Original Article

Low Preoperative Brief Resilience Scale Scores Are Associated With Inferior Preoperative and Short-Term Postoperative Patient Outcomes Following Primary Autograft Anterior Cruciate Ligament Reconstruction

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Purpose: To assess preoperative Brief Resilience Scale (BRS) scores as they relate to postoperative patient outcomes following primary autograft anterior cruciate ligament reconstruction (ACLR). **Methods:** All patients who underwent primary autograft ACLR from 2016 to 2021 and had a patient-reported follow-up of 1 year and a clinical follow-up of 6 months were included in final data analysis. Patients completed validated PROMs pre- and postoperatively. All patients were objectively assessed with range of motion (ROM) and KT-1000 arthrometer testing. Return to sport (RTS) data were obtained for all applicable patients. Patients were divided into 3 groups based on ± ½ the standard deviation for the mean preoperative BRS score. **Results:** In total, 170 patients who underwent primary autograft ACLR with a mean age of 20.1 years (range, 13-57 years) and a mean final follow-up time of 2.9 years (range, 1.0-5.8 years) were included in the final analysis. The mean preoperative BRS scores for the high-resilience (HR, n = 67), average-resilience (AR, n = 42), and low-resilience (LR, n = 61) groups were 28.1 (95% CI, 27.8-28.9), 24.5 (95% CI, 24.3-24.6), and 21.1 (95% CI, 20.5-21.7), respectively ($P < .001$). The HR group demonstrated significantly higher preoperative and postoperative patient-reported outcome measures (PROMs) compared to the AR and LR groups, with more differences seen with the LR group. The HR group demonstrated better knee extension in postoperative month 3 compared to the LR group (0.6° [95% CI, −1.2° to 0.1°] vs −2.3° [95% CI, −3.3° to −1.3°], $P = .006$). The HR group demonstrated a faster RTS time compared to the LR group (6.4 months [95% CI, 6.1-6.7] vs 7.6 months [95% CI, 7.1-8.1], $P = .002$). No differences were seen in RTS rate, knee flexion, or KT-1000 arthrometer measurements between the 3 groups. **Conclusions:** Low preoperative BRS scores were associated with inferior PROMs preoperatively and in the short-term postoperative period compared to those with higher preoperative BRS scores. Additionally, patients with lower preoperative BRS scores demonstrated a higher degree of knee extension loss 3 months postoperatively as well as a slower RTS. **Level of Evidence:** Level III, retrospective cohort study.

Anterior cruciate ligament (ACL) rupture is a common activity-related injury that can lead to substantial functional impairment with a long recovery process.[1,2] Surgical intervention is often indicated, especially in younger and more active patients, to restore knee stability and function.[3,4] Outcomes following ACL surgery have improved with advances in surgical technique and accelerated rehabilitation protocols.[5,6] Nonetheless, extension deficit following ACL reconstruction (ACLR) is still a relatively common complication with a reported incidence of 5% to 14%.[7] Loss of extension in patients who have undergone ACLR may lead to poor clinical outcomes such as construct failure and early-onset osteoarthritis.[8-11]

Patient resilience may help explain why some individuals psychologically respond to physiologic stress better than others.[12,13] The Brief Resilience Scale (BRS) is a 6-item questionnaire that is a means of assessing

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resilience as the ability to bounce back or recover from stress, and it may provide unique and important information about people coping with health-related stressors such as surgery.[14,15] While there are multiple resilience measurement scales, the BRS has proven to be among the best with psychometric ratings[15] and may prove to be useful in postoperative patient management following orthopaedic surgery.

Otlans et al.[16] demonstrated that resilience may contribute to favorable mental health and physical function following orthopaedic surgery. However, conflicting outcomes in current orthopaedic literature make it difficult to conclude that preoperative resilience scores are associated with postsurgical outcomes.[17-28] The BRS survey asks questions relating to the willpower of the patient such as, "I tend to bounce back quickly after hard times," and "I tend to take a long time to get over setbacks in my life."[14] Based on how a patient scores, it may be possible to gauge how well a patient may respond to the news of being diagnosed with an injury that requires surgical intervention and ultimately how they may cope with the postoperative rehabilitation process. Of the 4 published studies describing resilience scores in patients undergoing arthroscopic knee procedures,[18,21,27,28] 2 describe postoperative resilience in patients who underwent ACLR.[27,28] It is unknown whether administering the BRS survey preoperatively will relate to postoperative patient outcomes following ACLR.

The purpose of this study was to assess preoperative BRS scores as they relate to postoperative patient outcomes following primary autograft ACLR. We hypothesized that lower preoperative BRS scores will be associated with an increased risk of a postoperative extension deficit—defined as a loss of ≥5° of full knee extension—and worse patient-reported outcome measures (PROMs).

Methods

Study Design

Institutional review board approval was obtained prior to the induction of this study. This is a single-center retrospective cohort study examining all patients who underwent primary autograft ACLR with suture tape augmentation (STA) by the senior author (P.A.S.) and completed a preoperative BRS survey from 2016 and 2021 were considered for this study.

Inclusion and Exclusion Criteria

All skeletally mature patients aged ≥13 years who underwent primary autograft ACLR by the senior author and had at least a 1-year patient-reported follow-up via our institution's registry and at least a 6-month clinical follow-up in their patient chart were included. Those who received a revision ACLR, primary autograft ACLR without STA, primary allograft ACLR, primary ACL repair, and primary epiphyseal-sparing ACLR were excluded from final data analysis. Those with either inadequate patient-reported or clinical follow-up were deemed lost to follow-up and also excluded from the final analysis. All adolescent patients received preoperative hand radiographs to determine bone age prior to their procedure, which was correlated along with knee growth plate closure and Tanner staging for consideration of growth plate—sparing ACLR.

