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Younger age and hamstring tendon graft are associated with higher IKDC 2000 and KOOS scores during the first year after ACL reconstruction

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Abstract

Purpose Although reference values in healthy subjects have been published for both the International Knee Documentation Committee 2000 subjective knee form (IKDC 2000) and the Knee injury and Osteoarthritis Outcome Score (KOOS), data obtained during the first year after anterior cruciate ligament reconstruction (ACL-R) are sparse. The aim was to establish patient reference values for both questionnaires at different time points and depending on nine individual patient characteristics during the first year after ACL-R.

Methods Prospectively recorded data from a hospital-based registry were retrospectively extracted from the database. IKDC 2000 and KOOS questionnaires were self-administered pre-operatively and 6 weeks, 3 months, and 6 and 12 months following primary ACL-R. Score values were compared according to nine individual patient criteria: gender, age, body mass index, level of activity, involvement in competition, previous contralateral knee injury and/or surgery, graft type, meniscal repair and/or cartilage lesions. The feature which had a significant and consistent impact on the outcomes was considered as main reference.

Results Two-hundred and nighty-eight patients met the inclusion criteria. Overall, the score values increased over time after ACL-R. At 12 months, they were significantly greater than at any other time point ($p < 0.05$). The main individual feature influencing the IKDC 2000 score was age. Patients below 30 years of age had up to 9 points higher IKDC 2000 score values at all time points ($p < 0.05$). The main individual characteristic influencing the KOOS score was graft type. Patients with hamstring tendon grafts (STGR) had up to 15 points higher KOOS score values than patients with bone–patellar tendon–bone (BPTB) grafts during the first months after ACL-R ($p < 0.05$). At 12 months, no differences in KOOS score values could be identified anymore.

Conclusions Younger age (< 30 years) and STGR grafts were related to higher IKDC 2000 and KOOS score values within the first year after primary ACL-R. The patient reference values adjusted to age and graft provided in this study may help to identify patients with lower outcomes within the first year after ACL-R.

Level of evidence Level III.

Keywords Anterior cruciate ligament reconstruction · IKDC 2000 · KOOS · Patient-reported outcome · PRO

Abbreviations

ADL	Activity of daily living
ACL	Anterior cruciate ligament
ACL-R	Anterior cruciate ligament reconstruction
BMI	Body mass index
BPTB	Bone–patellar tendon–bone graft
IKDC 2000	The International Knee Documentation Committee 2000 subjective knee form
KOOS	Knee injury and Osteoarthritis Outcome Score
MDC	Minimal detectable change
STGR	Hamstring tendon graft
QOL	Quality of life

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Introduction

The two most frequently used patient-reported outcomes (PRO) after anterior cruciate ligament (ACL) reconstruction are the International Knee Documentation Committee 2000 subjective knee form (IKDC 2000) and the Knee injury and Osteoarthritis Outcome Score (KOOS) [7, 20]. The former was developed for a variety of knee conditions [12] and has shown promising results in monitoring patient's progress within the first year after ACL reconstruction (ACL-R) [19]. The KOOS [25] is well known through Scandinavian registries which have reported KOOS scores from pre-operative to l, 2 and 5 years after ACL-R [14, 15]. For both IKDC 2000 [3] and KOOS scores [22], normative reference values have been published in healthy subjects stratified for sex and age.

The IKDC 2000 and the KOOS scores are still not used on a systematic basis for pre- and post-operative patient assessment. Although some publications report IKDC 2000 and KOOS scores within the first year after ACL-R, to the best of our knowledge, no generally applicable patient reference values have been published within the first months of the healing phase. Thus, the natural course of these patients during this critical period of time remains unknown. Such reference values may help surgeons and other healthcare professionals to identify patients with early poor post-operative outcomes. In addition to this, further analysis is required to identify the most impacting individual patient variables which have been previously reported to influence PRO after primary ACL-R [2, 6, 10, 13, 24, 27].

The main purpose of this study was to give an overview of IKDC 2000 and KOOS scores within the first year after ACL-R by establishing patient reference values at several time points. The second purpose was to individualize these references according to the most relevant individual patient characteristics. The present study was purely descriptive and aimed to describe the outcomes after ACL-R. As a consequence, no hypothesis was formulated. The obtained knowledge will help for post-operative guidance by early detection of patients with lower outcomes.

