Knee Surgery, Sports Traumatology, Arthroscopy (2020) 28:3631–3638
https://doi.org/10.1007/s00167-020-05959-w

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No difference in revision rates between anteromedial portal and transtibial drilling of the femoral graft tunnel in primary anterior cruciate ligament reconstruction: early results from the New Zealand ACL Registry

Richard Rahardja[1] · Mark Zhu[1,3] · Hamish Love[4] · Mark G. Clatworthy[5] · Andrew Paul Monk[1,3] · Simon W. Young[1,2]

Received: 31 October 2019 / Accepted: 23 March 2020 / Published online: 1 April 2020

Abstract

Purpose The use of an accessory anteromedial portal to drill the femoral graft tunnel in primary anterior cruciate ligament (ACL) reconstruction was introduced in the 2000s in an effort to achieve a more anatomic femoral tunnel position. However, some early studies reported an increase in revision ACL reconstruction compared to the traditional transtibial technique. The aim of this study was to analyse recent data recorded by the New Zealand ACL Registry to compare outcomes of ACL reconstruction performed using the anteromedial portal and transtibial techniques.

Methods Analysis was performed on primary isolated single-bundle ACL reconstructions recorded between 2014 and 2018 by the New Zealand ACL Registry. Patients were categorised into two groups according to whether an anteromedial portal or transtibial technique was used to drill the femoral graft tunnel. The primary outcome was revision ACL reconstruction and was compared between both groups through univariate and multivariate survival analyses. The secondary outcomes that were analysed included subscales of the Knee Injury and Osteoarthritis Outcome Score (KOOS) and Marx activity score.

Results Six thousand one hundred and eighty-eight primary single-bundle ACL reconstructions were performed using either the anteromedial portal or transtibial drilling techniques. The mean time of follow-up was 23.3 (SD ± 14.0) months. Similar patient characteristics such as mean age (29 years, SD ± 11), sex (males = 58% versus 57%) and time to surgery (median 4 months, IQR 5) were observed between both groups. The rate of revision ACL reconstruction was 2.6% in the anteromedial portal group and 2.2% in the transtibial group (n.s.). The adjusted risk of revision ACL reconstruction was 1.07 (95% CI 0.62–1.84, n.s.). Patients in the anteromedial portal group reported improved scores for subscales of the KOOS and higher Marx activity scores at 1-year post-reconstruction.

Conclusion There was no difference in the risk of revision ACL reconstruction between the two femoral tunnel drilling techniques at short-term follow-up. We observed minor differences in patient-reported outcomes at 1-year follow-up favouring the anteromedial portal technique, which may not be clinically relevant. Surgeons can achieve good clinical outcomes with either drilling technique.

Level of evidence III.

Keywords Anterior cruciate ligament · ACL reconstruction · Tunnel drilling · Revision ACL · Patient-reported outcome measures

Introduction

Anterior cruciate ligament (ACL) reconstruction is a procedure that has undergone significant changes to surgical technique over many decades that have improved the success of treatment and prolonged the careers of athletes [1–5]. Since becoming an arthroscopic procedure, there has been interest in more "anatomical" reconstruction to restore the ACL to

✉ Richard Rahardja
rrah466@aucklanduni.ac.nz

Extended author information available on the last page of the article

its native location and structure to enhance the stability of the knee [6–14]. In particular, attention has been focused on the technique for drilling the femoral graft tunnel. Surgeons traditionally used a "transtibial" technique, where the femoral tunnel is drilled via and in line with the tibial tunnel [15, 16]. Some authors argue the transtibial technique can lead to a "non-anatomical" ACL reconstruction, as it tends to place the graft in a more vertical orientation compared to the native ACL [17–20].

The native femoral footprint of the ACL is well described, situated posterior to the lateral intercondylar ridge [14, 21, 22]. A number of studies have demonstrated that the use of an accessory anteromedial portal may have a higher success rate of placing the femoral tunnel within this native footprint, as the surgeon has greater flexibility since femoral tunnel positioning is independent of the tibial tunnel [21, 23–29]. Furthermore, biomechanical studies associate "anatomically" reconstructing the ACL at the native femoral footprint with increased objective knee stability [30–33].