Data Collection

Each patient was consented prior to completing the BRS survey and prior to being enrolled in our institution's registry. Preoperative BRS surveys were collected (Fig 1) by qualified research personnel with the senior author blinded to the individual patient scores. The BRS surveys were completed via paper copy and were used for the initial eligibility screening of patients. Those who completed a BRS survey but were not enrolled in our institution's registry and vice versa were excluded from final data analysis. The medical record and operative notes were reviewed to determine intraoperative characteristics such as graft type and concomitant procedures. Demographical data included age, sex, body mass index (BMI), and clinical information from the senior author's office notes. Clinical data that were collected included knee range of motion (ROM), which was assessed at each office visit along with KT-1000 arthrometer (MEDmetric) measurements that were collected preoperatively and at final follow-up by qualified research personnel who were blinded to pertinent physical examination findings. KT-1000 testing was performed with the knee at approximately 25° of knee flexion. Most patients had a final clinical follow-up of 1 year; however, some only had a documented final clinical follow-up of 6 to 11 months as they may have been fully cleared to return to sport (RTS) at that time. Additional data included the need for subsequent nonoperative and operative interventions aimed to treat any residual extension deficit. Nonoperative treatment for residual extension deficits included treatment with a dynamic extension splint (Mackie Knee Brace; Ortho Innovations), 1 to 2 additional physical therapy (PT) days a week, and 1 week of short-term oral corticosteroids (Medrol Dosepak, 4 mg; Pfizer).

Our institution's registry was queried to identify the patients with adequate patient-reported follow-up. All patients who had at least 1-year PROM follow-up were included in the final analysis. PROMs including the International Knee Documentation Committee (IKDC),[29] Lysholm knee survey and Tegner activity scale,[30] Veteran's Rand 12-item health survey (VR12),[31] Knee Injury and Osteoarthritis Outcome

Fig 1. The Brief Resilience Scale (BRS).[10]

Instructions: Use the following scale and __circle__ one number for each statement to indicate how much you disagree or agree with each of the statements.

1 = Strongly Disagree   2 = Disagree   3 = Neutral   4 = Agree   5 = Strongly Agree

1. I tend to bounce back quickly after hard times........................	1	2	3	4	5
2. I have a hard time making it through stressful events.................	1	2	3	4	5
3. It does not take me long to recover from a stressful event...........	1	2	3	4	5
4. It is hard for me to snap back when something bad happens.........	1	2	3	4	5
5. I usually come through difficult times with little trouble.............	1	2	3	4	5
6. I tend to take a long time to get over set-backs in my life...........	1	2	3	4	5

Scoring: The BRS is scored by first reverse coding items 2, 4, and 6 and then taking the mean of the all the items. Since the items are scored between 1 and 5, the mean you obtain would be between 1 and 5.

Fig. 1

The BRS. (Reproduced with permission from Bruce W. Smith, PhD.)

Score (KOOS) survey,[32] and the Marx Activity Rating Scale[33] were obtained through our institution's registry preoperatively and at the 3-month, 6-month, 1-year, 2-year, and 5-year postoperative time points, if applicable.

Surgical Technique

ACLR using either a quadrupled semitendinosis or all soft tissue full-thickness quadriceps tendon autografts were all performed via an all-inside technique using femoral (ACL TightRope II; Arthrex) and tibial suspensory button (TightRope ABS Button; Arthrex) adjustable loop fixation.[34] ACLR with bone—patellar tendon—bone (BTB) autografts were performed with a full tibial tunnel and fixed proximally using suspensory fixation in the same manner as the soft tissue grafts and distally with an interference screw (BioComposite; Arthrex).[35] All femoral sockets were created through anteromedial portal drilling. For those receiving suture tape augmentation (FiberTape; Arthrex) to act as an internal brace (IB) (InternalBrace; Arthrex), the IB was passed through the femoral suspensory button and fixed first independently of the graft using a bio-absorbable anchor (BioComposite SwiveLock C, 4.75 × 19.1 mm; Arthrex) on the tibia with the knee held in full hyperextension.[34-36] Tibial graft fixation was always done following final IB fixation while the knee was fully hyperextended. In all cases, the knee was cycled intraoperatively approximately 20 times, and graft retensioning was done on both the femoral and tibial sides for the all-inside ACLR constructs in full hyperextension. For BTB grafts, final graft retensioning was only done proximally, also in full hyperextension.

Additional pathologies such as meniscal tears and chondral lesions were addressed prior to the ACL procedure. Needed extra-articular procedures such as medial collateral ligament (MCL) repair vs reconstruction or anterolateral ligament reconstruction (ALLR) were performed following the ACL procedure.

Postoperative Rehabilitation and Clinical Data

An accelerated rehabilitation protocol[5] was initiated for all patients emphasizing early ROM with a take-home continuous passive motion (CPM) machine (KinexCONNECT; Kinex Medical Company) for the first 2 weeks postoperatively with instruction to use at least 8 hours a day. Supervised PT was prescribed twice a week beginning on postoperative day 2, with a focus on patellar mobilization, and quadriceps strengthening in full extension, emphasizing straight-leg raises without an extensor lag. Passive stretching for full extension was encouraged as needed. Use of a stationary exercise bike for active knee flexion was initiated 2 weeks postoperatively. Weightbearing status was dependent on type of meniscal repair and patients' demonstration of good quadriceps function and overall leg control. Patients generally achieved full weightbearing status by postoperative week 3. Closed-chain exercises were initiated once the patient achieved full weightbearing status.

