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Temporal relation of meniscal tear incidence, severity, and outcome scores in adolescents undergoing anterior cruciate ligament reconstruction

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Abstract

Purpose—Anterior cruciate ligament (ACL) rupture is increasingly common in adolescents. Time between ACL rupture and surgical reconstruction, surgical wait time, is related to concurrent meniscal tear incidence and possibly tear pattern. This study defines the relationship between meniscal tear characteristics and surgical wait time in adolescents with ACL rupture.

Methods—One-hundred and twenty-one consecutive adolescent (median age 16.1 years, range 9–19 years) ACL rupture patients undergoing primary ACL reconstruction were studied. All had documented surgical wait time, preoperative and 6-month post-operative outcome (Lysholm and pedi-IKDC) scores, and intraoperative meniscus tear characteristics. Meniscal tear severity was graded according to the Lawrence and Anderson system: non-surgical: grade 1; reparable: grade 2–3; irreparable: grade 4–5. Significant tears were defined as at least grade 2.

Results—Average age at surgery was 16.1 years. 48.7 % had surgical wait time greater than 6 months. 42.5 % of menisci were torn. With surgical wait time <6 months, there were more lateral than medial tears (48 vs 21 %, $p = 0.001$). With surgical wait time >6 months, medial tear incidence increased (50 vs 21 %, $p < 0.001$), there were more significant tears (63 vs 42 %, OR 2.3, $p = 0.02$), and preoperative Lysholm and pedi-IKDC scores were lower (58 vs 74, $p < 0.001$; 52 vs 61, $p < 0.007$). Scores were lower in patients with meniscus tears (63.8 vs 69.3, n.s.; 53.9 vs

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Authors' contribution S.Z. carried out statistical analysis, drafted the manuscript, and edited the manuscript. K.T. carried out data accumulation, performed statistical analysis, and drafted the manuscript. P.W. carried out data accumulation. E.E. reviewed and carried out statistical analysis, and edited the manuscript. R.B. designed the study, performed the surgeries, enrolled the patients, oversaw the study, and helped to draft the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest The author(s) declare that they have no conflict of interests.

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60.5, $p = .04$). Patients with public insurance had risks of surgical wait time greater than 3 months (OR 12.4, $p < 0.001$) and 6 months (OR 7.8, $p < 0.001$), and of a significant meniscus tear (OR 2.5, $p = 0.03$). Six-month post-operative pedi-IKDC scores improved more in meniscus tear patients (28.4 vs 21, $p = 0.05$).

Conclusions—This study shows a significant increase in medial meniscal tear incidence, decrease in preoperative scores, and worse tear severity with surgical wait time >6 months. Public insurance was a risk factor for longer surgical wait time and meniscus tear.

Keywords

Anterior cruciate ligament; Meniscus; Meniscal tear; Meniscectomy; Meniscal repair; Surgical wait time

Introduction

The ability to access timely medical care for paediatric orthopaedic surgery patients varies widely. Reasons for disparity in accessing timely treatments are likely multifactorial, and include patient factors, provider factors, and payer factors. Finances, insurance, referral networks, and authorization processes each may contribute. Additionally, private versus government-funded insurance type may contribute to discrepancies in timely access to care [8, 13, 16]. This access issue can lead to delays in care for these children, affecting the severity of their injury or the natural history of their disease.

Particularly, in patients with anterior cruciate ligament (ACL) rupture, delays in care can be associated with development of meniscal tears and/or chondral injuries before patients are definitively treated for their ACL injury. Previous studies have demonstrated an association between longer surgical wait time (surgical wait time) following ACL injury and increased incidence of meniscus pathology in paediatric patients [6, 9, 11, 13]. Meniscal healing potential is related to tear location, pattern, and severity, which may be affected by surgical wait time. Increasing severity of meniscal tear may be associated with poorer long-term outcomes and is an important area of research for these patients.

This study defines the relationship between meniscal tear characteristics and surgical wait time in adolescents with ACL rupture. Additionally, this study describes meniscal tear rates and severity in adolescent ACL tear patients with private insurance (PI) versus government-funded medical insurance (GI). The hypothesis of this study is that longer surgical wait times, as well as presence of significant meniscal tears at time of surgery, are associated with worse preoperative, intraoperative, and post-operative patient characteristics. A secondary hypothesis of this study is that insurance type impacts surgical wait times and surgical characteristics. This study evaluates surgical wait times, preoperative outcomes scores, intraoperative meniscal characteristics, and post-operative outcomes scores.