Despite an increase in the popularity of the anteromedial portal drilling technique, early studies associate its use with an increased risk of revision compared to the transtibial technique [34–37]. It was theorised that the increased risk was due to a learning curve faced by surgeons who transitioned from using the transtibial technique to the use of an accessory anteromedial portal to drill the tunnel [35]. This reason may be supported by Eysturoy et al. who found an increased risk of revision during the earlier use of the anteromedial portal technique, but found no difference in revision risk using more recent data when compared to the transtibial technique [38].

This study aimed to clarify the risk of revision ACL reconstruction between anteromedial portal and transtibial drilling of the femoral graft tunnel using data from the New Zealand ACL Registry. It is hypothesised that the effect of any learning curve will be minimised as the registry began capturing data in 2014, well after anteromedial portal drilling was introduced. Additionally, post-operative patient-reported outcome measures (PROMs) at 1 year will be compared between the two drilling techniques.

This study was performed to analyse whether there remains a higher rate of failure with the anteromedial portal technique and to provide feedback to surgeons who practise either drilling technique.

Materials and methods

Following exemption from the Health and Disability Ethics Committee (HDEC), a retrospective review was performed on prospectively captured data by the New Zealand ACL Registry. The operation of the registry has been declared as a protected quality assurance activity by the New Zealand Ministry of Health and all patients recorded in the registry have signed consent forms to participate.

Between 2014 and 2018, 7612 primary ACL reconstructions have been recorded. This study reviewed all primary isolated single-bundle ACL reconstructions performed using either the anteromedial portal or transtibial techniques when drilling the femoral graft tunnel ($n = 6353$). We excluded patients who underwent multi-ligament reconstruction, contralateral ACL reconstruction or any concurrent surgery such as osteotomy or unicompartmental knee replacement ($n = 165$).

The New Zealand ACL Registry

The New Zealand ACL Registry is a nationwide registry that began in 2014 and prospectively captures data on patient, surgical and follow-up variables. Since 2017, it is mandatory for all orthopaedic surgeons who perform ACL reconstructions to actively participate in the registry to achieve recertification [39]. As of 2018, based on comparisons to government healthcare data, it is estimated that approximately 85% of all ACL reconstructions performed in New Zealand are captured by the registry [40]. Patient demographic data are collected through a pre-operative form, while an intra-operative data form detailing each reconstruction procedure is completed by the surgeon. In addition, surgeons can fill out a post-operative complication form that details any early and late complications relating to the procedure. Patient-reported complications are confirmed with the treating surgeon. Patient-reported outcome measures (PROMs) including the Knee Injury and Osteoarthritis Outcome Score (KOOS) and Marx questionnaires are captured pre-operatively and post-operatively at 6 months, 1, 2 and 5 years.

Outcome of interest and predictor variables

The main predictor variable was femoral graft tunnel drilling technique (anteromedial portal versus transtibial) as recorded by the surgeon using the intra-operative data form. The primary outcome was revision ACL reconstruction occurring during the study period.

The secondary outcomes were patient-reported outcome measures (PROMs) captured by the registry at 1 year after reconstruction. All five subscales of the KOOS including symptoms, pain, activities of daily living (ADL), sport and recreation (Sport/Rec) and quality of life (QoL), and Marx activity score were analysed. Subscales of the KOOS are scored independently on a scale of 0–100 with 0 representing "extreme knee problems" and 100 representing "no knee problems" [41]. The Marx questionnaire is designed to ask patients how often they performed four activities including running, cutting, deceleration and pivoting when they were in their most active state [42]. The maximum activity score

is 16, indicating a patient who has performed all four activities more than four times a week.

Statistical analyses

Descriptive statistics were provided as mean values with standard deviation (SD) or median values with interquartile ranges (IQR). Univariate analysis of the rate of revision ACL reconstruction was performed using Chi-Square test. Kaplan–Meier survival analysis was performed to produce a survival plot with the associated number at risk and cumulative survival probabilities of revision. Incidence densities were calculated per 100 observed person-years. Hazard ratios (HR) with 95% confidence intervals (CI) were computed to compare the risk of revision between drilling techniques using a Cox proportional hazards regression model adjusting for patient and surgical covariates (age, sex, time from injury-to-surgery, graft choice, concomitant meniscal or cartilage injury, previous knee surgery, cause of injury and pre-operative Marx activity score). The assumption of proportional hazards was assessed via log(-log) plots and found suitable. KOOS and Marx scores were assessed for normality through visualization of Q–Q plots and histograms, before being analysed through Student's *t* test or Mann–Whitney *U* test. Results were considered statistically significant at $p < 0.05$. All analyses were performed using IBM SPSS Statistics version 25.