Patients were routinely seen in the office at 2 weeks, 10 weeks, 6 months, and 1 year postoperatively. However, additional visits were scheduled as needed to address motion problems. For all patients, ROM was assessed with the patient in the supine position. The senior author measured flexion loss with a goniometer and extension deficit with both a goniometer and with popliteal distance from a flat examination table.

If a patient was found to have a severe extension deficit following the initial postoperative visit, they were administered nonoperative means to aid in the correction of this deficit based on clinical judgment.

All patients who were found to have an extension deficit ≥5° were given an extension splint (Mackie Knee Brace; Ortho Innovations) to be worn at home and were particularly encouraged to wear them overnight. Additional nonoperative interventions included an upgrade in PT from 1 to 2 times per week to 3 to 4 times per week and the administration of 1-week low-dose oral corticosteroids (4 mg Medrol Dosepak). The low-dose steroids were administered to those with moderate to severe swelling about the anterior aspect of the knee, which would have been associated with a more severe deficit and extension lag. Of note, a patient may have only necessitated treatment with an extension splint alone while others may have necessitated treatment with all 3 depending clinical presentation. There was no formal protocol detailing the timeline for when these treatments started; however, they may have been started as early as postoperative week 5 or as late as postoperative week 10 depending on the severity of the extension deficit and communication between the patients, the senior author, and the physical therapists.

Statistical Analysis

It was determined that at least 39 patients would be needed in each group to detect a difference in postoperative knee extension when α is set to 0.05 with a β of 0.80. Patients were divided into 3 groups based on mean ± ½ standard deviation. For continuous variables, the normality of the distribution was assessed using the Shapiro-Wilk test. The Mann-Whitney *U* test or the Student *t* test was used to assess continuous variables based on the normality of the distribution. Further pairwise comparison was assessed via the Wilcoxon each pair test or an analysis of variance. Continuous variables were defined as either mean (95% CI) or median (interquartile range). The Cox proportional hazards model was performed to determine relationships between outcomes and continuous variables and are represented with 95% CIs (Wald test). Categorical variables were assessed using either the χ^2 or Fisher exact test and were represented as absolute frequency (percentage). The Fisher exact test was used when cell counts were fewer than 20, when a cell had a value of less than 5, and/or when values for a column or row were uneven. Nominal logistic regression analyses were performed to determine relationships between outcomes and categorical variables and are represented with 95% CIs (Wald test). Data analyses were performed using JMP, Version 17 (SAS Institute). For statistical analysis in this study, $P < .05$ was considered statistically significant. An a priori power analysis was not performed since all available patients were included in final data analysis.

Results

A total of 303 potentially eligible patients completed a preoperative BRS survey. Of these potentially eligible patients, 277 (91.7%) patients were enrolled in our institution's registry. Of the patients enrolled in our institution's registry, 250 (90.3%) had adequate patient-reported follow-up. Based on exclusion criteria, patients were excluded to revision (n = 15), ACL repair (n = 21), allograft ACLR (n = 8), epiphyseal-sparing ACLR (n = 3), and nonaugmented primary ACLR (n = 15), leaving a total of 188 patients who remained eligible. Eighteen patients (9.6%) were deemed lost to follow-up, leaving a total of 170 patients who were included in final data analysis (Fig 2).

Patient characteristics are summarized in Table 1. The mean patient age was 20.1 years (range, 13-57 years) and the mean final follow-up time of 2.9 years (range, 1.0-5.8 years). Other than mean BRS score, it was noted that patients in the average-resilience (AR) group demonstrated a higher BMI (26.7; 95% CI, 25.1-28.3) than both the high-resilience (HR) (24.8; 95% CI, 23.9-25.7) and low-resilience (LR) groups (24.0; 95% CI, 22.7-25.3), $P = .003$. There were no differences seen in BMI between the HR and LR groups. There were no differences seen in patient age at the time of surgery, final follow-up, sex, or laterality of the injured knee. Additionally, there were no differences seen in graft type, extra-articular procedures (i.e., anterolateral ligament reconstruction, medial collateral ligament repair with suture tape augmentation), meniscal pathology/procedures, or chondral procedures between the 3 groups.

Subsequent nonoperative and operative interventions are summarized in Table 2. Patients in the LR group demonstrated an increased odds of being prescribed low-dose oral corticosteroids in the postoperative period to address their residual extension deficit compared to the HR group (13% vs 1.5%, $P = .041$). Although not statistically significant, there was a trend of additional PT days prescribed to patients in the LR group compared to those in the HR group (28% vs 12%, $P = .07$). There were no significant differences seen in the necessitation of extension splinting or further subsequent surgery, including the need for subsequent contralateral ACLR.

Preoperative and postoperative PROMs are summarized in Table 3. All PROMs significantly improved postoperatively with the exception of activity levels, which significantly decreased compared to their preinjury levels ($P < .001$).

