Received: 26 June 2025 | Accepted: 12 August 2025

DOI: 10.1002/ksa.70061

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Knee Surgery, Sports Traumatology, Arthroscopy WILEY

# Estimation of the patient acceptable symptom state (PASS) threshold for the Banff Patellofemoral Instability Instrument 2.0

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**Funding information**

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## Abstract

**Purpose:** There is a paucity of studies reporting patient acceptable symptom state (PASS) thresholds for patient reported outcome measures validated for patellar instability. The aim of this study was to determine the PASS threshold for the Banff Patellofemoral Instability Instrument 2.0 (BPII) following surgery for recurrent patellar instability.

**Methods:** Patients who underwent patellar stabilisation surgery between 2013 and 2022 were included if they were ≥16 years of age and had ≥12 months of follow-up. The participants completed the BPII and a dichotomous PASS anchor question. The PASS threshold was then calculated using both the adjusted predictive modelling method and receiver operating characteristic (ROC) analysis.

**Results:** Complete data were available for 218 knees of 182 patients, with a median follow-up time of 46 months. The PASS threshold was 62.4 (95% confidence interval [CI]: 58.8–65.9) using the adjusted predictive modelling method, and 66.3 (95% CI: 58.1–80.0) using ROC analysis. Overall, 173 patients (79.4%) reported satisfactory symptom states, while 72.9% and 70.6% achieved the respective PASS thresholds. The adjusted predictive modelling method yielded narrower 95% confidence intervals with minimal threshold variation across different approaches for handling bilateral cases compared to ROC analysis (1.3 vs. 8.1 points).

**Conclusion:** The PASS threshold for BPII after patellar stabilisation surgery was 62.4 (out of 100 points). The adjusted predictive modelling method demonstrated superior precision and robustness in the PASS threshold calculation compared with the ROC analysis. This threshold provides a disease-specific reference for clinical decision making and research in patellofemoral instability.

**Level of Evidence:** Level III.

**KEYWORDS**

Banff Patellofemoral Instability Instrument (BPII), patellar dislocations, patellar instability, patient acceptable symptom state (PASS), patient reported outcome measure (PROM)

**Abbreviations:** AUC, area under the curve; BMI, body mass index; BPII, Banff Patellofemoral Instability Instrument 2.0; CI, confidence interval; IKDC-SKF, International Knee Documentation Subjective Knee Form; IQR, interquartile range; KOOS, Knee Osteoarthritis Outcome Score; MIC, minimally important change; MPFL-R, Medial Patellofemoral Ligament Reconstruction; PASS, patient acceptable symptom state; PROM, Patient-Reported Outcome Measure; ROC, receiver operating characteristic; SD, standard deviation; TTO, tibial tubercle osteotomy.

# INTRODUCTION

The patient acceptable symptom state (PASS) is a clinically derived threshold used to interpret a patient-reported outcome measure (PROM). PASS represents the PROM value at which patients consider their symptom state as satisfactory, and can be valuable for evaluating treatment success in research and facilitating clinician-patient communication about expected outcomes [3, 7, 17, 22, 27]. Although PASS thresholds have been investigated for several PROMs used in knee surgery [13, 19, 20], they have been underreported in studies on patellar instability [1, 21, 29], especially for validated disease-specific PROMs such as the Banff Patellofemoral Instability Instrument 2.0 (BPII), which are recommended for this patient group [2, 10, 11, 18]. Additionally, recent methodological studies have demonstrated that predictive modelling methods for PASS estimation are more precise than the frequently used receiver operating characteristic (ROC) analysis, especially when the proportion of satisfied patients exceeds 50% [14, 25].

To date, PASS values for BPII have not been reported. This study aimed to calculate the PASS threshold for the BPII score in patients surgically treated for patellar instability.

# METHODS AND MATERIALS

Patients who underwent surgery for recurrent patellar instability at either (1) a tertiary-care university hospital between 2013 and 2022 or (2) two local hospitals between 2021 and 2022, as part of a corresponding study [12], were screened for eligibility and included if they were ≥ 16 years of age at the time of follow-up, able to understand and complete the questionnaires and had at least 12 months of follow-up postoperatively. Patients with concomitant knee ligament injuries, osteoarthritis in the patellofemoral joint, chronic fixed patellar dislocations, and those who underwent surgery after a first-time dislocation due to osteochondral injuries were excluded. The study participants were contacted and asked to complete questionnaires.