Results

Six thousand one hundred and eighty-eight primary isolated single-bundle ACL reconstructions were performed using either the anteromedial portal or transtibial femoral tunnel drilling techniques between 2014 and 2018 (Table 1). The mean time of follow-up was 23.3 (SD ± 14.0) months. The anteromedial portal technique was used in 5285 reconstructions (85.4%), while the transtibial technique was used in 903 reconstructions (14.6%). The mean age of patients in this study was 28.9 years and 3597 patients were male (58%). The median time from injury-to-surgery was 4.2 months with the hamstring tendon as the most popular choice of graft ($n = 4616$, 74.6%), followed by the patellar tendon ($n = 1414$, 22.9%) and quadriceps tendon ($n = 50$, 0.8%). The majority of index ACL injuries were caused while playing a sport ($n = 5147$, 83.2%). Overall, 3728 patients had a concomitant meniscal injury (60%), while 2502 patients had a concomitant cartilage injury (40%). 232 patients had previous knee surgery prior to their primary ACL reconstruction (4%). Patient demographics were similar between the two drilling techniques, however, 38% of patients in the transtibial group had a patellar tendon autograft compared to 20% of patients in the anteromedial portal group.

Patients in the anteromedial portal group reported higher pre-operative Marx activity scores compared to patients in the transtibial group (mean scores 11.4 vs 11.2, $p = 0.04$) (Table 2). There was no difference in pre-operative KOOS scores between the two groups.

Revision in ACL reconstruction

There were 135 revisions in the anteromedial portal group (2.6%) compared with 20 in the transtibial group (2.2%, n.s.) (Table 3).

The number of revisions per 100 observed person-years was 1.3 (95% CI 1.1–1.6) in the anteromedial portal group, comparable to 1.1 (95% CI 0.7–1.8) in the transtibial group (Table 3).

The number at risk at 2 years in the anteromedial portal group was 2484 with a cumulative survival probability of 97.1% (95% CI 96.5–97.6) (Fig. 1). The number at risk at 2 years in the transtibial group was 474 with a cumulative survival probability of 97.9% (95% CI 96.4–98.8).

After adjusting for patient and surgical variables on multivariate analysis, there was no difference in the risk of revision between the anteromedial portal and transtibial drilling techniques (HR 1.07, 95% CI 0.62–1.84, n.s.).

In 3045 patients who had a minimum follow-up of 2 years, the revision rate was 4.3% in the anteromedial portal group and 3.7% in the transtibial group (adjusted HR 1.09, n.s.) (Table 5 in "Appendix").

When analysing the registry's post-operative complications data, there were 197 surgeon-reported graft failures in the anteromedial portal group (3.7%) and 32 in the transtibial group (3.5%, n.s.). On multivariate analysis, there was no difference in the risk of graft failure (adjusted HR 0.93, 95% CI 0.62–1.40, n.s.).

Patient-reported outcome measures

At 1-year post-reconstruction, the mean response rate was 45.9% for both the KOOS and Marx activity questionnaire (Table 4).

Patients in the anteromedial portal group reported higher scores for the pain, ADL, Sport/Rec, QoL and Marx scores. No difference was reported for the symptoms score.

Discussion

The most important finding of this study was that there was no difference in the rate and risk of revision between the anteromedial portal and transtibial femoral graft tunnel drilling techniques. However, patients in the anteromedial portal group reported higher scores for subscales of the KOOS and Marx activity score at 1-year post-reconstruction.