The HR group demonstrated higher preoperative KOOS pain subscale scores (68.9; 95% CI, 64.7-73.0]) compared to the AR (62.3; 95% CI, 57.4-67.2]) and LR (64.2; 95% CI, 59.9-68.5]) groups, $P = .032$. The HR group demonstrated higher preoperative KOOS

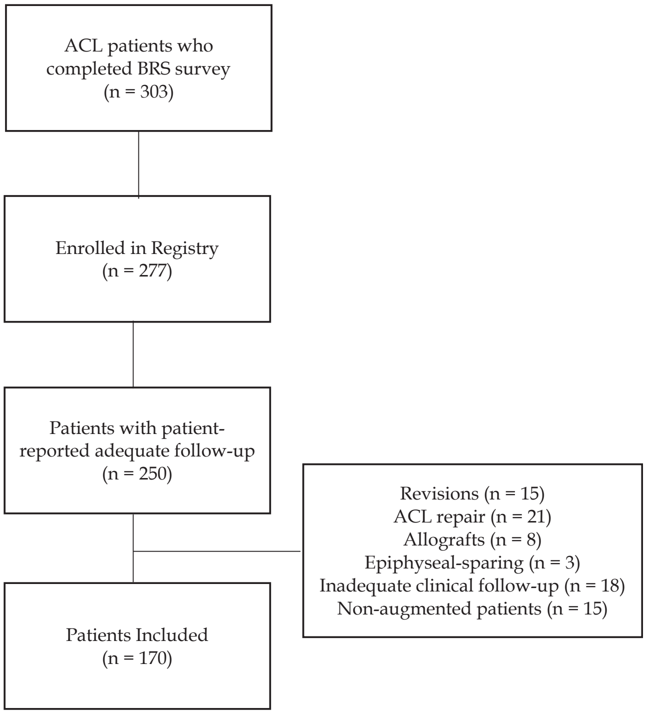

Fig 2. Flowchart summarizing patient inclusion based on criteria. (ACL, anterior cruciate ligament. BRS, Brief Resilience Scale.)

activities of daily living (ADL) subscale scores (76.4; 95% CI, 72.2-80.6) compared to the AR (67.3; 95% CI, 61.9-72.6) and LR (69.4; 95% CI, 64.9-74.0) groups, $P = .01$. The HR group demonstrated higher 3-month KOOS sport/recreation subscale scores (57.5; 95% CI, 51.1-63.9) compared to the LR (47.4; 95% CI, 39.6-55.2) group, $P = .043$. The HR group demonstrated higher preoperative and 6-month KOOS quality of life (QoL) subscale scores (36.8 [95% CI, 31.1-42.4]; 65.3 [95% CI, 60.3-70.3]) compared to the AR (32.7 [95% CI, 26.1-39.4]; 57.3 [95% CI, 50.6-64.0]) and LR (26.7 [95% CI, 21.9-31.6]; 56.4 [95% CI, 51.8-60.9]) groups, $P = .041$; $P = .009$. Additionally, the HR group demonstrated higher 3-month and 1-year KOOS QoL subscale scores (54.9 [95% CI, 50.2-59.5]; 75.0 [95% CI, 69.7-80.3]) compared to the LR (46.6 [95% CI, 41.8-51.5]; 68.1 [63.9-72.4]) group, $P = .021$; $P = .01$.

The HR group demonstrated higher 3-month, 6-month, and 1-year IKDC subjective scores (58.6 [95% CI, 55.7-61.6]; 75.7 [95% CI, 71.3-80.1]; 85.2 [95% CI, 82.0-88.4]) compared to the AR (53.8 [95% CI, 50.3-57.4]; 66.8 [95% CI, 60.9-72.7]; 79.8 [95% CI, 74.6-84.9]) and LR (54.2 [95% CI, 50.6-57.8]; 68.4 [95% CI, 64.9-71.9]; 80.3 [95% CI, 77.1-83.5]) groups, $P = .037$; $P = .004$; $P = .034$.

The HR group demonstrated higher 1-year Lysholm scores (91.5; 95% CI, 88.8-94.2) compared to the AR (84.3; 95% CI, 79.5-89.2) and LR (85.1; 95% CI, 81.9-88.2) groups, $P = .001$.

The HR group demonstrated higher 3-month Single Assessment Numeric Evaluation (SANE) scores (66.4; 95% CI, 62.4-70.4) compared to the LR (57.4; 95% CI, 52.1-62.6) group, $P = .01$.

The HR group demonstrated higher preoperative and 6-month VR-12 mental component score (MCS) (55.9 [95% CI, 53.7-58.1]; 57.0 [55.3-58.7]) compared to the AR (50.5 [95% CI, 48.1-52.9]; 53.9 [95% CI, 51.6-56.2]) and the LR (49.1 [95% CI, 46.6-51.6]; 52.6 [95% CI, 50.3-55.0]) groups, $P < .001$; $P = .003$. Additionally, the HR group demonstrated higher 1-year VR-12 MCS scores (56.9; 95% CI, 55.2-58.7) compared to the LR group (53.6; 95% CI, 51.3-56.6), $P = .01$.

There were no differences seen between groups regarding preinjury or postoperative Marx or Tegner activity levels, or preoperative and postoperative pain levels.

ROM and KT-1000 arthrometer measurements are summarized in Table 4. The HR group demonstrated a less degree of extension loss postoperative month 3 compared to the LR group (0.6° [95% CI, −1.2° to 0.1°] vs −2.3° [95% CI, −3.3° to −1.3°], $P = .006$). The remaining ROM parameters as well as KT-1000 testing were comparable between groups.

RTS data are summarized in Table 5. It was found that patients in the HR group demonstrated a faster RTS time compared to the LR group (6.4 months [95% CI, 6.1-6.7] vs 7.6 months [95% CI, 7.1-8.1], $P = .002$). There were no differences seen in RTS rate among groups or level of competition and participation in high-risk pivoting sports.

Nominal logistical regression analyses and the Cox proportional hazards model were unable to determine direct or factors between patient characteristics and BRS scores.