Materials and methods

Data were retrospectively extracted from a prospective hospital-based registry [28]. Patients with a primary ACL-R between 2011 and 2015 either with an ipsilateral bone–patellar tendon–bone (BPTB) autograft or a three- to four-strand hamstring tendon (STGR) autograft were considered. They were included regardless of their associated meniscal surgery (resection and repair) and/or cartilage damage. Patients were excluded if they had revision ACL-R.

Data collection

Data were prospectively collected by surgeons, physiotherapists, study nurses and researchers in their daily clinical practice and were saved in a secure database. The IKDC 2000 and the KOOS were self-administered pre-operatively (up to 60 days before ACL-R) as well as 6 weeks (range 76–137 days), 3 months (range 2.5–4.5 months), 6 months (range 5.5–7 months) and 12 (range 11–13 months) months after the ACL-R. The administration of the questionnaires was delayed to 8 weeks and 4 months for patients with a concomitant meniscal repair at the time of the ACL-R. All these appointments are standardized within the patient follow-up implemented in the institution. This approach allowed minimizing variability in outcomes.

At their first visit, the nurse recorded the patient's weight and height, and age, and asked about pre-injury level of activity (type of sport and involvement in competition) as well as their previous lower leg injuries. Standardized surgical protocols were filled in by the surgeon allowing gathering information on graft type, associated lesions to the medial/lateral menisci or to the cartilage.

Outcome variables

For both the IKDC and the KOOS questionnaires, scores were converted to a 0 (worst) to 100 (best) scale as previously recommended [12, 25]. The intraclass correlation coefficient of the IKDC score was previously reported to reach 0.90–0.95 [5]. Its minimal detectable change (MDC) ranges from 8.8 to 15.6 for similar pathologies. Across five subscales of the KOOS score, the ICC was 0.61–0.95 and the MDC ranges between 5 and 12 [5]. Both scores have been reported to have a high test–retest reliability (ICC > 0.81 for both scales); content validity: > 75% of relevant items for IKDC 2000 and Symptoms, Activity of daily living (ADL) and Quality of life (QOL) subscales of KOOS; and no floor effects [19].

Nine patient characteristics were analyzed: (1) gender (M/F), (2) age at injury was classified into two groups (< 30; ≥ 30 years of age) [4, 20], (3) body mass index (BMI below or above 25 kg/cm^2), (4) pre-injury level of activity classified according to Grindem et al. into three grades: level-I sports (handball, soccer, basketball), level-II sports (volleyball, gymnastics, tennis, alpine skiing), level-III sports (running, cycling, swimming) or non-regular sporting activities [10], (5) pre-injury involvement in competition, (6) previous injury/surgery to the contralateral knee, (7) graft type (BPTB/STGR), (8) meniscal repair, (9) cartilage

damage in the medial/lateral compartment of the knee (Outerbridge grade II–IV) [21].

All patients signed a written informed consent to enter this study approved by the National Ethics Committee for Research (N°201101/05 version 1.0). Data acquisition was reported to the National Data Protection Committee.

Statistical analysis

SPSS software version 22.0 (IBM Statistical Package of Social Sciences) was used for all statistical analyses. The normality of distribution of the IKDC 2000 score and KOOS subscales were tested using the Kolmogorov–Smirnov test for all evaluation periods.

First, IKDC 2000 and KOOS subscale scores were compared throughout the follow-up (pre-operative, 6 weeks, and 3, 6 and 12 months after the ACL-R) using ANOVA or Kruskal–Wallis tests if the scores were not normally distributed. Bonferroni correction was used for pairwise comparisons.

If the IKDC 2000 and all the KOOS subscale outcomes were normally distributed, ANOVAs were used to compare whether the outcomes differed between patient characteristic subgroups. The results were reported as mean (±) standard deviation (SD). If the outcomes were not normally distributed, Kruskal–Wallis tests were used to compare whether the outcomes differed between patient characteristic subgroups. Results were then reported as median and interquartile range (IQR). Bonferroni correction was used for pairwise comparisons.

To establish reference values for both IKDC 2000 and KOOS subscales, the patient characteristic which had a significant and consistent impact on the outcomes amongst the five periods of follow-up was considered. Consistency was assessed looking at the number of studied time points (pre-operative, 6 weeks, and 3, 6 and 12 months) where the variable significantly influenced the outcome. A variable impacting the outcome at five time points was considered as more consistent than another impacting at only three time points and was prioritized to establish reference values. Once the outcome variable of interest was selected, independent t-tests were used to compare group characteristics to appreciate potential confounding factors. The level of significance was set as $p \leq 0.05$ for all analyses.

