screw is used (7-9 mm screw if the bone quality is suboptimal), and in a graft larger than 8 mm a 8-10 mm screw is used.

Statistical analysis

Statistical analysis was done using the BMDP Statistical Package (Statistical Solutions Ltd, Cork, Ireland). The non-parametric data was evaluated with Chi-square (between the groups). Continuous data was evaluated using two-group and paired t tests. The minimum level of significance was P=.05.

The descriptive statistics are presented as means with standard deviation (SD) or counts with percentages. The AM and TT groups were compared preoperatively with the t test for continuous variables, and Pearson's chi-square test for categorical variables. Repeated measures of the changes in outcomes (Tegner, Lysholm, IKDC scores, side-to side laxity difference evaluation) were compared between groups with mixed-effects models and an unstructured covariance structure (i.e., the Kenward-Roger method for calculating the degrees of freedom). Fixed effects included the group, the time, and group ´ time interactions. We used age, sex and baseline values as covariates. The repeated measurements were taken at different time points, 1 and 2 years. Mixed models allowed analyses of unbalanced datasets without imputation; therefore, we analyzed all available data with the full analysis set. Repeated measures of the pivot shift test were compared between groups with random-effects logit model. Model included age, sex as covariates. A bootstrap method was used when the theoretical distribution of the test statistics was unknown or in the case of a violation of the assumptions (e.g. non-normality). Hommel’s adjustment will be applied to correct levels of significance for multiple testing. Normal distributions were evaluated graphically and with the Shapiro–Wilk W test. All analyses were performed with Stata 16.1 (StataCorp LP; College Station, TX, USA).

3. Results

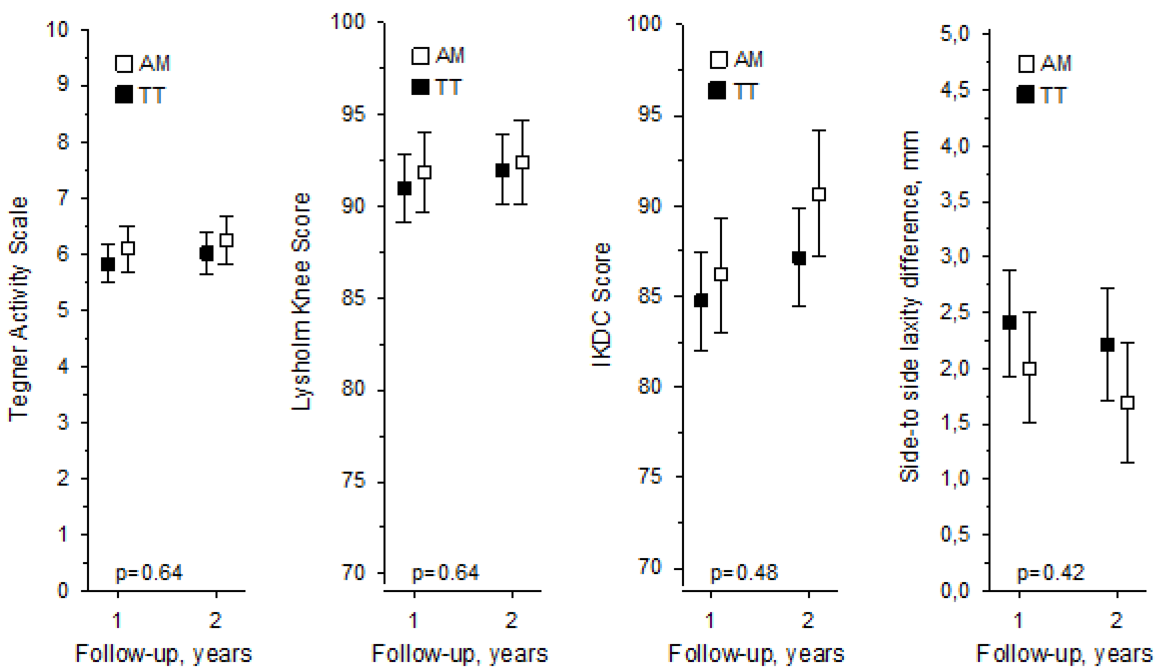
Patients answered questionnaires preoperatively and at 1- and 2- year follow-ups. Improvement was seen in the following tests: Tegner activity level from preoperative 2 in the AM group and 3 in the TT group to 6 at 2-year follow-up. Lysholm preoperative score from 73 in the AM group and 76 in the TT group to over 90 points in both groups. IKDC scores improved in both groups between 1- and 2- year follow-ups. (Tables 1 and 2) No statistically significant differences between the groups were found.