Local and regional ethical approvals (Regional Committee for Medical and Health Research Ethics, ID 2022/488689 and 2020/185067) were obtained before the initiation of the study, and all patients provided written consent prior to enrolment.

## Outcome measures

Data on patient demographics and surgical procedures were collected from medical records. Questionnaires were distributed to study participants either by mail or electronically from January 2024 to March 2025. The BPII questionnaire comprises 23 equally weighted items that evaluate key aspects relevant to disease-specific quality of life for patients with patellar instability [9, 15]. The final composite score is calculated as the mean of all answered item scores and ranges from 0 to 100 with higher score indicating a higher quality of life [9, 15]. The Norwegian translation of the BPII was recently validated and has demonstrated good psychometric properties in several domains [12]. Additionally, patients were asked to answer 'yes' or 'no' to an anchor question similar to the one proposed by Tubach et al; [27] "Taking into account all the activities you have during your daily life, your level of pain, and also your functional impairment, do you consider that your current state is satisfactory?"

## Surgical techniques

All patients were treated surgically according to the standards of the respective hospitals. The procedures included reconstruction of the medial patellofemoral ligament (MPFL-R) using a hamstring or quadriceps autograft, osteotomy of the tibial tubercle (medialization and/or distalization), mini-open thin flap trochleoplasty, derotational osteotomy of the femur, and Insall proximal realignment (plication of the vastus medialis with lateral release). Further description of these techniques can be found in two previously published studies from our group [28, 29].

## Statistical analysis

Statistics were performed using R for Windows version 2024.12.1 (R Foundation for Statistical Computing, Vienna, Austria). The a priori significance level was set to 0.05 and the Kolmogorov–Smirnov test was used to assess the normality of continuous variables. Scale variables are presented as mean ± standard deviation with 95% confidence interval (CI) for normally distributed data, or as medians with interquartile ranges (IQR) for data that did not follow a normal distribution. Differences between responders and non-responders were assessed using the Wilcoxon rank sum test (age at the time of surgery, body mass index (BMI), and chi-square test (sex distribution)). The Wilcoxon rank-sum test was also used to compare BPII scores between those who reported their knee status as satisfactory (PASS 'Yes') and those who considered it unsatisfactory (PASS 'No').

Predictive modelling was used to identify the PASS threshold for BPII. Originally developed for minimally important change (MIC) evaluation, this method can also be applied for PASS calculations with superior precision compared to traditional ROC analysis [20, 26]. Simulation studies have demonstrated that ROC analysis systematically overestimates cut-off values when the proportion of satisfied patients exceeds 50%, whereas predictive modelling can adjust for such prevalence-related bias [23, 25, 26]. The method relies on logistic regression, where the PASS anchor is a dichotomous dependent variable and the postoperative BPII is the independent variable. To account for potential bias that can occur when the dependent variable (proportion of improved patients) is not normally distributed, an adjusted predictive model was used, as proposed by Terluin et al. [23]:

$$PASS_{adjusted} = PASS_{predicted} - (0.090 + 0.103 * Cor) * SD * \text{log-odds}(sat),$$

where $PASS_{predicted}$ is the threshold value derived from logistic regression, where the likelihood ratio equals 1 (the score at which the post-test probability of a patient being in an acceptable state equals their pre-test probability), Cor is the point biseral correlation between the anchor and the postoperative BPII score, SD is the standard deviation of the postoperative BPII score, and log-odds(sat) is the natural logarithm of the proportion of satisfied patients: ln(proportion with acceptable symptom state/1-proportion with acceptable symptom state).