Results

Two-hundred ninety-eight patients met the inclusion criteria and gave their consent (204 males; 94 females). The mean age for males was 28 ± 9 years and for females 30 ± 12 years. Overall, 32% of patients were females. 61% were below 30 years of age, 60% had a BMI lower than 25 kg/m^2, 63% were involved in a level I sport before the injury, 63% were involved in competition before the injury, 16% had a previous injury to the contralateral knee, 49% received a BPTB graft, 40% had a meniscal repair at the time of the ACL-R and 24% had a cartilage damage. The IKDC 2000 and the KOOS were available pre-operatively for 160 patients, at 6/8 weeks for 158 patients, at 3/4 months for 224 patients, at 6 months for 180 patients and at 12 months for 86 patients.

Overall score values throughout the follow-up

Normal distribution was only observed for the IKDC 2000 score pre-operatively and at 6/8 weeks after surgery. It was thus decided to report medians and IQR (Table 1). Overall, the score values increased over time after the ACL-R and the values at 12 months were significantly higher than at any moment of the follow-up. Pairwise comparisons showed that the KOOS-Pain score differed at all time points. For the IKDC 2000, KOOS symptoms, KOOS-ADL and KOOS-Sport/rec, all scores differed except between the pre-operative and the 3-month post-operative assessment. Finally, for KOOS-QOL, pre-operative and 6/8-week assessment as well as 3- and 6-month assessment were not significantly different.

IKDC 2000

Younger age, BMI below 25 kg/cm^2, previous involvement in competitive sports and STGR graft type significantly led to a higher IKDC 2000 score at minimum three periods of the follow-up (Table 2). Age was the only characteristic impacting the score at all time points and patient reference values were established accordingly (Fig. 1). At any time of the follow-up, patients under 30 years of age had significantly greater scores than patients above 30 years of age ($p < 0.05$). The older group displayed more often a BMI above 25 kg/cm^2 (53% vs 31% for under 30 years of age), had more cartilage lesions graded II–IV (39% vs 13% for under 30 years of age) and were less involved into competitive (31% vs 84% for under 30 years of age) and level I sports (36% vs 81% for under 30 years of age).

KOOS

The type of graft significantly influenced the following KOOS subscales during the follow-up: pain, ADL, Sport/Rec and QOL (Table 3). Patients with STGR grafts showed significantly higher median scores in pain, ADL, Sport/Rec and QOL at 6/8 weeks, 3\4 months and 6 months ($p < 0.05$), compared to BPTB. No difference existed between different graft groups neither in the pre-operative KOOS scores nor at 12 months after surgery. The patient reference values of the KOOS score were, therefore,

Table 1 IKDC 2000 and KOOS subscales (median and IQR) in patients with primary ACL reconstruction

Number of patients	Pre-operative 160	6/8 weeks 158	3/4 months 224	6 months 180	12 months 86
IKDC 2000*					
Median	65[b]	57[a]	72[b]	80[a]	93[a]
IQR	[54–77]	[46–64]	[61–78]	[69–89]	[85–97]
Range	11–99	13–99	26–100	28–100	32–100
KOOS - Symptoms*					
Median	75[b]	68[a]	79[b]	86[a]	93[a]
IQR	[61–89]	[57–79]	[68–86]	[75–93]	[86–96]
Range	18–100	25–96	21–100	25–100	64–100
KOOS - Pain*					
Median	78[a]	75[a]	86[a]	92[a]	97[a]
IQR	[67–89]	[58–83]	[78–94]	[81–97]	[92–100]
Range	17–100	17–100	31–100	39–100	58–100
KOOS - ADL*					
Median	91[b]	81[a]	94[b]	97[a]	100[a]
IQR	[78–97]	[66–91]	[84–99]	[93–100]	[98–100]
Range	21–100	18–100	0–100	44–100	72–100
KOOS - Sport/Rec*					
Median	60[b]	35[a]	60[b]	75[a]	90[a]
IQR	[40–75]	[14–55]	[40–75]	[65–90]	[80–96]
Range	0–100	0–100	0–100	5–100	20–100
KOOS - QoL*					
Median	38[c]	38[c]	56[d]	63[d]	81[a]
IQR	[25–50]	[25–56]	[38–69]	[50–75]	[69–94]
Range	0–100	0–100	0–100	13–100	19–100