With the KT-2000 laxity measurements there was a 5,25 mm preoperative difference compared to the non injured knee in both groups. In 2- year follow-up this difference diminished to 1.7 - 2.2 mm. (Tables 1 and 2)

Table 1. Tegner, Lysholm, IKDC scores and side-to side laxity difference evaluation preoperatively before ACL reconstruction with AM and TT techniques

	AM	TT	P-value
Tegner Activity Scale, mean (SD)	2(1.4)	3(1.7)	0.015
Lysholm Knee Score, mean (SD)	73(16.6)	76(14.4)	0.1
IKDC Score, mean (SD)	55(15.9)	59(14.4)	0.1
Side-to side laxity difference, mm, mean (SD)	5.3(2.6)	5.2(3.0)	0.9

Table 2. Tegner, Lysholm, IKDC scores and side-to side laxity difference evaluation 1- and 2- years after ACL reconstruction with AM and TT techniques. The values were adjusted for age, sex and baseline values. The whiskers represent a 95% confidence interval. Hommel's adjustment will be applied to correct levels of significance for multiple testing.



In IKDC classification (A to D) the distribution of classes was equal between the two groups in one and two year follow-ups. No statistical differences were found. (Table 3)

Table 3. IKDC classifications 1- and 2- years postoperatively (Chi-square) after ACL reconstruction with AM and TT techniques.

	A	B	C	D	P-value
1 year follow-up					
AM	41	43	3	1	
TT	48	32	4	0	0.3
2 years follow-up					
AM	36	19	5	0	
TT	43	12	3	0	0.2

Lachman test showed more laxity in the AM group in one year follow-up, however without a statistical difference. At two year follow-up, this difference had disappeared. (Table 4)

Table 4. Clinical stability (Lachman) evaluation 1- and 2- years postoperatively (Chi-square), after ACL reconstruction with AM and TT techniques.

Lachman	-	+	++	P-value
1 year follow-up				
AM	68	19	2	
TT	76	9	1	0.1
2 years follow-up				
AM	47	8	4	
TT	51	6	1	0.3

Pivot shift test revealed no differences between the two groups, one or two years postoperatively. (Table 5)

Table 5. Pivot shift evaluation 1- and 2- years postoperatively (Chi-square) after ACL reconstruction with AM and TT techniques.

Pivot shift	-	+	++	P-value
1 year follow-up				
AM	83	5	1	
TT	82	3	1	0.7
2 years follow-up				
AM	51	4	4	
TT	56	1	1	0.1

The follow-up time of our study was two years. Originally we had 132 patients in the AM group and 133 patients in the TT group. Attendance has been poor; at one year follow-up there were 68,2% in the AM group and 64,7% of the patients in the TT group. At the two year follow-up attendance was 45,5% in the AM and 43,6% in the TT group. All our patients were approached with letters and given at least two different consultation times. The reasons for not attending were not given.

4. Discussion

In active football players there has been a statistically significant difference in favor of the AM technique. This is thought to result from a more anatomical insertion of the graft in femoral side. In the one and two years follow-up there were significantly better results in Lachman test and KT-2000™ arthrometer results in the AM group, although this difference was lost in the three to five and six to ten years of follow-up [13].