Table 1 Baseline demographics

Demographic	Overall		Anteromedial		Transtibial	
	n	%	*n*	%	*n*	%
Number of reconstructions	6188		5285	85.4	903	14.6
Mean follow-up length, months (± SD)	23.3 (± 14.0)		23.2 (± 14.1)		23.8 (± 13.2)	
Sex						
Male	3597	58.1	3086	58.4	511	56.6
Female	2591	41.9	2199	41.6	392	43.4
Age (years)						
Mean ± SD	28.9 ± 10.7		28.9 ± 10.7		29.1 ± 10.6	
≤ 20	1521	24.6	1310	24.8	211	23.4
> 20	4667	75.4	3975	75.2	692	76.6
Months to surgery						
Median (IQR)	4.2 (5.2)		4.2 (5.2)		4.3 (5.0)	
≤ 6	4095	66.2	3489	66.0	606	67.1
> 6	2081	33.6	1787	33.8	294	32.6
NR	12	0.2	9	0.2	3	0.3
Graft choice						
Patella	1414	22.9	1067	20.2	347	38.4
Hamstring	4616	74.6	4081	77.2	535	59.2
Quadriceps	50	0.8	46	0.9	4	0.4
NR	108	1.7	91	1.7	17	1.9
Meniscal injury						
Yes	3728	60.2	3205	60.6	523	57.9
No	1776	28.7	1479	28.0	297	32.9
NR	684	11.1	601	11.4	83	9.2
Cartilage injury						
Yes	2502	40.4	2115	40.0	387	42.9
No	3633	58.7	3124	59.1	509	56.4
NR	53	0.9	46	0.9	7	0.8
Previous knee surgery						
Yes	232	3.7	193	3.7	39	4.3
No	5956	96.3	5092	96.3	864	95.7
Cause of injury						
Sport	5147	83.2	4415	83.5	732	81.1
Non-sport	949	15.3	793	15.0	156	17.3
NR	92	1.5	77	1.5	15	1.7

Table 2 Pre-operative PROMs

Demographic	*n* = 6188				
	Total responses		Anteromedial	Transtibial	*p* value
	n	%	Mean ± SD	Mean ± SD	
Symptoms	6060	97.9	65.9 ± 18.1	65.3 ± 18.3	n.s
Pain	5993	96.8	71.5 ± 17.2	70.9 ± 17.2	n.s
Activities of daily living	5999	96.9	80.1 ± 17.8	79.5 ± 17.1	n.s
Sport and recreation	5732	92.6	45.6 ± 26.3	44.1 ± 26.2	n.s
Quality of life	5981	96.7	33.1 ± 19.2	31.9 ± 18.7	n.s
Marx activity	5970	96.5	11.4 ± 5.0	11.2 ± 4.9	0.035

Table 3 Univariate comparison of revision rates

Demographic	*n* = 6188		
	Anteromedial	Transtibial	*p* value
Overall sample	5285	903	
Revisions, n	135	20	
Revisions, %	2.6	2.2	n.s
Observed person-years	10,080.3	1765.3	
Incidence density per 100 person-years (95% CI)	1.3 (1.1–1.6)	1.1 (0.7–1.8)	

The use of an accessory anteromedial portal has increased when drilling the femoral graft tunnel in primary ACL