For comparison, ROC analysis was performed, and the highest Youden index (sensitivity/1 − specificity) was considered as the optimal PASS threshold [31]. To calculate the 95% CI around the PASS thresholds, non-parametric bootstrapping was performed by resampling the original dataset 1000 times to estimate the variability of the threshold values [24]. To investigate whether the time from surgery influenced the PASS threshold for the BPII score, bootstrap analysis of the difference in the PASS threshold between those with ≤ 2 years and those with > 2 years of follow-up was performed. The results were considered statistically significant if the 95% CI for the difference did not include zero. To assess the influence of bilateral surgeries on the PASS thresholds, a sensitivity analysis was performed by comparing the original data with the worst-case, best-case, and mean score approaches for bilateral cases.

# RESULTS

A total of 270 knees of 226 patients were included in the study. Of these, complete outcome data were collected for 218 knees in 182 patients (response rate, 80.7%), with a median follow-up time of 46 months (IQR 24.8–73.0 months). There were no significant differences between the responders and non-responders (Supporting Information: Table S1).

**TABLE 1** Demographic features at baseline ($n = 270$ knees).[a]

| Variable | Value |
|---|---|
| Female sex, *n* (%) | 169 (62.6) |
| Right knee treated, *n* (%) | 117 (43.3) |
| Age at the time of surgery, median (IQR) | 18.0 (16.0–24.0) |
| Body Mass Index, median (IQR) | 24.2 (21.5–26.9) |

Abbreviation: IQR, interquartile range.

[a]Data are presented as no. of knees (%) or median = numbers.

The demographic features and patient characteristics are listed in Table 1, and 261 of the knees (96.7%) underwent surgery at the tertiary care university hospital. Of 218 knees with complete data, 8.7% underwent isolated MPFL-R while 86.3% received MPFL-R in combination with other procedures (Table 2).

The overall median BPII score in the cohort was 79.6 (IQR 59.4–90.0). There was a significant difference in BPII scores between PASS 'Yes' and PASS 'No' responders (Figure 1), and the point-biserial correlation between BPII and the anchor question was 0.63 (95% CI: 0.55–0.71, $p < 0.001$).

The PASS threshold for the BPII score was determined to be 62.4 (95% CI: 58.8–65.9) using the adjusted predictive modelling method, and 66.3 (95% CI: 58.1–80.0; AUC 0.91) with ROC analysis (Supporting Information: Figure S1).

The proportion of knees that achieved the adjusted PASS threshold was closer to the true PASS (those who answered 'yes' to the PASS anchor question) than in the ROC analysis (Table 3).

No significant differences in PASS thresholds were observed between early (≤24 months) and late (>24 months) follow-up groups (bootstrap analysis, 95% CI including zero), with the adjusted predictive modelling method demonstrating superior precision (narrower confidence intervals) compared to ROC analysis across all time periods (Figure 2).

Sensitivity analysis of different bilateral case handling methods demonstrated minimal variation in adjusted predictive modelling PASS thresholds (1.3 points) compared to substantial variation (8.1 points) in ROC-based thresholds, representing a six-fold greater variability (Supporting Information: Table S1). All bilateral cases underwent staged surgery.

# DISCUSSION

The principal finding of the study was a PASS threshold for BPII of 62.4 (95% CI: 58.8–65.9) 46 months (IQR 24.8–73.0 months) after surgery for recurrent patellar instability, using the adjusted predictive modelling method.

**TABLE 2** Distribution of surgical procedures in knees with complete outcome data ($n = 218$ knees).[a]

| Surgical procedure | N (%) |
|---|---|
| Isolated MPFL-R | 19 (8.7) |
| MPFL-R + TTO | 87 (39.9) |
| MPFL-R + trochleoplasty | 43 (19.7) |
| MPFL-R + TTO + trochleoplasty | 55 (25.2) |
| MPFL-R + DFO | 3 (1.4) |
| Insall | 4 (1.8) |
| Insall + TTO | 1 (0.5) |
| TTO and/or trochleoplasty without MPFL-R or Insall | 6 (2.8) |

Abbreviations: DFO, derotational femoral osteotomy; MPFL-R, medial patellofemoral ligament reconstruction; TTO, tibial tubercle osteotomy.
[a]Data are presented as no. of knees (%).