Materials and methods

Consecutive adolescent (9–19 years) patients with an ACL rupture who underwent primary ACL reconstruction by a single attending orthopaedic surgeon were studied. Initial

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consultation with the treating orthopaedic sports medicine surgeon occurred either directly or after being referred by their primary care provider as per the rules of each administering medical insurance plan.

Patients were classified by insurance type as having either private-funded and private-administered medical insurance (PI) or government-funded, private-administered medical insurance (GI). Private-funded medical plans included Preferred Provider Organizations (PPO) or commercial Health Maintenance Organizations (HMO), with a variety of different companies administering the medical insurance plans. Government-funded plans were funded through the MediCaid programme (MediCal in California) and were administered by a variety of different private HMO (MediCal-HMO) companies.

All patients had ACL rupture diagnosed by the attending orthopaedic surgeon on the basis of a thorough history, physical examination, and magnetic resonance imaging (MRI). MRI radiology report was used to identify whether a patient had a possible or definite medial or lateral meniscus tear. Patients recommended for surgery demonstrated functional knee instability after injury and/or were competitive athletes participating in sports requiring pivoting/cutting. Surgery was not recommended until patients regained full knee extension, demonstrated >110° of knee flexion, and had a minimal knee effusion (typically 2–4 weeks after injury). Prospectively, patients had documented time between initial injury and surgery, paediatric International Knee Documentation Committee (pedi-IKDC) scores, Lysholm scores, and intraoperative meniscus tear characteristics. All patients underwent arthroscopic-assisted ACL reconstruction surgery with either a bone–patellar tendon–bone autograft and interference screw fixation or hamstring autograft and suspensory (femur) and interference screw (tibial) fixation. All femoral tunnels were created using an anteromedial portal technique.

Each patient had, at the time of ACL reconstruction surgery, the status of each meniscus (medial and lateral) documented in the operative note according to the circumferential zone classification [5]. Meniscal tears were further classified according to the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) classification system, based on location, type, size, and quality [2]. Tears were then graded in the same manner used by Anderson and Anderson [1] and Laible et al. [10] for final classification. The following grades were given to each tear based on operative report dictations: 0 = no tear, 1 = non-surgical tear, 2 = reparable tear of < 50 % thickness, 3 = reparable bucket handle tear, 4 = irreparable tear of >50 % thickness, and 5 = irreparable bucket handle tear (Fig. 1) [1, 11]. When needed, the following previously described tear characteristics were used to guide the senior author in assigning classifications of insignificant, reparable, and irreparable: insignificant = radial tears <4 mm, partial thickness, or vertical longitudinal stable <8 mm; reparable = vertical longitudinal tears in the red/red zone >8 mm in length; irreparable = all other tears [10, 17]. Tear status was defined based on tear characteristics, and not on whether the meniscus was actually debrided or repaired, to remove surgeon bias in determining classification grade.

Preoperative demographics of all patients were recorded. Preoperative questionnaires were administered at the patient's ACL preop appointment, which was typically 3 weeks before

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surgery and several weeks after the initial injury. Primary outcomes were post-operative pedi-IKDC and Lysholm scores, which were administered at 6 months postop.

Research approval was granted by the Institutional Review Board at the University of California Los Angeles(UCLA), IRB number 12-001515. Lysholm and pedi-IKDC scores were given to every patient as standard of care. Data were accessed and collected for patients who underwent surgery from 2010 to 2015 and were deidentified prior to analysis.

Statistical analysis

Sample size was estimated. Using an estimate that the outcome score effect size would be approximately 10 % difference with a standard deviation of 10 % for both Lysholm and IKDC scores, with equal group proportions, approximately 17 patients would be required in each group to achieve a sufficiently powered study.

Fisher's exact test was used to assess the relationship between tear incidence and classification among those with surgical wait time of <3, 3–6, 6–9, 9–12, and >12 months, and between surgical wait time of <6 and >6 months. Odds ratio analysis was conducted between the control group of <6 months surgical wait time and case group of >6 months surgical wait time, and also between <3 months surgical wait time and >3 months surgical wait time. Student's two-tailed *t* test analysis was performed to compare continuous variables. Meniscal tears were categorized as significant (grades 2–5) versus insignificant (0–1) or irreparable (grades 4–5) versus non-irreparable (grades 0–3).