* $p < 0.05$ Score significantly differed throughout the follow-up of the patient

[a]Score significantly differed from all other times points

[b]Score significantly differed from 6/8 weeks, 6 months and 12 months after surgery

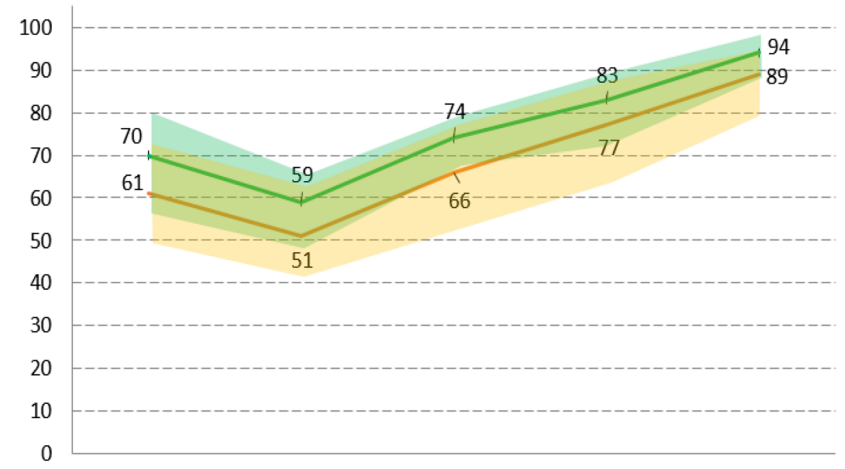
[c]Score significantly differed from 3 months, 6 months and 12 months after surgery

[d]Score significantly differed from pre-operative, 6/8 weeks and 12 months after surgery

Table 2 Overview the median IKDC 2000 score values according to patient characteristics

Number of patients	Pre-operative 160	6/8 weeks 158	3/4 months 224	6 months 180	12 months 86
Gender (male/female)	67/64	57/55	72/72	82/79	92/94
Age (< 30 / ≥ 30 years old)	70/61*	59/51*	74/66*	83/77*	94/89*
BMI (< 25 / > 25 kg/m^2)	70/61*	55/59	72/71*	82/77*	94/87*
Pre-injury level of activity (level I/II/III)	68/66/61	57/49/56	74/71/68*	83/77/79	94/86/91
Competitive sports (no/yes)	63/70*	53/57	66/74*	77/83*	87/94*
Contralateral knee injury (no/yes)	67/61	57/53	72/70	83/75*	93/87
Graft (BPTB/STGR)	67/64	53/59*	69/75*	77/84*	92/94
Meniscal repair (no/yes)	64/69	57/55	71/73	83/78	92/93
Cartilage (Grade 0–I/II–IV)	70/60*	55/59	72/75	79/83	93/93

*Patient characteristic significantly influenced the IKDC 2000 score ($p < 0.05$)



N		Preoperative 160	6/8 weeks 158	3/4 months 224	6 months 180	12 months 86
< 30 years	IQR	[56-80]	[48-65]	[67-79]	[72-89]	[88-98]
	Range	11-99	15-99	39-100	44-100	66-100
≥ 30 years	IQR	[49-72]	[41-62]	[52-77]	[63-87]	[79-95]
	Range	33-85	13-79	26-98	28-100	32-100

Fig. 1 Normative reference of IKDC 2000 (median, IQR, range) in patients after primary ACL reconstruction in different age groups (< 30 years and ≥ 30 years). Patients under the age of 30 had significantly 6–9 points higher IKDC 2000 scores at all analyzed time points ($p < 0.05$)

established according to whether BPTB or STGR graft was used (Fig. 2). Patients with BPTB grafts were more likely to be males (81% vs 56% in STGR grafts), involved in competition (70% vs 56% in STGR grafts) and level I sports (73% vs 53% in STGR grafts).

Discussion

The main finding of the study was that the values of the KOOS and IKDC 2000 scores increased at every time point during the first year after ACL-R and that they were mostly influenced by graft type and age, respectively. In comparison with patients above 30 years of age, younger patients (< 30) had consistently higher IKDC 2000 median score values (6–9 points) before and during the first year after surgery. The median values of the KOOS score in patients with STGR ACL-R were 2–15 higher in comparison with patients with BPTB grafts during the first 6 months following surgery, but with no difference observed at 1 year.