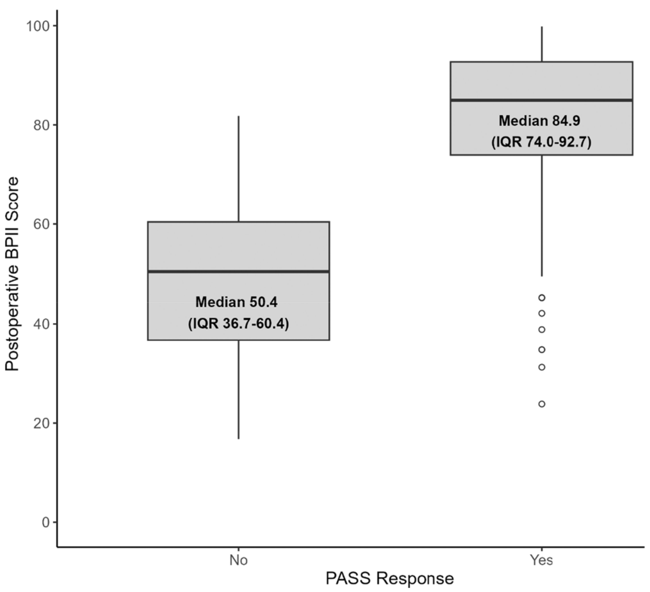


**FIGURE 1** Distribution of postoperative BPII scores stratified by the PASS response. The boxplot shows the median BPII scores (thick horizontal line), interquartile range (box boundaries), data range (vertical line), and outliers (individual points). Patients answering 'Yes' to the PASS question demonstrated significantly higher BPII scores compared to those answering 'No' (median [IQR]: 84.9 [74.0–92.7] vs. 50.4 [36.7–60.4], $W = 769$, $p < 0.001$). BPII, Banff Patellofemoral Instability Instrument 2.0; PASS, patient acceptable symptom state.

**TABLE 3** Proportion of knees achieving PASS.[a]

| Method | n = | % |
|---|---|---|
| True PASS | 173 | 79.4 |
| Adjusted predictive modelling | 159 | 72.9 |
| ROC analysis | 154 | 70.6 |

Abbreviations: N, number of knees; PASS, patient acceptable symptom state; ROC, reciever operating characteristic.
[a]True PASS = those who answered 'yes' to the PASS anchor question.

This is the first study to present a PASS threshold for the BPII score, providing an important reference point for interpreting outcomes after patellar stabilisation surgery. At the group level, this threshold can be important when evaluating the effects of treatment across similar study populations, as it allows us to compare the proportion of patients reaching PASS [6, 7, 17]. Furthermore, these thresholds can help clinicians in individual patient counselling by setting realistic expectations for surgical outcomes and serve as a clinical reference for interpreting individual BPII scores after surgery [17]. In such clinical contexts, the corresponding 95% CI (58.8–65.9) of the PASS threshold can provide additional information regarding the precision of the estimate; BPII scores above or below this interval are more likely to represent a true symptom state, whereas values within the interval may require additional clinical assessment to determine whether the symptom state is truly satisfactory. However, individual considerations are important given that PASS thresholds are based on group-level data [14].

The adjusted predictive modelling method has several advantages over ROC analysis in estimating the PASS threshold, especially when the proportion of satisfied patients exceeds 50% [23]. In the present study, 79.4% reported a satisfactory symptom state, leading to a likely overestimated ROC-derived threshold (66.3) compared to the predictive modelling estimate (62.4). This finding is consistent with the simulation study by Terluin et al. [23]. Additionally, the adjusted predictive modelling method demonstrated superior precision with narrower 95% CIs (58.8–65.9) compared to the ROC-derived threshold (58.1–80.0), and the proportion of patients achieving the PASS threshold using predictive modelling (72.9%) was closer to the true proportion of patients reporting satisfactory symptoms (79.4%) compared to ROC analysis (70.6%). Furthermore, the sensitivity analysis revealed greater robustness of the adjusted predictive modelling method when handling bilateral cases, with minimal threshold variation (1.3 points) compared to the substantial variation in ROC-derived thresholds (8.1 points). These findings support existing literature demonstrating the superiority of adjusted predictive modelling in estimating PASS thresholds [5, 8, 14, 23], thereby strengthening the validity and reliability of the PASS value in the current patient cohort.