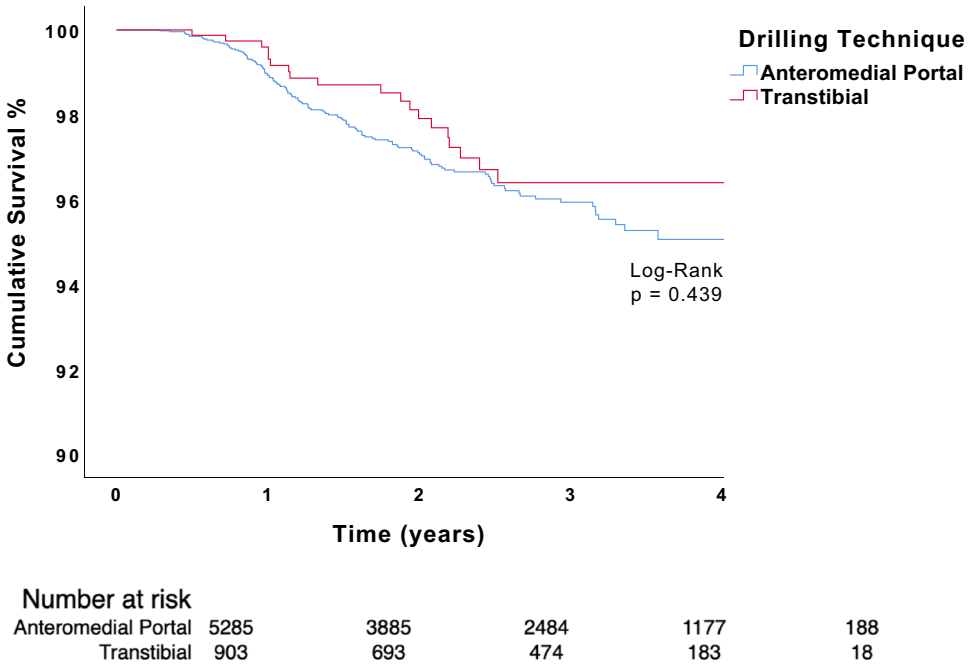

Fig. 1 Cumulative survival probability of revision following primary ACL reconstruction

Table 4 Post-operative 1-year PROMs

Demographic	$n = 6188$				
	Total responses		Anteromedial	Transtibial	*p* value
	n	%	Mean ± SD	Mean ± SD	
KOOS—symptoms	2848	46.0	80.6 ± 15.0	79.0 ± 17.0	n.s
KOOS—pain	2842	45.9	87.7 ± 13.0	85.4 ± 14.4	0.007
KOOS—activities of daily living	2849	46.0	93.6 ± 10.9	91.5 ± 12.4	< 0.001
KOOS—sports and recreation	2831	45.7	74.5 ± 20.6	69.5 ± 22.7	< 0.001
KOOS—quality of life	2849	46.0	64.3 ± 21.7	61.0 ± 23.0	0.004
Marx activity	2840	45.9	6.8 ± 5.0	5.9 ± 5.0	0.001

reconstruction, as it provides the surgeon with greater flexibility when deciding where to place the femoral graft tunnel [43, 44]. Despite this potential advantage, Tejwani et al. from the Kaiser Permanente ACL Registry found a 1.3 times higher risk of revision when using the anteromedial portal technique [37]. Similarly, Desai et al. from the Swedish National Knee Ligament Register reported a 1.4 times higher risk of revision and theorised that a learning curve associated with the anteromedial portal technique may explain this observation [34]. Although the anteromedial portal allows surgeons to "anatomically" reconstruct the ACL, it does not always result in accurate graft tunnel placement at the native footprint [45]. Variation in tunnel positioning targets especially during the early use of this technique may have contributed to a tunnel placed too anteriorly, reduced tunnel length and other technical difficulties that may have increased the rate of failure, but could have been prevented with experience and refinement [20, 27, 45–47]. Clatworthy et al. and Williams et al. found a higher rate of failure when first switching to an anteromedial portal technique, but noted they concurrently altered tunnel positioning to the "central" femoral footprint, in contrast to the "anteromedial bundle" position they used with the transtibial technique [48, 49]. They reported their failure rate reduced when they changed the femoral tunnel position back to the "anteromedial bundle" position while still using an anteromedial portal technique.

In contrast to the referenced registry studies, the New Zealand ACL Registry began capturing data in April 2014, providing surgeons with adequate time to adjust to a different technique and allowing for a fairer comparison between techniques. The lack of association between revision and drilling technique in this study may support the existence of a previous learning curve that has now been overcome by surgeons. Results from the Danish Knee Ligament Reconstruction Register may also support this theory. Rahr-Wagner

et al. found a 2.04 times higher revision risk with the anteromedial portal technique compared to the transtibial technique during the period January 2007 to December 2010 [35], whereas Eysturoy et al. found no difference in revision risk between the two techniques (HR 0.99, $p = 0.96$) during the later time period of January 2012 to December 2015 [38].

This study found that patients in the anteromedial portal group reported improved pain, ADL, Sport/Rec, QoL and Marx activity scores at 1-year post-reconstruction when compared to patients in the transtibial group. Despite the association with improved KOOS, the difference in mean scores was small, ranging from as low as a 1.6-point difference to as high as a 5-point difference when compared to the transtibial technique. Furthermore, the mean pre-operative activity levels were higher in the anteromedial portal group and may explain the similar observation at 1-year post-reconstruction. This suggests that the difference in post-operative scores is unlikely to be clinically significant.