To assess the effect of multiple variables on the outcome, multinomial logistic regression analysis was used. A separate model was constructed for IKDC outcome at 6 months, categorized as (1: <40; 2: 40–59; 3: 60–79; 4: ≥80) and a second regression model for Lysholm scores categorized as described in the questionnaire (1: <65; 2: 65–83; 3: 84–89; 4: ≥90).

Results

One-hundred and twenty-one patients were included in this study. Demographics are listed in Table 1. The following comparisons were made: surgical wait time, tear characteristics, post-operative scorers, procedures performed, insurance type through the use of two-tailed *t* tests, odds ratio, and multivariate analyses.

Surgical wait time

Comparison of surgical wait time was categorized by 3-month intervals (0–3, 3–6, 6–9, 9–12, 12+), and dichotomized to >6 months versus <6 months (Tables 2, 3). There was a significant temporal relationship between surgical wait time and medial meniscal tear rates (linear regression m = 2.5, Pearson R = 0.6, f = 0.02). There was a near-stable distribution of lateral meniscal tear rates across surgical wait time groups (linear regression $m = 1.3$, Pearson $R = 0.9$, f = n.s.; Figure 2). There was no significant relationship between surgical wait time and procedure performed (debridement vs. repair) among tears that were surgically acted upon.

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Tear characteristics

There was a temporal relationship between surgical wait time and irreparable tear incidence (Fig. 2). There was a nearly significant increase in irreparable tear versus non-irreparable incidence with >6 months of surgical wait time (39 vs 25 % patients; odds ratio 1.9, n.s.).

There was no significant difference in Lysholm or pedi-IKDC scores between irreparable and non-irreparable tear groups (61 vs 67, n.s.; 53 vs 57, n.s.). Pedi-IKDC scores were significantly lower with significant compared with insignificant tears for all menisci (53.9 vs 60.5, $p = 0.04$), but Lysholm scores did not reach significance (63.8 vs 69.3, n.s.).

There was no significant correlation between presence of tear (medial or lateral) on MRI and presence of tear on intraoperative evaluation (Pearson R 0.4, 0.5; n.s.).

Post-operative scores and insurance type

Change in post-operative scores for surgical wait time groupings and tear severity is presented in Table 4. Comparisons of the insurance type are presented in Table 5. There was a significant association between GI and surgical wait time >3 months, surgical wait time >6 months, and significant tears (Table 5).

Multivariate analyses

Multivariate analyses with continuous surgical wait time, categorical insurance type, and categorical significant medial and lateral meniscus tear revealed a significant association between surgical wait time and categorical IKDC score at 6 months [Likelihood ratio (LR) 88.2, $p = 0.03$]. Categorical Lysholm at 6 months was associated with surgical wait time (LR 100.2, $p = 0.005$) and lateral significant tear (LR 114.1, $p = 0.003$).

Discussion

The most important finding of the present study was the sensitivity of the outcome questionnaires to surgical wait time and meniscal tears. Importantly, the Lysholm questionnaire showed sensitivity to presence of significant lateral meniscal tears on multivariate analyses. The pedi-IKDC showed sensitivity to both increased surgical wait time and to the presence of a significant meniscus tear, as well as to an increased improvement from preop to postop in patients with a significant meniscus tear, on univariate analyses.

These data largely support our hypothesis on outcomes scores sensitivity to meniscal tears. The questions contained within the Lysholm questionnaire are weighted more towards meniscal symptoms (locking, pain with stairs or squatting) than ACL deficiency symptoms as compared to the pedi-IKDC, which is a possible reason why the Lysholm questionnaire was more sensitive to presence of a meniscus tear on multivariate analyses. Bengtsson et al. [3] and Risberg et al. [15] found that the Lysholm score was less sensitive ACL tears than meniscal tears. The authors suggest that both the Lysholm and pedi-IKDC scores are important in ACL tear patients, given that there is a high incidence in meniscal pathology with ACL rupture.

