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 two femoral bone tunnels in anterior cruciate ligament (ACL) reconstruction. The femoral tunnel can be drilled transtibially (TT) or through an anteromedial portal (AM).

Methods: 300 patients with ACL reconstructions were chosen for this study. They were divided into two groups: 150 patients with anteromedial drilling (AM) and 150 with transtibial (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. 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 results when using AM drilling.

Results: In the AM group there were 18 and in the TT group 17 revision procedures which were excluded from the study, leaving 132 patients in the AM group and 133 in the TT group for evaluation. In the one year follow-up there were 90 patients (68,2 %) in the AM group and 86 patients (64,7 %) in the TT group. In the two year follow-up there were 60 (45,5 %) and 58 (43,6 %) patients, respectively. The Tegner activity level was consistently higher in the TT group from preoperatively to two year follow-up postoperatively ($p < 0.05$). The IKDC score was better at two year follow-up in the TT group ($p < 0.05$). Statistical analysis was done using the BMDP Statistical Package (Statistical Solutions Ltd, Cork, Ireland).

Conclusion: There was a statistically significant difference in IKDC score at two year follow-up, in favor of the TT drilling group compared with the AM group ($p < 0.05$). No other differences were found between these groups. Both drilling techniques resulted in improved patient performance and patient satisfaction. Also, we found no data supporting the hypothesis that AM drilling technique provides better rotational stability to the knee. Trial registration: ISRCTN16407730 Keywords: Anterior cruciate ligament reconstruction; clinical outcome; anteromedial; transtibial

1. Background

Arthroscopic assisted ACL reconstruction has become a standard procedure to control anterior-posterior and rotational stability after ACL injury. In 2006 in the United States, ACL reconstruction procedure was performed on 129,836 patients. When corrected for population the number of operations was 43 per 100,000 person-years. The incidence of ACL reconstruction is increasing especially in females and in persons younger than 20 and older than 40 years [1]. In Swedish studies based on national registers indicate an ACL reconstruction incidence of 80 per 100,000 person-years [2]. In Finland there were 3100 ACL reconstructions in 2013, incidence of 57 per 100,000 person-years [3].

Different fixation methods have been developed and different approaches to create the bone tunnels. There are two commonly used drilling techniques for the femoral tunnel. In the 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 in to the posterior fourth quadrant of the femoral condyle in the sagittal plane and in to 10:30-o´clock position in the right and 1:30-o´clock position in the left knee in the frontal plane. The anteromedial drilling is done from low anteromedial portal and it has been said to provide better rotational stability to the knee, by creating a more oblique femoral tunnel positioning [4]. This drilling technique is thought to mimic better the anatomical femoral insertion of the anterior cruciate ligament.

A survey done in 2010 among the members of the American Orthopaedic Society for Sports Medicine disclosed that 70–85% use the TT technique of drilling the femoral tunnel through the tibial tunnel [5, 6].

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

2. Methods

For this study we chose retrospectively 300 consecutive patients admitted to Orton Hospital, Helsinki Finland. The reconstructions took place from January 2006 to August 2011. According to the drilling technique they were divided into two groups: 150 ACL reconstructions using AM and 150 reconstructions using TT drilling technique. In the AM group the reconstructions were done using either TLS™ technique and semitendinosus graft (n = 87) or Retrobutton™ in femoral tunnel and BioScrew™ in tibial tunnel with 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 semitendinosus-gracilis graft.

Mean age of the patients was 34 years (12–64 years), 12 to 64 years in the AM group (mean age 35 years) and 13 to 59 years in TT group (mean age 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).

Side-to-side laxity measurements were excluded from the patients who had bilateral ACL tear whether operated or not in the contralateral knee, because of comparison of the operated knee to the control knee would have distorted the results. 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 took part in one year follow-up. In the two year follow-up the corresponding numbers and percentages were 60 (45,5%) and 58 (43,6%), respectively.

All the reconstructions were performed by two experienced orthopedic surgeons (AH, JS) performing both AM and TT techniques.

Postoperative care was identical in both groups. Immediate mobilization was allowed, no knee braces were used. Partial weight bearing was allowed immediately and full weight bearing, as tolerated 2 weeks postoperatively. Exercise bicycling and other light motion was allowed at 3 weeks. At 6 weeks active knee extension, deep-water running, proprioceptive exercises and weight training was begun in physiotherapeutic guidance. 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 no restrictions were recommended.

To evaluate the results we used the subjective International Knee Documentation Committee (IKDC) score (0-100), Lysholm knee score (0-100), Tegner activity level (0–10) and the Kujala patello-femoral score (KPS 0-100). As clinical tests we used the Lachman test and the anterior drawer test to determine anterior laxity, and pivot shift to determine rotatory instability. 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) and the injured knee was compared to the control one. These tests and scores were collected before the operation and during the 1- and 2-years follow-ups. Patients also evaluated their activity level before the trauma (Tegner).

TLS™ reconstruction technique was described by Collette and Cassard [7]. Normally it is sufficient to use only semitendinosus tendon as a graft. In the TLS™ workstation the tendon was prepared to form a four-fold short graft (50–55 mm), a 7 mm wide polyethylene terephthalate tape was pulled through both ends of the graft. With this tape a preloading of 500N for 2 minutes was performed in the same workstation.

