OUTSIDE-IN VS. ANTEROMEDIAL PORTAL DRILLING DURING PRIMARY ACL RECONSTRUCTION: COMPARISON AT TWO YEARS

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ABSTRACT

Background: Anteromedial (AM) and outside-in (OI) are two commonly used techniques for drilling the femoral tunnel during anterior cruciate ligament reconstruction (ACLR). The purpose of this study was to compare clinical and radiographic outcomes of patients undergoing primary ACLR using either AM or OI femoral drilling with minimum two year follow-up.

Methods: Overall, 138 prospectively enrolled patients undergoing primary ACLR underwent AM or OI femoral drilling. Patients were categorized by femoral drilling technique and were evaluated pre-operatively as well as at six weeks and two years post-operatively. Outcomes scores were collected at each visit using SF-36 PCS and MCS components, KOOS, and the Knee Activity Rating Scale. Complications, including graft failure, stiffness requiring manipulation under anesthesia, and revision surgery were also collected.

Results: Overall, 47 (34.1%) patients underwent AM femoral drilling and 91 (65.9%) patients underwent OI femoral drilling. Univariate analysis revealed no difference in pre-operative outcomes with the exception of the AM group having higher KOOS Knee Pain (p=0.023) and WOMAC Pain (p=0.036) scores. Postoperatively, OI femoral tunnels had a higher radiographic coronal angle (68.8°±8.6° vs 51.4°±11.3°; p<0.001) and knee extension (1.2°±2.7 vs 2.9°±4.0°; p=0.010). There were no differences in knee flexion, complications, or graft failure. Postoperatively, the AM group had higher KOOS ADL and WOMAC Functional (85 vs. 79 ,p=0.030) scores at the six week mark, although these differences did not meet the minimal clinically importance difference1. Graft failure at two years were similar in the AM and OI groups (8.5% vs. 6.6%, p=0.735). Multivariate analysis showed no clinical outcome differences between AM and OI techniques.

Conclusions: ACL reconstruction using the AM technique yielded lower radiographic coronal tunnel angle and slightly decreased knee extension. The theoretical risk of graft failure secondary to higher coronal angle of the graft as it passes around a sharper femoral tunnel aperture was not observed. Additionally, differences in pre-operative KOOS Knee pain existed but these differences were not significant postoperatively. We conclude no clinically relevant differences by two years in patients undergoing primary ACL reconstruction using either AM or OI femoral drilling techniques.

Level of Evidence: Level II Prospective Comparative Study

INTRODUCTION

Nearly 200,000 ACL reconstructions are performed in the United States annually[2]. The most frequently cited reason for revision ACL reconstruction reported in the literature is surgical technique, with the vast majority related to malposition of the bony tunnels[3,4,5,6,7]. Although surgeons were able to define the femoral origin of the ACL almost half a century ago[8], it has been difficult to place grafts in this position with the historically popular transtibial (TT) technique[9,10,11,12]. For this reason, a variety of arthroscopic techniques have evolved in order to provide more anatomic femoral tunnel positioning.

There have been multiple studies that link a TT approach with a higher likelihood of producing a vertical graft. Verticality of the graft may lead to knee instability and a higher chance of poor clinical outcomes[7,13]. Other authors have studied the accuracy of femoral tunnel placement using anteromedial portal, outside-in, and transtibial techniques[14]. A 2013 survey identified that the majority of surgeons in North America and internation-

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ally prefer anteromedial approaches for placement of the femoral tunnel[15]. There are many studies comparing the biomechanical and radiographic outcomes associated with these various femoral tunnel techniques,[16,17] but the literature is lacking in comparing the clinical outcomes. There are several methods to assess tunnel placement including intra-operative fluoroscopy, post operative computed tomography (CT) scan, post-operative radiographs and post-operative MRI. Radiographs of the knee are useful and cost effective in determining the anatomic placement of a graft and have been shown to accurately predict graft placement when validated with three dimensional CT scans[18]. Recently it has been shown that kinematics, relative position of the tibia, and cartilage loading patterns may be different in AM placed grafts versus OI grafts[16].

Given the lack of short and mid-term follow-up investigations comparing patients with AM or OI placed grafts, the purpose of this study was to prospectively compare clinical and radiographic outcomes of patients undergoing primary ACL reconstruction using either AM or OI technique with minimum two-year follow-up.