An inverse correlation between the IKDC 2000 score and age has previously been reported in healthy subjects, with significantly lower score values in subjects over 35 years of age [3]. These findings suggest that the lower IKDC 2000 score values observed in patients over 30 in the present study may be related to age rather than to the type of ACL-R or other individual patient characteristics. In a study on 88 patients operated with STGR between 2002 and 2010, Fabio et al. [7] did not find statistically significant differences in the mean IKDC 2000 score at an average follow-up of 3, 5 years between patients below 30, from 30 to 40 and over 40 years at the time of the ACL-R. This is in contrast to the present study where patients over 30 years of age had lower IKDC 2000 scores. However, the latter were also more likely to have a BMI above 25 kg/cm^2 and grade II–IV cartilage lesions, and were less involved in competitive and level I sports [23]. Likewise, BMI, pre-injury involvement in competitive sports and graft type did also influence the IKDC 2000 score at one or several time points after surgery. These factors may, therefore, be considered in future studies to establish even more precise patient reference values. In this respect, it should be stated that it was not the aim of the present study to identify predictive factors for poor outcomes.

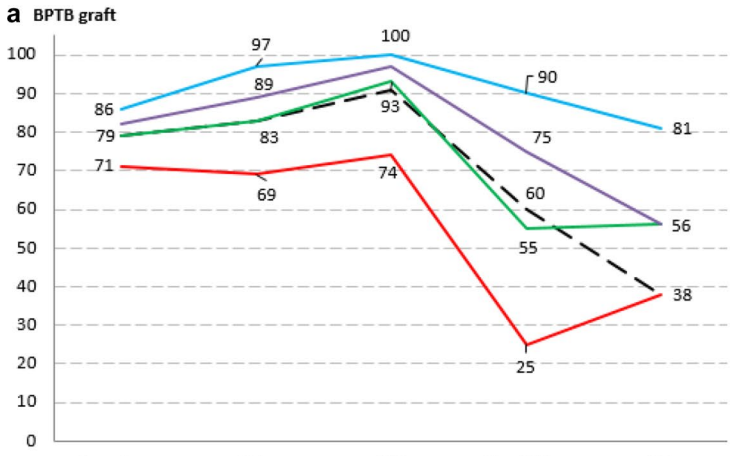
Previous studies reported some association between post-operative IKDC 2000 score and pre-operative BMI [13, 26]. A BMI above 25 kg/cm^2 resulted in lower IKDC 2000 score values before, and 3, 6 and 12 months after surgery in the present study. Further studies are needed to conclude on the relevance of this finding as it has been suggested that BMI was not a strong clinical predictor of IKDC 2000 [23]. Interestingly, patients with a pre-operative BMI lower than 25 kg/m^2 were identified to have significantly higher IKDC 2000 scores already at the pre-operative state. Likewise, patients who were involved in competitive sports had higher pre-operative scores (median 6–8 points). The reasons for this are not known, but it appears that these two factors increase the likelihood to higher scores after injury, hence suggesting that post-operative differences were not necessarily related to the ACL-R itself. Finally, patients with a BPTB graft had lower outcomes than patients with STGR graft within the first months after the ACL-R but this difference was not observed anymore at 12 months. They were more likely to be males,

Table 3 Overview of the median KOOS score values according to patient characteristics