The paucity of studies reporting PASS thresholds for PROMs used in patellar instability makes it difficult to compare the findings of the current study. To date, only two studies have determined PASS thresholds after patellar stabilising surgery for commonly used knee PROMs (Kujala, IKDC-SKF, Lysholm and KOOS) [21, 30]. However, neither included disease-specific questionnaires nor reported the proportion of patients who actually achieved the calculated PASS thresholds. Both studies did examine patient satisfaction using the

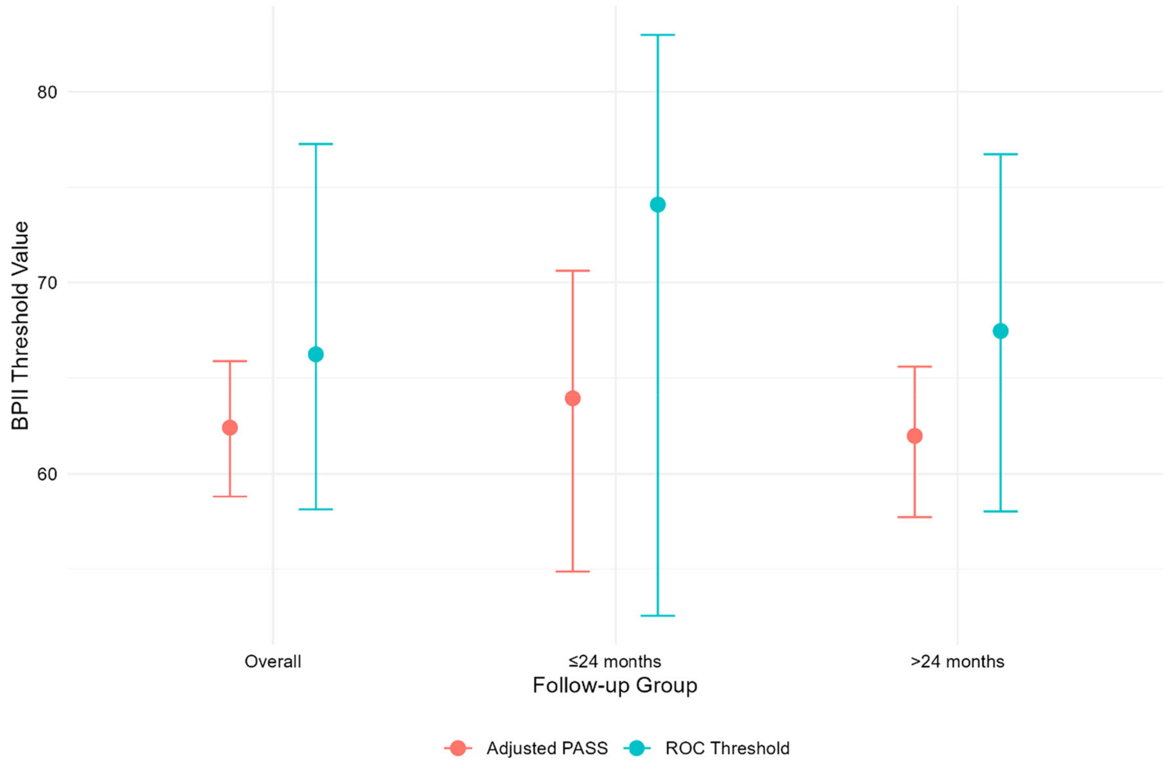


**FIGURE 2** PASS threshold values for BPII scores stratified by follow-up duration, comparing adjusted predictive modelling method (red) and ROC analysis (blue). Points represent the calculated PASS thresholds with 95% confidence intervals (error bars) for the overall cohort ($n = 218$), ≤24 months ($n = 55$), and >24 months ($n = 163$) follow-up groups. Adjusted predictive modelling: 62.4 (overall), 63.9 (≤ 24 months), 61.9 (> 24 months); bootstrap difference 95% CI: −7.4 to 10.1. ROC analysis: 66.3 (overall), 73.8 (≤ 24 months), 67.2 (> 24 months); bootstrap difference 95% CI: −17.9 to 20.5. BPII, Banff Patellofemoral Instability Instrument 2.0; PASS, patient acceptable symptom state; ROC, receiver operating characteristic.