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Another important finding in this study was the relationship between presence of a medial meniscal tear and time to surgery >6 months. Interestingly, there was no significant correlation between presence of meniscal tear on acute injury MRI and intraoperative evaluation. This poor prediction ability has previously been described elsewhere [4]. The effect of increasing time between injury and surgery and increased incidence of meniscal (and chondral) pathology has been widely reported upon previously [6, 7, 11–13].

Third, the current study found a relationship between time to surgery and meniscal tear severity. Longer surgical wait time was associated with a higher rate of significant compared with insignificant meniscal tears. Few previous studies identify this relationship of tear severity to surgical wait time, and this study lends important insight into this question, with implications for future efforts in research and patient care.

Finally, this study found a significant association between longer surgical wait times and public insurance. There was also a significant association between government insurance and presence of a medial meniscus tear at time of surgery. This association raises important questions about the impact of government insurance on the natural history of ACL tear disease process, especially in light of the changing healthcare environment and challenges faced by patient and provider.

The delay to surgery is often multifactorial and includes payer (such as restrictive rules for where medical care can be delivered, delays in the payment authorization process, and reimbursement for services), patient (such as transportation, communication, and financial issues) and provider (such as delayed referral or limited access to subspecialist appointments and surgeries) factors. Publicly insured patients have been shown to have increased difficulty in obtaining appointments [8], visit multiple emergency rooms more often [16], and have longer delays to initial appointment [14]. Given the significant association between public insurance and longer surgical wait time found in our patient population, this is an important socio-economic finding that likely deserves continued investigation.

The clinical implications of this study are valuable to the surgeon and patient. Knowledge of the factors that can contribute to surgical delays is an important step in improving patient care. An especially challenging patient population is the under- and uninsured patient, and the surgical team should focus on awareness of and minimization of delay factors in order to optimize patient outcomes.

In this study, although meniscal reparability was defined based on standard meniscal repair guidelines, the number of menisci repaired did not reflect the guidelines in every case. In addition to all of the classically defined reparable meniscal tears being repaired in this cohort, 8 of the 42 so-called irreparable meniscal tears were also repaired. The author’s bias is to stretch the indications for meniscal repair to include unstable vertical tears in the red/white zone in children and adolescents in particular.

There are several limitations in this study. As a single surgeon series, there is inherent bias in both the classification of meniscal tears and selection of patients in general. However, as noted earlier, the surgeon made every attempt to make objective classifications irrespective of what surgical action was performed. Additionally, there are likely demographic and

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patient-specific factors which may impact their outcomes scores, such as body weight, activity level, and cultural norms. Our population was largely Hispanic and under-insured, and there may have been factors apart from payer source that contributed to longer surgical wait times, influencing outcomes. Our 6-month follow-up rate of 54.5 %, a limitation to this study, was consistent with our overall low follow-up experience in our patient population. An association between patient population and public insurance with lower follow-up has been previously explored in the literature [18]. Additionally, this study did not examine the relationship between chondral injury and insurance type or time to surgery. Chondral injuries were not consistently documented in the medical record in our patients. In the authors' experience, quantification of the size and extent of chondral damage is more difficult than that of meniscal injury. Finally, the study was not randomized or controlled, and a future randomized study between surgical wait times, if deemed to be ethical, may provide stronger data.

Conclusions

This study demonstrated increased severity of and rates of meniscal tears and lower preoperative pedi-IKDC and Lysholm scores in adolescent patients with ACL ruptures and >6 months of time between injury and surgery. Patients with public insurance also had longer surgical wait times and an increased risk of having a medial meniscus tear at time of surgery. Long-term follow-up studies should document whether patients with severe meniscal tears at the time of ACL reconstruction have poorer functional outcomes than those with insignificant or reparable meniscal pathology, which would provide further insight into the challenges facing today's paediatric orthopaedic patient.