The graft was introduced as anatomically and isometrically as possible in to the bone sockets in femur and tibia. 10–15 mm deep bone sockets were made with a hand-powered retrodrill, which was introduced 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 were created doing 360 degree turns slowly while gently pulling the retrodrill outwards. The graft was then pulled inside the knee, the tapes were slipped through the drill tunnels and with the tapes the graft was pulled to the right tension. A 10 mm titanium screw was inserted to lock the tapes only not touching the graft itself, the length of the screw was 20 mm in femur and 25 mm in tibia.

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

The graft in Rigidfix™ fixation was 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. Drill guides were used, and the depth of the transtibially drilled femoral tunnel was 30 mm to 40 mm. With Rigidfix^{TM} instrumentation, 2 transverse drill tunnels were drilled to receive the fixation devices. After the graft was passed in to the drill tunnel by pulling it with No. 2 Vicryl loop left in the graft end, 2 Rigidfix^{TM} implants were tapped through the drill guide sleeves transfixing the graft and advanced to the bone medial to the drill tunnel. For the Intrafix^{TM} tibial fixation, No. 1 absorbable whipstitch in the graft ends was used, and the graft was spread in to 4 quadrants between the sleeve and the drill tunnel. After cycling the knee 10 to 15 times, the graft was tightened, and the expansion sleeve and the screw were introduced concentrically by which the 4 limbs of the graft could be compressed between the bony tunnel and the device. Three different screw sizes were used: if the graft size was less than or equal to 8 mm, the 6 mm to 8 mm screw was used (7 mm to 9 mm screw if the bone quality was suboptimal), and if the graft was larger than 8 mm, the 8 mm to 10 mm screw was used.

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 $P = .05$.

3. Results

With respect to age ($p = 0.904$) or gender ($p = 0.280$) there was no difference between the two groups. A lateral meniscal procedure was performed on 4 patients in the AM group and none in the TT group ($p = 0.043$), a medial meniscal procedure on 1 patient in the AM group and 2 patients in the TT group ($p=0.254$). Unexpectedly, there was a slightly higher Tegner activity level in TT group before the surgery and the same tendency was seen in one and two year follow-up results. The IKDC score was higher in one year follow-up in the TT group, but there was no statistical difference ($p = 0.5800$). In two year follow-up IKDC score was higher in the TT group with a statistically significant difference ($p = 0.0424$). There was no statistical difference between the groups according to the Lysholm score. (Table 1)

Table 1. Tegner, Lysholm and IKDC scores (mean and range) preoperatively, at 1 and 2 years follow-up.

	AM	TT	P-value
Tegner pre trauma	6 (3-10)	7 (2-10)	0.4445
Tegner preoper	3 (0-6)	3 (0-8)	0.0151
Tegner 1y follow-up	6 (1-10)	6 (0-10)	0.0382
Tegner 2y follow-up	6 (2-10)	7 (2-10)	0.0565
Lysholm preoper.	75 (20-100)	78.5 (22-100)	0.1498
Lysholm 1y follow-up	94 (41-100)	95 (37-100)	0.2754
Lysholm 2y follow-up	94.5 (42-100)	96 (50-100)	0.0600
IKDC preoper.	55 (7-92)	59 (24-95)	0.0965
IKDC 1y follow-up	88 (36-100)	91 (23-100)	0.5800
IKDC 2y follow-up	91 (42-100)	95 (48-100)	0.0424

Preoperatively, the measured anterior-posterior side-to-side laxity difference (SSD) was similar in both groups. In one and two years follow-up the SSD was less (in millimeters) in TT group. There was, however, no significant statistical differences (p = 0.2916 and 0.0871, respectively). (Table 2)

Table 2. Side-to side laxity difference (mm) preoperatively and 1 and 2 years postoperatively.

	AM	TT	P-value
Preoperatively	4.9 ± 2.9	5.1 ± 3.0	0.5901
1 year follow-up	2.4 ± 2.3	2.0 ± 2.6	0.2916
2 years follow-up	2.4 ± 2.7	1.6 ± 1.9	0.0871

In clinical Lachman stability test there was more laxity in AM group in one year follow-up, however without statistical difference. At two year follow-up, the difference had evened out. (Table 3)

Table 3. Clinical stability (Lachman) evaluation 1 and 2 years postoperatively (Chi-square).

	AM	TT	P-value
Preoperatively	4.9 ± 2.9	5.1 ± 3.0	0.5901
1 year follow-up	2.4 ± 2.3	2.0 ± 2.6	0.2916
2 years follow-up	2.4 ± 2.7	1.6 ± 1.9	0.0871

	-	+	++	P-value
1 year follow-up				
AM	68	19	2	
TT	76	9	1	0.1165
2 years follow-up				
AM	47	8	4	
TT	51	6	1	0.3262

The pivot shift test revealed no differences in rotational stability between the two groups, one or two years postoperatively. (Table 4)

Table 4. Pivot shift evaluation 1 and 2 years postoperatively (Chi-square).