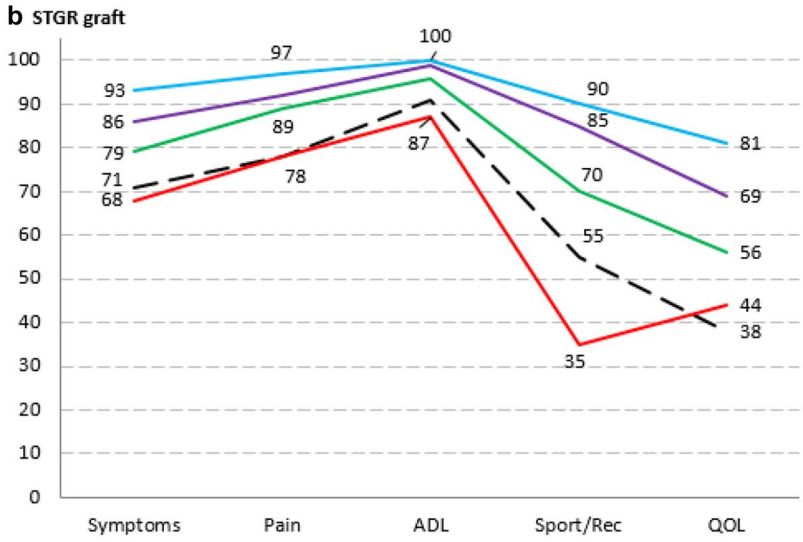
	Pre-operative ($n=160$)					6/8 weeks ($n=158$)					3/4 months ($n=226$)					6 months ($n=182$)					12 months ($n=88$)				
	S	P	ADL	SP	QoL	S	P	ADL	SP	QoL	S	P	ADL	SP	QoL	S	P	ADL	SP	QoL	S	P	ADL	SP	QoL
Gender (male/female)				63/55																	88/96				
Age (< 30 /≥ 30 years old)								85/75				89/86	96/91	65/60					80/75						
BMI (< 25 / > 25 kg/m^2)	79/71		93/85					85/76										99/96	80/75						
Pre-injury level of activity (level I/II/III)																									
Competitive sports (no/yes)								77/84						55/65					75/80						
Contralateral knee injury (no/yes)																		99/94							
Graft (BPTB/STGR)							69/78	74/87	25/35	38/44		83/89	93/96	55/70			89/92	97/99	75/85	56/69					
Meniscal repair (no/yes)													93/96												
Cartilage (Grade 0–I/II–IV)																									

Only significant differences ($p < 0.05$) are reported

KOOS subscales *S* symptoms, *P* pain, *ADL* activity of daily living, *SP* sports, *QoL* quality of life



		Symptoms	Pain	ADL	Sport/Rec	QOL
Preoperative (n=75)	IQR	[64-89]	[72-92]	[81-97]	[40-80]	[25-50]
	Range	43-100	42-100	40-100	0-100	0-100
6/8 weeks (n=78)	IQR	[56-79]	[56-81]	[62-87]	[10-45]	[19-50]
	Range	25-96	17-97	18-100	0-100	0-94
3/4 months (n=112)	IQR	[68-86]	[78-92]	[81-97]	[35-70]	[38-69]
	Range	36-100	36-100	0-100	0-100	0-100
6 months (n=92)	IQR	[71-93]	[79-97]	[91-100]	[56-85]	[44-75]
	Range	50-100	47-100	46-100	5-100	13-100
12 months (n=41)	IQR	[86-98]	[89-100]	[98-100]	[80-98]	[69-94]
	Range	71-100	58-100	72-100	20-100	25-100



	Symptoms	Pain	ADL	Sport/Rec	QOL
Preoperative (n=85)	[56-86]	[63-89]	[75-97]	[31-74]	[25-53]
	18-100	17-100	21-100	0-100	0-100
6/8 weeks (n=80)	[58-79]	[63-86]*	[75-93]*	[20-65]*	[25-63]*
	36-96	33-100	45-100	0-100	6-100
3/4 months (n=112)	[65-86]	[79-94]*	[88-99]*	[45-80]*	[40-74]
	21-100	31-100	34-100	0-100	6-100
6 months (n=88)	[79-93]	[89-97]*	[96-100]*	[70-94]*	[56-81]*
	25-100	39-100	46-100	5-100	13-100
12 months (n=45)	[86-96]	[92-100]	[98-100]	[85-98]	[69-94]
	64-100	72-100	75-100	30-100	19-100

Fig. 2 Normative reference of KOOS subscales (median and IQR) in patients with primary ACL reconstruction according to different graft type: **a** BPTB, **b** STGR. *Median score for STGR patients was significantly higher compared to BPTB patients, $p < 0.05$

involved in competition and level I sports, which reflect a pre-operative selection bias. Some of these characteristics may act as confounding factors and future studies should help to better understand the interaction between them.

As for the KOOS score, the main individual influencing variable during the first months of the follow-up period was the type of graft. Patients with BPTB grafts had lower KOOS score values than patients with STGR grafts. The former were more likely to be males although males have been previously associated with higher scores [16, 29]. The patients received a STGR or BPTB graft according to surgeon's preference and level of sports participation. Those with BPTB grafts were more likely to be involved in competitive and level I sports. Despite significant differences during the first 6 post-operative months, score values between BPTB and STGR patients equalized at 12 months after surgery for all KOOS subscales. This is comparable to previous publications reporting no differences between graft types at 12 months after surgery, except for the subscales ADL and Sport/Rec [18, 24]. Kvist et al. [14] reported significant differences in the mean KOOS scores between BPTB and STGR patients at 1 year after surgery but the differences accounted for only 1–2 points which may not be a clinically relevant difference [5]. Further investigations are needed to better understand the reasons of these findings.