METHODOLOGY

Following institutional review board approval, patients who underwent primary ACLR were identified from a prospectively maintained, single institution ACLR registry. Patients who underwent ACL reconstruction from 2011 to 2014 were included in the registry. There were a total of 138 patients who underwent primary ACLR by four surgeons. Patient information including age, sex, and preoperative patient reported outcome scores were obtained. Other data collected include operative information (graft type, concomitant injuries, fixation device) and post operative clinical information (patient reported outcome scores, radiographic measurements, and clinical exam measurements). Range of motion was defined in terms of flexion and extension at the knee. Extension was reported in the number of degrees short of full extension.

Patients were divided into two groups according to the technique used to place the femoral tunnel, which was based on surgeon preference. The AM technique utilized a low anteromedial portal that was localized with a spinal needle. A flexible reaming system allowed for subsequent drilling of the tunnel over a guidepin with the knee in hyperflexion while visualizing through the anterolateral portal. The graft was fixed with either suspensory or screw fixation. The OI technique utilized a Flipcutter (Arthrex) and a separate incision on the lateral aspect of the distal femur. A drill guide was placed against the lateral femoral cortex with a targeting guide centered over the femoral footprint of the ACL. An all-in-one guide pin and reamer is introduced from outside-in into the notch, followed by reaming in the reverse direction. This technique utilizes the camera in an anteromedial portal. The graft was fixed with suspensory fixation in all but one patient in the OI group.

There were 47 patients in the anteromedial group and 91 patients in the OI group. Complete data was available for 31 and 64 patients from each group for a follow-up rate of 66% and 70% respectively. Patients were evaluated clinically at baseline, six weeks and two years post-operatively and radiographically at six weeks postoperatively. Outcomes scores were collected at each visit using SF-36 PCS and MCS components, KOOS, and the Knee Activity Rating Scale. Two authors (TC and ZR) made radiographic measurements to assess the placement of the femoral tunnel using AP and lateral knee radiographs recorded at the patient's six week follow up visit. The site of the femoral tunnel was measured in the AP direction on a lateral radiograph of the knee using the quadrant technique proposed in a previously validated study by Sommer et al[19]. The coronal obliquity with relation to the femur's anatomic axis was measured using a technique relying on the head of an interference screw described by Shah[20]. In patients that had a tight rope device used instead of an interference screw, this measurement was made using a technique described by Illingsworth18 in which a line drawn down the femoral tunnel forms the angle with the femur's anatomic axis.

Univariate analysis allowed comparison of demographic and operative characteristics for patients who undergoing ACLR with AM or OI drilling. Select variables ($p < 0.1$) were subsequently used to create a multivariate logistic regression model to identify independent risk factors for graft failure, complications, and outcome scores. Significance was defined as $p < 0.05$ and results were reported as odds ratios (ORs) and 95% confidence intervals (95% CIs). Model performance was assessed through the c-statistic and model calibration, with Hosmer-Lemeshow chi-square statistics. All data and statistical analysis was performed with use of SAS (version 9.3; SAS Institute).

RESULTS

Overall 138 patients were followed for a minimum of two years after primary ACLR. The anteromedial group (AM) consisted of 47 patients while the outside-in (OI) consisted of 91 patients. Complete data was available (Table 1) for 31 and 64 patients from each group for a follow up rate of 66% and 70% respectively.

The two groups did not significantly differ with respect to the average patient age, male/female ratio, concomitant injury or pathology diagnosed at the time of surgery, and the majority of the baseline patient reported outcome scores (Tables 1 and 4). There was a significant difference in pre-operative KOOS Pain and