The addition of an ALLR resulted in an increased risk for decreased ROM at 3 months postoperatively (hazard ratio, 1.8; 95% CI, 1.1-3.1; $P = .028$). However, there was no increased risk for inferior PROMs or necessitation of subsequent intervention associated with ALLR. When controlling for ALLR, the LR group still demonstrated a greater degree of extension loss at 3 months compared to the HR group, $P = .008$. There were no other variables associated with significant postoperative patient outcomes.

Discussion

This study had several important findings. Most notably, patients in the HR group demonstrated significantly higher preoperative and postoperative PROMs, particularly in the early postoperative period. Additionally, patients in the LR group demonstrated a greater degree of extension deficit 3 months postoperatively. It was also noted that patients in the HR

Table 1. Patient Characteristics

Characteristic	HR (n = 67)	AR (n = 42)	LR (n = 61)	*P*
BRS score	28.1 (27.8-28.9)	24.5 (24.3-24.6)	21.1 (20.5-21.7)	<.001
Age, y	20.8 (18.5-23.1)	20.4 (17.9-22.9)	19.0 (17.1-20.9)	.39
Final follow-up, y	2.9 (2.5-3.3)	3.2 (2.7-3.7)	2.7 (2.3-3.0)	.29
Body mass index	24.8 (23.9-25.7)	26.7 (25.1-28.3)	24.0 (22.7-25.3)	.003
Sex				.27
Male	38 (57)	20 (48)	26 (43)	
Female	29 (43)	22 (52)	35 (57)	
Laterality				.34
Right	25 (37)	21 (50)	29 (48)	
Left	42 (63)	21 (50)	32 (52)	
Graft type				.45
ASTQ	38 (57)	28 (67)	34 (56)	
HTA	18 (27)	10 (24)	13 (21)	
BTB	11 (16)	4 (9.4)	14 (23)	
ALL reconstruction	7 (10)	6 (14)	11 (18)	.47
MCL repair + STA	4 (6.0)	6 (14)	8 (13)	.28
Meniscal tear	45 (67)	22 (52)	37 (61)	.30
MM procedure	n = 29	n = 12	n = 17	.95
Repair	24 (83)	11 (92)	14 (82)	
APM	5 (17)	1 (8.3)	3 (18)	
LM procedure	n = 35	n = 16	n = 32	.76
Repair	25 (71)	13 (81)	27 (84)	
APM	10 (29)	3 (19)	5 (16)	
Chondral procedure	n = 5	n = 6	n = 4	.61
Chondroplasty	4 (80)	5 (83)	3 (75)	
Microfracture	1 (20)	(0)	(0)	
OCAT	(0)	1 (17)	1 (25)	

NOTE. Data represented as mean (95% CIs) or absolute frequency (percentage).

ALL, anterolateral ligament; APM, arthroscopic partial meniscectomy; AR, average resilience; ASTQ, all-soft tissue quadriceps tendon autograft; BRS, Brief Resilience Scale; BTB, bone—patellar tendon—bone; HR, high resilience; HTA, hamstring tendon autograft; LM, lateral meniscus; LR, low resilience; MCL, medial collateral ligament; MM, medial meniscus; OCAT, osteochondral allograft transplant; STA, suture tape augmentation.

group demonstrated a quicker RTS time compared to those in the LR group.

Clinically, it was found that patients in the LR group demonstrated greater loss of knee extension 3 months postoperatively. This would have been the time when treatments for residual extension deficits were initiated or enhanced as there was a trend for additional PT days being necessary for patients the LR group, as well as significantly more LR patients being treated with low-dose oral corticosteroids in the short-term postoperative period. It is important to note that despite the significant difference between groups at 3 months, the loss of knee extension was correctable as ultimately extension was comparable at 6 months and 1 year between groups. Extra-articular stabilization was identified as potential confounder to this extension loss, but each group included a comparable proportion of those who received this additional augmentation.

Table 2. Subsequent Surgical Intervention

Intervention	HR (n = 67)	AR (n = 42)	LR (n = 61)	*P*
Extension bracing	15 (22)	13 (31)	19 (31)	.47
Additional physical therapy	8 (12)	7 (17)	17 (28)	.07
Oral corticosteroids	1 (1.5)	4 (9.5)	8 (13)	.041
Time to second surgery, mo	13 (5-19)	4 (2-26)	9 (6-16)	.70
Arthrolysis	3 (4.5)	3 (7.1)	5 (8.2)	.68
Revision ACLR	1 (1.5)	(0)	(0)	.46
Meniscal procedure	4 (6.0)	2 (4.8)	1 (1.6)	.45
Chondral procedure	1 (1.5)	1 (2.4)	(0)	.52
Hardware removal	1 (1.5)	1 (2.4)	1 (1.6)	.94
Contralateral ACLR	2 (3.0)	2 (4.8)	4 (6.6)	.63

NOTE. Data represented as absolute frequency (percentage) or median (interquartile range).

ACLR, anterior cruciate ligament reconstruction; AR, average resilience; HR, high resilience; LR, low resilience.