Associated meniscal repair did not affect the KOOS score. In the IKDC 2000 score, a small difference could be identified after 3–4 months with repaired patients showing a higher IKDC score. This is surprising because meniscal repair is generally considered to slow down the rehabilitation process after ACL-R because patients' knees are immobilized with a brace and range of motion is restricted to 0°–0°–90° during the first 6 weeks after surgery. The data indicate that this additional surgical procedure has no or only a minor effect on the patients' short-term outcome. One year may not be long enough to assess potential negative effects of associated injuries. It is not known here whether meniscal repair or cartilage status at the time of ACL-R will be predictive of lower IKDC-2000 and KOOS in the long term as previously shown [2, 6, 8].

It is still debated which score is the most appropriate for patient follow-up after ACL-R. Within the first year after ACL-R, the IKDC 2000 score has been reported to outperform the KOOS score and may thus be more appropriate [11, 17]. It was found to have a higher clinical relevance (89%), no ceiling effect, and an acceptable construct validity (more than 75%) and responsiveness (86%) for patients with an ACL injury [19]. In the present study, measurement properties of the IKDC 2000 and KOOS scores were not evaluated. However, the ceiling effect (most of the patients score rapidly near the maximum score of 100) could easily be observed for pain and ADL subscales of the KOOS score at 6- and 12-month follow-up. At the opposite, the KOOS score is thought to be more reliable to assess the long-term consequences of ACL injuries which is the reason why both questionnaires were implemented in our institution [28].

Overall, the KOOS and IKDC 2000 score values increased over time after ACL-R. At 12 months, they were significantly greater than at any other moment of the follow-up period. This is in line with a recent systematic review [1], showing that clinically significant improvements occurred in the KOOS score up to 1 year and in the IKDC score up to 6 months after surgery. No further improvement could be observed from 12 to 24 months after the ACL-R. KOOS score values at 1 year after primary ACL-R were higher in the present study in comparison with previous reports from the Danish [15], the UK [9] and the Swedish ACL registries [14]. This may be related to the fact that the present data were obtained from a single institution, unlike national registries which include a high number of centres. This may suggest that standardized care in a single centre can have a positive influence on the surgical outcome.

The study is not without limitations. The number of patients varied at each time point of the follow-up period. This may have influenced the score values in either direction. However, it can be assumed that the large number of patients in comparison with previous studies may have counterbalanced this effect. Nevertheless, future studies should take this potential weakness into consideration. The aim of the study was not to identify predictive factors for lower outcomes but to establish the baseline of what should be considered as a normal evolution during the first year after ACL-R. ACL patients displayed different subjective scores according to their age and to the graft they received. The observed differences were not only statistically significant but they also reached the MDC [5] suggesting a true difference beyond measurement error. Although the authors agree that many other factors than age and graft may influence PRO scores, the goal of the study was to provide a first rough description of their evolution during the first months after ACL-R before considering an even more complex analysis. The reported results may provide a good representation of the reality of daily clinical care due to the large number of included patients and may thus be generalizable to other populations (external validity). Orthopaedic surgeons and rehabilitation specialists may use the obtained values, stratified according to age and graft, to identify patient with lower outcomes early after ACL reconstruction. It will help them to provide patients with a better post-operative guidance.

Conclusion

This study provides patient reference values according to age at injury for the IKDC 2000 score and graft type for the KOOS score within the first year after primary ACL-R.

Patients under the age of 30 had consistently higher IKDC 2000 score values. Patients with STGR graft had higher KOOS median scores than BPTB patients during the first 6 months following the ACL-R. No differences were observed at 12 months after ACL-R. These reference values may help for post-operative treatment guidance and eventually early detection of patients with lower outcomes.

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Compliance with ethical standards

Conflict of interest Nina Magnitskaya, Caroline Mouton, Alli Gokeler, Christian Nuehrenboerger, Dietrich Pape and Romain Seil declare that they have no conflict of interest.

Ethical approval All patients signed a written informed consent to enter this study approved by the National Ethics Committee for Research (N°201101/05 version 1.0). Data acquisition was reported to the National Data Protection Committee.

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