	-	+	++	P-value
1 year follow-up				
AM	83	5	1	
TT	82	3	1	0.7966
2 years follow-up				
AM	51	4	4	
TT	56	1	1	0.1477

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 5)

Table 5. IKDC classifications 1 and 2 years postoperatively (Chi-square).

	A	B	C	D	P-value
1 year follow-up					
AM	41	43	3	1	
TT	48	32	4	0	0.3596
2 years follow-up					
AM	36	19	5	0	
TT	43	12	3	0	0.2635

The IKDC score was better at two year follow-up in the TT group ($p < 0.05$). (Table 1)

4. Discussion

300 patients with anterior cruciate ligament injuries were treated with an arthroscopic reconstruction of ACL. Patients were divided into two equal groups, drilling the femoral tunnel either with transtibial or anteromedial technique. Comparison of three ACL fixation devices showed no statistically or clinically relevant differences in the results two years postoperatively [8]. Therefore there was no elimination of patients from this study due to a particular fixation technique. With the Tape Locking Screw™ (TLS) fixation technique the graft used was semitendinosus tendon and in the other two techniques the gracilis tendon was also harvested. The follow-up data was collected and this study was done retrospectively. We wanted to investigate if there is a significant difference in the follow-up results between these groups irrespective of the fixation method.

These tests and scores were collected before the operation and during the 1- and 2-years follow-ups. Patients also evaluated their activity level before the trauma (Tegner). Collecting this kind of patient data has been a routine procedure at Orton Hospital since early1990´as a part of quality control and ongoing research project.

This study compared the results of anteromedial drilling and transtibial drilling in ACL reconstruction at 2-year follow-up. The results showed that both of these techniques provide good clinical result. Tegner activity score was consistently higher in the TT group starting from preoperative examinations (p-value < 0,05).

Statistically significant difference was recorded in IKDC score at two year follow-up in the TT group (p-value = 0,0424). IKDC score was 95 (48–100) in the TT group and 91 (42–100) in the AM group. In the two year follow-up there were 58 patients (43,6%) in the TT group and 60 (45,5%) in the AM group.

The TT technique in ACL reconstruction has been considered the commonplace and has been used for decades [9, 10]. The bony sockets in tibia and femur have proven to be reliable and hardly any blow-out fractures of the posterior cortex of femur have occurred. Griffin et al and Fu et al have presented good and excellent results in 80–95% of cases [11, 12]. Regardless of these good results there has been criticism considering this technique. It has been questioned if TT technique can target the original ACL femoral insertion. Unanatomically positioned graft worsens the function of the knee [13, 2]. In active football players there has been a statistically significant difference in favor of the AM technique, which is thought to result from a more anatomical insertion of the graft in femoral side [5]. In the one and two years follow- up there were significantly better results in Lachman test values, 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 [5].

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 arthrosis of the knee seems to be anterior laxity. Removal of the medial meniscus is considered 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 tibia. If the hamstring muscles are weak, they cannot oppose the subluxation occurring from the action of the quadriceps muscle [15]. The requirement for the graft to be placed in an anatomical insertion in the femoral tunnel is thought to be the drilling from its own anteromedial portal [16]. On the other hand, by moving the tibial tunnel medially and proximally closer to the joint line, it is possible to make the tunnel more horizontal and through this tunnel 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]. Considering the rotational instability of the knee the placement of the graft has been thought to be of great value. The more horizontal graft placement seems to result in a more stable knee in cadaveric specimens [19].

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 = 0,1477).

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 is a thing to remember 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]. The AM drilling resulted in a more stable knee with anterior drawer, Lachman, and Pivot Shift tests, also [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 [9, 19, 22, 23]. Cheng et al discovered that AM technique provided better outcomes in Lachman test, Pivot Shift test, IKDC, and Lysholm scores [23].

In our previous study statistical difference has not been found between these two drilling methods, although the intent was to compare different fixation methods [8]. In this study some patients were athletes, some were participating in recreational sports, but also middle aged physically active citizens were included in our study. 26% 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). Tegner score, before the trauma leading to operation, was 6 in the AM group and 7 In the TT group. No statistical difference in the basic activity level of the patients was found. In previous studies 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 [5]. These results, nevertheless, suggest that best clinical results are achieved when operated with the method known and handled properly.

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 being that AM technique is a newer and more complex procedure leading to more technical failures and thus a higher revision rate compared with the TT technique [24].

The follow-up time of our study has been 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% of the patients 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.

5. Conclusions

In this two year follow-up of transtibial and anteromedial drilling technique in ACL reconstruction, there was a statistically significant difference in IKDC score favouring the TT drilling group (median 95, range 48- 100) against the AM group (median 91, range 42-100) (p=0.0424). Our results suggest that best clinical results are achieved when operated with the method known and handled properly.

6. Abbreviations

ACL. Anterior cruciate ligament.

TT. Transtibial.

AM. Anteromedial.

IKDC. International Knee Documentation Committee.

TLS. Tape locking screw.

KPS. Kujala patello-femoral score.

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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