Table 3. Preoperative and Postoperative Patient-Reported Outcome Measures

PROM	HR (n = 67)	AR (n = 42)	LR (n = 61)	*P*
VAS				
Preoperative	2.5 (2.0-3.0)	2.9 (2.2-3.5)	2.7 (2.2-3.2)	.34
3 month	1.0 (0.7-1.4)	1.2 (0.7-1.7)	1.1 (0.8-1.4)	.70
6 months	1.0 (0.7-1.3)	1.1 (0.6-1.6)	1.0 (0.7-1.3)	.91
1 year	0.7 (0.4-1.0)	1.2 (0.6-1.8)	0.8 (0.5-1.1)	.59
Final follow-up	0.6 (0.3-0.8)	0.9 (0.5-1.4)	0.6 (0.3-0.9)	.071
KOOS				
Pain				
Preoperative	68.9 (64.7-73.0)	62.3 (57.4-67.2)	64.2 (59.9-68.5)	.032
3 months	84.2 (81.5-87.0)	83.0 (79.6-86.4)	82.1 (79.2-85.1)	.58
6 months	88.4 (85.8-91.0)	86.1 (81.4-90.8)	86.9 (84.2-89.6)	.61
1 year	91.3 (89.1-93.6)	87.2 (82.8-91.6)	88.7 (86.0-91.3)	.20
Final follow-up	91.7 (89.6-93.7)	89.3 (86.0-92.5)	89.7 (86.9-92.5)	.54
Symptoms				
Preoperative	58.3 (53.8-62.8)	52.9 (47.2-58.5)	55.7 (50.9-60.5)	.27
3 months	70.2 (66.2-74.2)	68.0 (63.4-72.7)	69.2 (65.1-73.3)	.69
6 months	77.2 (73.7-80.8)	72.2 (66.4-78.0)	75.4 (71.6-79.1)	.46
1 year	82.6 (80.0-85.6)	75.0 (69.3-80.7)	78.4 (74.4-82.4)	.11
Final follow-up	84.8 (82.1-87.5)	79.3 (75.1-83.4)	81.4 (77.7-85.1)	.13
ADL				
Preoperative	76.4 (72.2-80.6)	67.3 (61.9-72.6)	69.4 (64.9-74.0)	.01
3 months	91.8 (89.8-93.7)	91.7 (89.6-93.7)	87.8 (84.8-90.9)	.18
6 months	95.3 (93.3-97.2)	93.6 (90.5-96.8)	93.3 (90.9-95.8)	.25
1 year	96.4 (94.7-98.2)	93.8 (90.7-96.9)	94.4 (92.5-96.3)	.12
Final follow-up	97.7 (96.6-98.8)	94.6 (92.0-97.1)	96.0 (94.3-97.7)	.17
Sport/Recreation				
Preoperative	21.7 (15.9-27.4)	20.0 (12.2-27.8)	23.0 (16.1-30.0)	.73
3 months*	57.5 (51.1-63.9)	47.4 (39.6-55.2)	47.4 (39.6-55.2)	.067
6 months	75.4 (70.6-80.3)	75.9 (70.2-81.7)	70.3 (65.1-75.5)	.13
1 year	84.3 (80.0-88.6)	79.7 (74.3-85.2)	80.7 (76.6-84.8)	.094
Final follow-up	85.0 (80.5-89.5)	82.9 (77.0-88.8)	82.7 (78.7-86.7)	.40
QoL				
Preoperative	36.8 (31.1-42.4)	32.7 (26.1-39.4)	26.7 (21.9-31.6)	.041
3 months[†]	54.9 (50.2-59.5)	49.0 (44.4-53.5)	46.6 (41.8-51.5)	.052
6 months	65.3 (60.3-70.3)	57.3 (50.6-64.0)	56.4 (51.8-60.9)	.009
1 year[‡]	75.0 (69.7-80.3)	69.2 (62.1-76.3)	68.1 (63.9-72.4)	.054
Final follow-up	79.4 (74.8-84.0)	76.2 (68.5-83.9)	78.6 (74.4-82.8)	.84
IKDC				
Preoperative	41.7 (37.3-46.1)	37.0 (31.8-42.1)	38.8 (34.7-42.9)	.34
3 months	58.6 (55.7-61.6)	53.8 (50.3-57.4)	54.2 (50.6-57.8)	.037
6 months	75.7 (71.3-80.1)	66.8 (60.9-72.7)	68.4 (64.9-71.9)	.004
1 year	85.2 (82.0-88.4)	79.8 (74.6-84.9)	80.3 (77.1-83.5)	.034
Final follow-up	86.4 (83.1-89.6)	83.6 (77.4-89.7)	84.2 (81.0-87.4)	.42
Lysholm				
Preoperative	51.1 (44.8-57.4)	43.2 (35.9-50.4)	49.0 (43.5-54.6)	.18
3 months	77.5 (73.2-81.9)	75.6 (70.7-80.5)	74.4 (70.4-78.4)	.27
6 months	83.6 (79.9-87.3)	78.3 (72.9-83.7)	80.8 (77.1-84.6)	.22
1 year	91.5 (88.8-94.2)	84.3 (79.5-89.2)	85.1 (81.9-88.2)	.001
Final follow-up	89.8 (87.3-92.2)	85.6 (80.6-90.6)	85.9 (82.2-89.5)	.27
Tegner[‖]				
Preinjury	7.9 (7.5-8.2)	7.8 (7.3-8.2)	8.0 (7.7-8.4)	.62
Preoperative	4.5 (3.7-5.3)	3.3 (2.4-4.3)	4.7 (3.9-5.5)	.083
3 months	3.4 (3.0-3.8)	3.1 (2.5-3.7)	3.9 (3.2-4.5)	.17
6 months	5.4 (4.8-6.0)	4.6 (3.9-5.3)	5.2 (4.6-5.8)	.17
1 year	7.0 (6.4-7.5)	6.1 (5.4-6.9)	6.7 (6.1-7.3)	.22
Final follow-up	6.6 (6.1-7.2)	6.3 (5.2-7.3)	6.1 (5.6-6.6)	.38
Marx[‖]				
Preinjury	14.0 (13.2-14.9)	13.4 (12.3-14.6)	12.8 (11.6-13.9)	.19
1 year	10.6 (9.3-11.8)	10.3 (8.5-12.1)	10.2 (8.9-11.5)	.84
Final follow-up	10.9 (9.6-12.2)	9.9 (8.1-11.7)	10.6 (9.2-12.0)	.74
SANE				
Preoperative	39.1 (32.9-45.4)	39.5 (32.5-46.5)	32.2 (26.6-37.7)	.17