The strengths of this study include the analysis of data recorded in a more recent time period to previous studies that have analysed data recorded during the early use of the anteromedial portal technique. Furthermore, the availability of a large patient population allows for greater certainty when attempting to identify any meaningful statistical associations. However, this study is not without limitations. Although the New Zealand ACL Registry captures the drilling technique used by the surgeon, it does not evaluate tunnel positioning or "anatomical reconstruction" using a tool such as the Anatomic Anterior Cruciate Ligament Reconstruction Scoring Checklist (AARSC) [50]. As a result, this study is a comparison between the anteromedial portal and transtibial drilling techniques, rather than the effectiveness of anatomically reconstructing the ACL. While it provides reassurance that good clinical outcomes can be obtained with both drilling methods, further work incorporating such data would be needed to identify whether the accuracy of tunnel placement between techniques influences the outcome of treatment. In addition, revision ACL reconstruction may underestimate the true rate of repeat ACL injury as not all patients who suffer a graft rupture may proceed to undergo a revision. Despite this, revision is a robust and well-defined outcome that is easily captured by a national registry. Furthermore, there is no reason to suggest patients would be less likely to undergo revision depending on the drilling techniques used. In this study, the average response rate for PROMs was approximately 46% at 1-year post-reconstruction. This is comparable to the Danish Knee Ligament Reconstruction Register which reported a 31% response rate at 1-year post-reconstruction [35]. The low post-operative response rate could potentially introduce bias into the analysis. However, as the operative data are prospectively collected, the response rate at 1 year is not expected to be greatly influenced by the drilling technique. The New Zealand ACL Registry is actively in contact with patients to achieve a more complete capture of PROMs. It is expected that these response rates will improve with time and maturation of the registry, allowing for a more in-depth analysis in the future. To mitigate against the variable follow-up durations of each patient, the Cox regression model was utilised and an analysis on only patients with a minimum follow-up of 2 years was performed, which demonstrated consistent results ("Appendix").

The clinical relevance of this study is that surgeons can achieve good clinical outcomes with either drilling technique.

Conclusion

At a mean follow-up of 23 months, no difference in the risk of revision ACL reconstruction was observed between the anteromedial portal and transtibial techniques when drilling the femoral graft tunnel. Minor differences in patient-reported outcomes were observed. Good clinical outcomes can be achieved with the use of either drilling technique.

Acknowledgements The authors would like to acknowledge Charlotte Smith from the New Zealand ACL Registry for her ongoing support and assistance with data administration. RR would to like to acknowledge the Maurice and Phyllis Paykel Trust for providing student support.

Funding No funding for this study.

Compliance with ethical standards

Conflicts of interest We, the authors, declare that we have no conflicts of interest with relation to this study. MGC reports that he does consulting for Johnson & Johnson, receives fellowship funding from Johnson & Johnson and Arthrex, and receives royalties from Arthrex, none of which are related to this study.

Ethical approval Health and Disability Ethics Committee exemption as an audit activity.

Appendix

See Table 5.

Table 5 Patients with minimum 2-year follow-up—univariate analysis and multivariate[a] Cox proportional hazards regression

Demographic	$n = 3045$		
	Anteromedial Portal	Transtibial	p value
Overall sample	2560	485	
Revision ACL reconstruction			
n	110	18	
%	4.3%	3.7%	n.s
Hazard ratio[a] (95% CI)	1.09 (0.60–1.97)	Reference	n.s

[a]Analysis adjusted for patient age, sex, graft choice, months to surgery, meniscal injury, cartilage injury, previous knee surgery, cause of injury and pre-operative Marx activity score

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Affiliations

Richard Rahardja[1] · Mark Zhu[1,3] · Hamish Love[4] · Mark G. Clatworthy[5] · Andrew Paul Monk[1,3] · Simon W. Young[1,2]

[1] University of Auckland, 85 Park Road, Auckland 1023, New Zealand

[2] Department of Orthopaedic Surgery, North Shore Hospital, Auckland, New Zealand

[3] Department of Orthopaedic Surgery, Auckland Hospital, Auckland, New Zealand

[4] Forte Sports, Christchurch, New Zealand

[5] Department of Orthopaedic Surgery, Middlemore Hospital, Auckland, New Zealand