Table I. Patient Demographics

	Anteromedial	Outside-In	P-value
Number of Patients	47	91	
Male/Female	21/26	46/45	0.5133
Mean Age (years)	25.04	25.4	0.8496
Pre Op KOOS	62.16	58.28	0.245
Pre Op KOOS Pain	68.96	60.23	**0.0232**
Pre OP Womac Pain	78.86	70.58	**0.0361**
Pre OP SF36 Mental	56.48	54.48	0.2435
Pre OP SF36 Physical	40.76	37.40	0.0800
Pre OP KOOS ADL	72.86	69.42	0.3531
Pre OP Womac Functional	72.86	69.41	0.3531
Pre OP Knee Activity Score	12.6	11.4	0.2228
Associated Injury			
Lateral Meniscus Tear	19	41	0.6031
Medial Meniscus Tear	17	30	0.7067
Meniscus Repaired	7	22	0.2047
MCL Injury	9	17	0.9469
LCL Injury	7	7	0.1842
PCL Injury	1	3	1

Table II. Operative Values

	Anteromedial	Outside-In	P-value
Graft Choice			
Hamstring	34	53	0.1039
Bone-tendon-bone	13	16	0.1685
Tibialis Anterior	0	22	**<0.0001**
Autograft/Allograft	43/4	61/30	**0.0015**
Femoral Fixation			
Suspensory	34	90	**<0.0001**
Screw	13	1	**<0.0001**
Tibial Fixation			
Suspensory	0	14	**0.0025**
Screw	47	77	**0.0025**

Table III. Post-Operative Outcomes

	Anteromedial	Outside-In	P-value
Mean Coronal Angle (degrees)	51.37	68.78	**<0.0001**
Lateral Quadrant	1.044	1.092	0.2677
Flexion (degrees)	117.7	119.2	0.6042
Extension (degrees)	2.87	1.16	**0.0105**
Post Op 6 Week Knee Activity Score	12.9	12	0.372
Post Op 2 Year Knee Activity Score	12.6	10.5	0.075
Post Op 6 Week KOOS	72.28	68.09	0.1063
Post Op 2 Year KOOS	84.65	81.11	0.2317
Post Op 6 Week WOMAC Pain	87.91	83.03	0.0836
Post Op 2 Year WOMAC Pain	93.43	89.63	0.1154
Complications at 6 weeks	1	2	0.062
Complications at any time	8	8	0.1544
Re-rupture	4(8.5%)	6(6.6%)	0.7345

WOMAC Pain scores between the two groups. The majority of patients were injured with a rotational force at the knee in a non-contact sporting event (58%). The most common graft choice overall was hamstring autograft (n=83, 60%). However, a significantly larger number of tibialis anterior allograft was used in the OI group (n=22 vs n=0, p<0.0001). Allograft was more commonly used in the OI group (n=30 vs n=4; 33% vs 8.5%, p=0.0015). The majority of the femoral fixation was suspensory in both groups, and tibial fixation was most often an interference screw (n=122, 124; 88% and 90%, respectively (Table 2).

Extension (2.9°±4.0° vs 1.2°±2.7; p=0.010) and mean coronal angle (51.4°±11.3° vs 68.8°±8.6°; p<0.001) were significantly different between the two groups (Tables 3 & 4). There were no differences clinical outcome scores with the exception of AM group having a higher six week and two year post-op KOOS ADL and WOMAC Functional scores(85 vs. 79 ,p=0.030). The remainder of the measured variables including complication and re-rupture rates showed no significant difference at six weeks or two years. Multivariate analysis showed no difference between groups in any of the clinical, radiographic or patient reported outcomes.

Complications were similar between the two groups at six weeks and two years. These were defined as reasons to return to the operating room within two years. At two year follow-up there were eight complications in the AM group and eight complications in the OI group. Graft failure (one from MRSA infection in the OI group) accounted for all but four of the complications in the AM group and all but two of the complications in the OI group. There were two cases of hardware removal for

Table IV. Post-Operative Clinical Scores

Outcome	Anteromedial	Outside-In	P-value
Post Op 6 Week Knee Activity Score	12.9	12	0.372
Post Op 2 Year Knee Activity Score	12.6	10.5	0.075
Post Op 6 Week Physical Score	44.24	43.0	0.3994
Post Op 6 Week Mental Score	53.77	53.01	0.6404
Post Op 2 Year Physical Score	50.84	49.10	0.3367
Post OP 2 Year Mental Score	54.97	53.82	0.5254
Post Op 6 Week KOOS Knee Pain	78.39	73.24	0.0955
Post Op 2 Year KOOS Knee Pain	87.93	83.25	0.1250
Post Op 6 Week KOOS ADL	85.28	79.41	**0.0296**
Post OP 2 Year KOOS ADL	94.95	91.10	0.0593
Post OP 6 Week WOMAC Functional	85.28	79.41	**0.0296**
Post OP 2 Year WOMAC Functional	94.95	91.10	0.0593
Post Op 6 Week KOOS	72.28	68.09	0.1063
Post Op 2 Year KOOS	84.65	81.11	0.2317
Post Op 6 Week WOMAC Pain	87.91	83.03	0.0836
Post Op 2 Year WOMAC Pain	93.43	89.63	0.1154
Post Op 6 Week WOMAC Stiffness	67.44	68.25	0.8319
Post Op 2 Year WOMAC Stiffness	77.86	78.31	0.9190