(continued)

Table 3. Continued

PROM	HR (n = 67)	AR (n = 42)	LR (n = 61)	*P*
3 months[‡]	66.4 (62.4-70.4)	63.5 (58.4-68.7)	57.4 (52.1-62.6)	.029
6 months	76.8 (72.1-81.4)	76.6 (73.0-80.2)	74.8 (70.9-78.7)	.30
1 year	87.4 (84.1-90.8)	85.4 (81.4-89.3)	85.8 (82.6-89.0)	.30
Final follow-up	90.6 (87.6-93.6)	88.1 (84.3-92.0)	88.7 (85.4-92.0)	.20
VR-12				
Physical				
Preoperative	37.0 (34.4-39.7)	37.6 (34.4-40.8)	37.5 (35.4-39.7)	.99
6 months	49.8 (48.0-51.5)	48.6 (46.2-51.0)	48.6 (46.9-50.3)	.40
1 year	52.2 (50.5-53.8)	51.5 (49.4-53.6)	52.3 (51.0-53.7)	.85
Final follow-up	53.2 (51.8-54.7)	51.3 (49.2-53.4)	52.3 (50.8-53.8)	.081
Mental				
Preoperative	55.9 (53.7-58.1)	50.5 (48.1-52.9)	49.1 (46.6-51.6)	<.001
6 months	57.0 (55.3-58.7)	53.9 (51.6-56.2)	52.6 (50.3-55.0)	.003
1 year[‡]	56.9 (55.2-58.7)	56.1 (53.9-58.2)	53.6 (51.3-55.8)	.039
Final follow-up	56.9 (55.1-58.8)	56.0 (53.6-58.4)	54.2 (51.8-56.6)	.14

NOTE. Data represented as mean (95% CI).

ADL, activities of daily living; AR, average resilience; HR, high resilience; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; LR, low resilience; PROM, patient-reported outcome measure; QoL, quality of life; SANE, SANE, Single Assessment Numeric Evaluation; VAS, visual analog scale; VR-12, Veteran's Rand 12-Item Health Survey.

*Significant difference between HR and LR groups, $P = .043$.

[†]Significant difference between HR and LR groups, $P = .021$.

[‡]Significant difference between HR and LR groups, $P = .01$.

[‖]Significant difference between preinjury and postoperative levels in all groups, $P < .001$.

Additionally, when controlling for this variable, there was still a difference between the HR and LR groups regarding extension loss, in favor of the HR group.

All PROMs significantly improved postoperatively except for the Marx score and Tegner activity levels, which both significantly decreased at final follow-up compared to preinjury levels. Following ACLR, it is not unusual for activity levels to decrease over time across a cohort, especially if a large percentage of patients do not go on to play sports at the next level.[37-39]

It was found that patients within the HR group demonstrated significantly higher preoperative and postoperative PROMs compared to the AR and LR groups, most notably the LR group. There have been numerous studies linking an individual's resilience to their mental well-being,[40-44] as well as their expectations following a procedure.[45-47] Most of the differences seen between the groups were during the preoperative period and up to 1 year postoperatively, with comparable results seen at final follow-up among all groups.

Table 4. Preoperative and Postoperative Range of Motion and KT-1000 Arthrometer Measurements

Measurement	HR (n = 67)	AR (n = 42)	LR (n = 61)	*P*
Extension				
Preoperative	−0.4° (−1.2° to 0.5°)	−1.3° (−2.7° to 0.1°)	−1.4° (−3.1° to 0.2°)	.30
3 months*	−0.6° (−1.2° to 0.1°)	−1.2° (−2.0° to −0.4°)	−2.3° (−3.3° to −1.3°)	.018
6 months	0.1° (−0.5° to 0.7°)	0° (−0.6° to 0.7°)	−0.5° (−1.1° to 0°)	.65
1 year	0.8° (0.4° to 1.1°)	0.7° (0.1° to 1.3°)	0.8° (0.4° to 1.2°)	.78
Flexion				
Preoperative	119° (114° to 125°)	116° (109° to 124°)	116° (111° to 122°)	.62
3 months	133° (131° to 135°)	130° (126° to 134°)	132° (128° to 136°)	.32
6 months	139° (137° to 140°)	138° (136° to 140°)	140° (138° to 141°)	.17
1 year	139° (137° to 140°)	140° (138° to 142°)	140° (138° to 141°)	.51
KT-1000, mm				
30 lb				
Preoperative	5.7 (5.2 to 6.3)	5.4 (5.0 to 5.8)	5.8 (5.3 to 6.2)	.63
1 year	1.0 (0.6 to 1.4)	0.6 (0.2 to 1.0)	0.5 (0.1 to 0.9)	.29
Manual maximum				
Preoperative	7.1 (6.5 to 7.7)	6.3 (5.7 to 7.0)	7.0 (6.3 to 7.6)	.29
1 year	1.4 (0.9 to 1.8)	1.0 (0.6 to 1.4)	0.8 (0.4 to 1.3)	.64

NOTE. Data represented as mean (95% CI).