Acknowledgments

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Abbreviations

ACL	Anterior cruciate ligament
PI	Private insurance
GI	Government insurance
PPO	Preferred provider organization
HMO	Health maintenance organization
ISAKOS	International society of arthroscopy, knee surgery and orthopaedic sports medicine
pedi-IKDC	Pediatric international knee documentation committee

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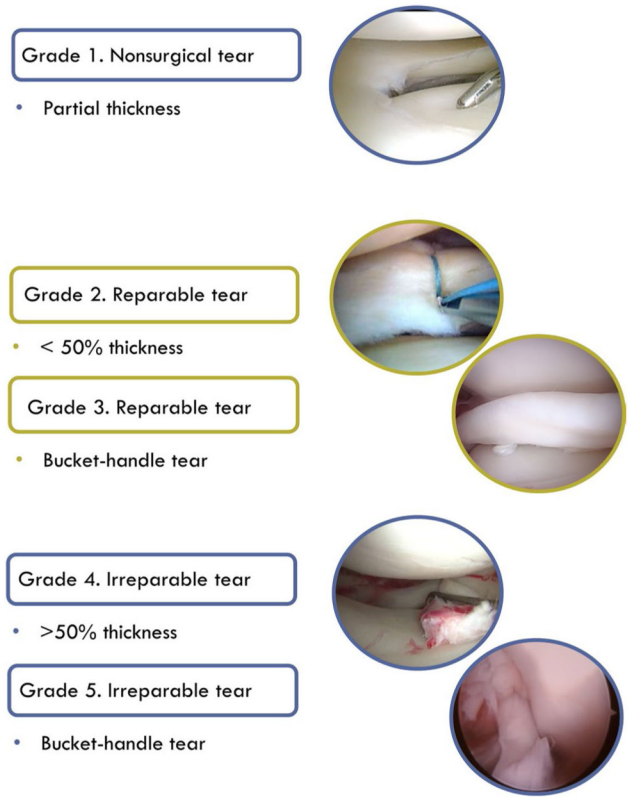

Fig. 1.

Meniscus tear classification. Meniscus tear classification, as utilized by Anderson and Anderson [1] and Laible et al. [10]. Grades were given based on tear characteristics and irrespective of whether surgical action was performed. Images are anonymous patient images from this study, printed with permission

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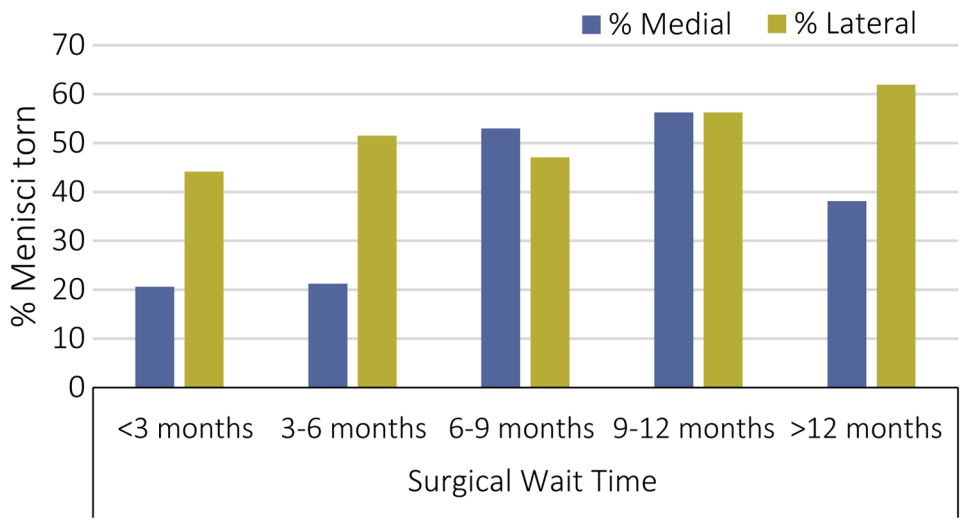

Fig. 2.

Meniscal tear incidence versus surgical wait time. Graphical depiction of incidence of medial and lateral meniscal tears in each surgical wait time group. % Menisci torn given as a percentage of total available menisci in that surgical wait time group

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Table 1

Demographics

Number of subjects	121	
Male	63 (52 %)	
Mean age (years)	16.9	
Median age (range)	16.1 (9–19)	
Number of patients with MRI	106	
Mean days to MRI after injury (range)	142 (1–1432)	
Preoperative MRI findings[a]		
Medial tear (%)	41	
Lateral tear (%)	35	
Torn menisci at time of surgery[b]	42	
Medial tear (%)	33	
Lateral tear (%)	51	
Questionnaire completion rate	Surgical wait time	
	<6 months[1]	>6 months[2]
Pedi-IKDC (%)	82.3	41.2
Lysholm (%)	75.8	72.9