Kopf et al have suggested that a graft placed too superiorly in the femoral lateral wall does not provide as good a rotational stability of the knee as a more horizontally placed graft insertion does [14]. This rotational instability may lead to premature knee arthrosis. The main factor in developing arthrosis of the knee seems to be anterior laxity. Removal of the medial meniscus is considered even more harmful in anterior cruciate laxity since it can increase the anterior subluxation of the tibia. The laxity of the ACL causes wear in the posterior and medial part of the tibial cartilage. If the hamstring muscles are weak, they cannot oppose the subluxation occurring from the action of the quadriceps muscle [15]. For the ACL graft to be placed anatomically in the femur, anteromedial drilling is thought to be the best option [16]. Also, by moving the tibial tunnel medially and proximally closer to the joint line, it is possible to make the tibial tunnel more horizontal and through this the femoral tunnel can be drilled closer to the ACL´s anatomical insertion site [17]. Chhabra et al found similar results in their study [18]. Assessing the rotational instability of the knee the placement of the graft is considered to be of great value. The more horizontal graft placement seems to result in a more stable knee in cadaveric specimens [19].

Chang et al have showed in their cadaver study, that the horizontally and anteromedially drilled femoral tunnel is clearly shorter in the lateral femoral condyle than a tunnel drilled transtibially. This must be taken into account when making a decision for femoral fixation method. It is possible that using the cross-pin femoral fixation the cross-pin may bypass the femoral tunnel or be situated only partly inside the bone which weakens the grafts attachment to the bony tunnel and the tensile strength of the graft [20]. These same conclusions were found in the study of Bedi et al [21]. In this study AM drilling resulted in a more stable knee using anterior drawer, Lachman, and Pivot Shift tests [21].

Based on cadaver studies it seems that in ACL reconstruction a more horizontally placed graft provides more stability and eliminates more efficiently rotational instability of the knee. However, TT technique has been used with good results for many decades [2, 19, 22, 23]. Cheng et al discovered that AM technique provided better outcomes in Lachman and Pivot Shift test, IKDC and Lysholm scores [23].

In a recent study analyzing the results from the Danish Knee Ligament Reconstruction Register Rahr-Wagner et al. found an increased risk of revision when AM technique was used for creating the femoral tunnel compared with the TT technique. One plausible explanation according to the authors is that AM technique is newer and more complex procedure leading to more technical failures and thus a higher revision rate compared with the TT technique [24].

Rotational instability can potentiate the risk of re-rupture of the ACL. Pivot shift is a clinical test for this instability. In our study, pivot shift was slightly positive or positive in 8 cases of the AM group (13,6%) and in 2 cases of the TT group (3,5%) in 2-year follow-up. There was no statistical difference ($p = 0,1$).

In our previous study statistical difference has not been found between these two drilling methods, although the intent was to compare different fixation methods [11]. Patients with high demand, such as top league football players, had better results when using more anatomic insertion site in the femur (anteromedial drilling) and thus it may be the method of choice in top athletes when uncompromised rotational stability is needed [9]. Our results, nevertheless, suggest that best clinical results are achieved when operated with the method known and handled properly.

5. Conclusions

In contrast to existing studies there was no evidence of one or the other of the femoral tunnel drilling techniques being better in controlling rotational instability of the knee after ACL reconstruction. Both drilling techniques resulted in improved patient performance and patient satisfaction.

6. Abbreviations

ACL. Anterior cruciate ligament.

TT. Transtibial.

AM. Anteromedial.

IKDC. International Knee Documentation Committee.

TLS. Tape locking screw.

SSD. Side-to-side laxity difference.

7. Declarations

Ethics approval and consent to participate. The Hospital District of Helsinki and Uusimaa Operative Ethics Committee considers the research plan ethically acceptable (HUS / 364/13/03/02/2015).

Informed written consent was obtained from all the participants.

Consent for publication. Not applicable.

Availability of data and materials. The data supporting the results reported in this article is kept and stored in ORTON Orthopaedic Hospital, Helsinki, Finland.

Competing interests. We have no competing interests.

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Authors' contributions. Authors K-MN and LM have equal contribution in processing the data and writing this article. AH and JS performed the surgeries and were the originators of this study. They also participated in the writing process. VB was involved in co-ordination of the study as well as in the writing of this article. All authors have read and approved the final manuscript.

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