AR, average resilience; HR, high resilience; LR, low resilience.

*Significant difference between HR and LR groups, $P = .006$.

Table 5. Return to Sport

Parameter	HR (n = 60)	AR (n = 30)	LR (n = 52)	*P*
RTS rate	51 (85)	26 (86)	41 (79)	.24
RTS time, mo*	6.4 (6.0-6.9)	7.1 (6.5-7.6)	7.6 (7.1-8.1)	.014
Level of competition				.50
College	19 (38)	6 (23)	7 (18)	
High school	22 (43)	12 (48)	22 (54)	
Recreational	10 (19)	8 (29)	12 (28)	
Pivoting sport?†	43 (85)	25 (82)	34 (83)	.94

NOTE. Data represented as absolute frequency (percentage) or mean (95% CI).
AR, average resilience; HR, high resilience; LR, low resilience; RTS, return to sport.
*Significant difference between the HR and LR group, $P = .002$.
†Includes basketball, football, soccer, volleyball, and rugby.

A possible explanation to this may be that lower resiliencies in those undergoing ACLR may affect short-term PROMs more than long-term PROMs because they are experiencing a more difficult time coping with the procedure itself and during the rehabilitation process. An explanation to why these PROMs are comparable at final follow-up may be because nearly all patients demonstrated restored full knee ROM and were all back to their normal activity levels.

In a cohort study performed by Drayer et al.[21] examining active-duty military patients, it was found that patients with lower preoperative resiliencies demonstrated lower pre- and 6-month postoperative PROMs following arthroscopic knee surgery. We were able to find similar results and even noted some differences in PROMs as far as 1 year following surgery. A major difference between our studies is that we only considered patients who received ACLR, whereas Drayer et al.[21] included all patients who received an arthroscopic knee procedure. We are unsure how various different arthroscopic knee procedures affect patient resilience preoperatively.

In a recent study by Meade et al.,[28] it was found that patients with lower postoperative BRS scores demonstrated inferior PROMs as well as increased pain levels compared to those with higher scores. Although we found similar results regarding PROMs, we were unable to find a difference regarding pain levels. It may be possible that higher pain levels postoperatively may impact a patient's resilience, which was stated in their limitations. Additionally, we are unsure how patient resilience changes from the preoperative to postoperative setting, if it changes at all.

Although we only considered ACLR for our study, we did have heterogeneity regarding the type of graft used. Some grafts, particularly the quadriceps tendon and BTB autografts, have been noted to increase the risk of postoperative knee stiffness.[48,49] Additionally, certain concomitant pathologies such as meniscal lesions have also been shown to increase the risk for decreased ROM in the postoperative period.[48-50] Our secondary analyses did not suggest that graft type or concomitant meniscal/chondral pathologies had a significant role in loss of knee extension, PROMs, or RTS outcomes.

Patients in the HR group demonstrated quicker RTS times compared to those in the LR group. In a study performed by Zhang et al.[27] examining RTS and SANE scores following autograft ACLR, they concluded that resilience measured by BRS administered 6 months postoperatively is inadequate to determine RTS outcomes. They stratified their patients into 3 groups, with 1 group containing 12 patients, the second group containing 9, and the last group containing 35; additionally, a power analysis was not performed prior to or following this study, so it is likely that this study was underpowered to truly determine a difference in RTS outcomes.[27] The quicker progression through the postoperative rehabilitation process for the HR group may be due to less attention needed to focus on improving postoperative ROM as they typically had adequate motion by their second postoperative visit. However, ROM was not documented at any other time point of this study other than scheduled office visits (i.e., at 1 month, 2 months, 3 months, 4 months, etc.).

Limitations

This study was not without limitations. The retrospective nature of this study makes it subject to selection bias; therefore, to eliminate this bias, consecutive patients were screened from a definitive starting point. Knee ROM was not assessed with a goniometer in all cases, which makes this parameter subject to measurement bias. The senior author and the patients were blinded to the preoperative BRS surveys, so despite not using a specialized instrument to assess knee ROM, all patients were assessed in the exact same manner. Additionally, the senior author has 37 years of clinical experience; therefore, measurement bias risk may be mitigated. Other potential reasons for loss of knee extension such as noncompliance with postoperative rehabilitative efforts such as CPM machine usage, physical therapy visits, and home exercises were not assessed. Regarding the implementation of nonoperative interventions to correct the extension deficit in the short-term postoperative period, there was no standardized protocol outlining the time each intervention was added/increased, which may have resulted in an allocation bias of these treatments. However, since both parties were blinded to the BRS scores, we believe that some of this risk was mitigated as the senior author was solely treating the severity of the symptoms as he would if the BRS survey was never administered in the first place. Another limitation may have been a result of the parents being in the room when the younger patients were completing their BRS surveys, which may have led to a survey bias. Although this study was powered to determine moderate differences between groups, it was not powered to determine associations between graft type/concomitant interventions and outcome. Therefore, graft heterogeneity and concomitant procedures such as ALLR and meniscal lesions may have led to unaccountable confounding variables. Also, there was not a standardized postoperative protocol for the implementation of nonoperative interventions in the event of a residual extension deficits as patients may have been seen prior to their 3-month visit and treated more aggressively initially based on the severity of deficit present.

Conclusions

Low preoperative BRS scores were associated with inferior PROMs preoperatively and in the short-term postoperative period compared to those with higher preoperative BRS scores. Additionally, patients with lower preoperative BRS scores demonstrated a higher degree of knee extension loss 3 months postoperatively as well as a slower RTS.

Disclosure

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