prominent hardware, one case of a loose body removal, and one case of a cyclops lesion in the AM group. In the OI group there were two cases of arthrofibrosis requiring manipulation under anesthesia.

DISCUSSION

While many aspects of ACL reconstruction have been studied, it is clear that the location of the femoral tunnel affects knee kinematics as well as patient functional outcomes[19,21]. There is still controversy regarding the best technique to achieve an anatomic location of the femoral origin of the ACL. There is reproducible evidence that supports improved knee mechanics, more anatomic graft placement on the femur, and improved knee stability using an independent drilling method over a transtibial method[22,23,24]. However, current evidence fails to reveal clinically significant differences between techniques[24]. In this study, we showed no difference in clinical outcomes at two years post-operatively for patients undergoing AM or OI femoral drilling during primary ACLR using a prospectively maintained, single institution ACLR database.

Although clinical outcomes between groups were similar at the two year time point, the coronal oblique angle was significantly higher for femoral tunnels drilled using the OI technique. In a previous study, Chang[25] reported no difference in coronal obliquity when comparing AM and OI techniques. In the present study, patients in the OI group had a higher angle of obliquity, consistent with a more vertically oriented graft. Previous studies have identified more obliquity in tunnels placed through an AM and OI compared to a TT approach[26]. Increased verticality has corresponded to more laxity with anterior tibial translation and increased rotational instability[26]. However, we did not observe higher graft failure rates at two year follow-up.

When assessing range of motion following ACL reconstruction, the OI group had better extension than those in the AM group but the clinical significance of this difference (1.5 degrees) is likely inconsequential[27]. Clinically it appears the minimum amount of a flexion contracture that leads to anterior knee pain is approximately five degrees[27]. Therefore, this observation represents a statistical difference that has poor clinical relevance.

While our reported complication rate may seem high for primary ACL reconstruction in the AM group, the majority of complications listed were sensitivity from prominent hardware and arthrofibrosis. Other surgeons with higher thresholds for returning to the operating room may not consider these as complications. Our six week complication rates were similar to others reported in the literature[28] at around 2%. However, our early complications were all re-ruptures related to new trauma or infection. Compared to the MOON data which reported 4.4% re-rupture at two year follow up in primary ACL reconstruction, our re-rupture rate was 7.2% in all comers. However, our mean patient age was younger at 25 years compared to 27.4 years, a risk factor that has been associated with higher increases in re-ruptures[29].

Our clinical results compare favorably with other reported clinical results in the literature. In a systematic review with meta-analysis, Riboh et al[24] found no significant difference in patient reported outcome measures at short to mid-term follow up between independent drilling groups. In a study by Lansdown[16], at one year postoperatively patients in the OI group had similar KOOS scores to those in the AM group with improved scores in the KOOS-symptoms category. This was a small study with only 10 patients per cohort.

Major strengths of our study include prospectively gathered data in a group of patients treated by multiple surgeons, at minimum two year follow-up. The present study has several limitations. Follow-up was limited to two years and included<80% of patients within the database. Additionally, the majority of AM ACLR procedures were performed by a single surgeon, and there was limited crossover between techniques for the four surgeons contributing to the database. Furthermore, we did not report an activity level measure, which in combination with patient age, is the most predictive of subsequent graft rupture[29]. Finally, the influence of concomitant injuries and post operative protocols on patient reported outcomes was not addressed specifically.

In conclusion, we found no clinically relevant differences by two years in patients undergoing primary ACL reconstruction using either the AM or outside in femoral drilling techniques.

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