Values presented are the number o patients within each group unless otherwise noted. Pedi-IKDC = pedi-IKDC outcomes questionnaire, Lysholm = Lysholm outcomes questionnaire

[a]Possible or definite tear based on radiological report

[b]Based on intraoperative findings and report

[1]<6 months was considered to be less than or equal to 183 days, total patients in group was 62

[2]>6 months was considered greater than 183 days, total patients in group was 59

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Table 2

Comparison of surgical wait time groups >6 months versus <6 months

	SWT > 6 mo	SWT < 6 mo	Statistical significance
Medial tears	50 %	21 %	$p = 0.0001$
Surgical procedure: debridement	47.8 %	70 %	n.s.
Lateral tears	55.5 %	48 %	n.s.
Surgical procedure: debridement	46.2 %	55 %	n.s.
Significant tears	63 %	42 %	$p = 0.02$, OR = 2.3
Significant medial tears	39 %	19 %	$p = 0.01$, OR = 2.6
Significant lateral tears	35 %	27 %	n.s.
Irreparable tears	39 %	25 %	n.s.
Lysholm preop score	58	74	$p < 0.001$
Pedi-IKDC preop score	52	61	$p = 0.007$

Values presented are the percentage of tears in surgical wait time (SWT) groups >6 months and < 6 months. Insignificant tear = grades 0, 1. Significant tear = grades 2, 3, 4, 5. Preoperative scores were also compared for SWT groups. Lysholm = Lysholm outcomes questionnaire. Pedi-IKDC = Pedi-IKDC outcomes questionnaire. *p* values are from Student's 2-tailed *t* test

OR—odds ratio

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Table 3

Comparison of medial versus lateral tears for surgical wait time groups

Group	Medial tears *n* (%)	Lateral tears *n* (%)	Statistical significance
<3 months	7 (20.5)	15 (44.0)	n.s.
3–6 months	7 (21.2)	17 (51.5)	$p = 0.04$
6–9 months	9 (52.9 %)	8 (47.0)	n.s.
9–12 months	10 (62.5)	9 (56.3)	n.s.
>12 months	8 (38.1)	13 (61.9)	n.s.

Values presented are the percentage of tears in surgical wait time groups <3 months and 3–6 months. *p* values are from Student's 2-tailed *t* test

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Table 4

Preop to postop change in outcome score

	Lysholm	*n*	*p* value	Pedi-IKDC	*n*	*p* value
Surgical wait time <6 mo	16.6	23	0.07	24.5	24	n.s.
Surgical wait time >6 mo	23.7	29		25.5	29	
Insignificant tear	17.5	24	0.12	21	24	0.05
Significant tear	23.2	28		28.4	29	
Non-irreparable tear	23.4	36	n.s.	23.4	36	n.s.
Irreparable tear	26.9	16		28.6	17	

Values presented are the average change in score from preop to postop within each labelled group, for the given number of patients, *n*. Insignificant tear = grades 0, 1. Significant tear = grades 2, 3, 4, 5. Non-irreparable tear = grades 0, 1, 2, 3. Irreparable tear = grades 4, 5. Lysholm = Lysholm outcomes questionnaire. Pedi-IKDC = Pedi-IKDC outcomes questionnaire. *p* values are from Student's two-tailed *t* test

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Table 5

Comparison of insurance type

	PI (%)	GI (%)	Statistical significance
Surgical wait time >3 mo	15	85	$p < 0.001$, OR 12.4
Surgical wait time <3 mo	68	32	
Surgical wait time >6 mo	9	91	$p < 0.001$, OR 7.8
Surgical wait time <6 mo	42	58	
Irreparable tear: all	22.5	33	n.s.
Irreparable tear: lateral	19	20	n.s.
Irreparable tear: medial	3	14	n.s.
Significant tear: all	35	57	$p = 0.03$, OR 2.5
Significant tear: lateral	32	31	n.s.
Significant tear: medial	13	34	$p = 0.029$, OR 3.5

Values presented are the percentage of tears in insurance groups PI = Private Insurance and GI = Government Insurance. Surgical wait time = surgical wait time. Significant tear = grades 2, 3, 4, 5. Irreparable tear = grades 4, 5. *p* values are from Fisher's exact test (surgical wait time) or Student's two-tailed *t* test (tear severity)

OR odds ratio