binary PASS anchor question; Walsh et al. [30] found that 79% of patients answered 'yes' following isolated MPFL reconstruction at 6–12 months, which aligns with our findings, while Qiao et al. [21] reported 93% satisfaction at 59 months following combined MPFL reconstruction and tibial tubercle osteotomy. This variation (79% vs. 93%) likely reflects differences in surgical procedures, follow-up duration, and patient populations rather than true differences in clinical outcomes measured by PROMs. It therefore highlights the importance of using disease-specific satisfaction measures in similar patient cohorts when comparing different treatments [1, 14, 17].

This study had several limitations. The cross-sectional design permits data collection only at a single time point and limits the evaluation of temporal changes in PASS over time. However, no statistical differences were found in the PASS threshold between patients with ≤ 2 years and > 2 years of follow-up, suggesting some threshold stability over time. Furthermore, the lack of baseline BPII data prevents the assessment of both baseline dependency, where patients with higher (better) baseline scores typically require higher postoperative scores to report satisfaction [8, 14, 16], and change scores such as MIC values although the latter was not the aim of the current study. Additionally, the potential ceiling effects of preoperative BPII scores could not be assessed because of the absence of baseline data. However, a previous study from our group on a cohort with similar patient characteristics demonstrated no ceiling effects for preoperative BPII sum scores [12]. Selection bias may also exist as patients from only three hospitals in the same region were included, but the high response rate of 80.7%, along with no differences between the responder and nonresponder groups (age, sex and BMI), increases the likelihood of a representative study population. While variations in surgical procedures across hospitals could affect generalisability, this limitation is likely minimal given that 97% of procedures were performed at the same tertiary care university hospital using uniform techniques. Moreover, the adjusted PASS method assumes normally distributed PROM scores, and the impact of the non-normal distribution of BPII scores in the current cohort remains unclear [24]. In addition, the reliability of the anchor question could not be assessed using the recently recommended confirmatory factor analysis because of the collection of BPII sum scores rather than individual item responses [26]. However, the finding of a point-biserial correlation of 0.63 between the anchor question and BPII score indicates an acceptable criterion validity [4]. Finally, the PASS thresholds of BPII found in this study were specific to the current patient cohort treated with an individualised surgical approach. Although this diversity in procedures reflects real-world clinical practice, future external validation with larger registry-based cohorts is needed to assess variations in patient satisfaction and BPII scores.

# CONCLUSION

The PASS threshold for BPII after patellar stabilisation surgery was 62.4 (out of 100 points). The adjusted predictive modelling method demonstrated superior precision and robustness in the PASS threshold calculation compared with the ROC analysis. This threshold provides a disease-specific reference for clinical decision making and research in patellofemoral instability.

## AUTHOR CONTRIBUTIONS

**Per Arne Skarstein Waaler**: Conceptualisation; study design; data collection; statistical analysis; drafting of manuscript. **Eivind Inderhaug**: Conceptualisation; supervision; review and editing of manuscript. **Thomas Birkenes**: Supervision statistical analysis; review and editing of manuscript. **Asle Birkeland Kjellsen**: Review and editing of manuscript. **Trine Hysing-Dahl**: Conceptualisation; supervision; study design; data collection; review and editing of manuscript.

## ACKNOWLEDGEMENTS

The corresponding author has received partial funding (1 month research leave with full salary) from The Norwegian Knee Ligament Register, Department of Orthopedic Surgery, Haukeland University Hospital, Bergen, Norway.

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

## ETHICS STATEMENT

Regional Committee for Medical and Health Research Ethics, ID 2022/488689 and 2020/185067. All patients provided written consent prior to enrolment.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

**How to cite this article:** Waaler PAS, Inderhaug E, Birkenes T, Kjellsen AB, Hysing-Dahl T. Estimation of the patient acceptable symptom state (PASS) threshold for the Banff Patellofemoral Instability Instrument 2.0. Knee Surg Sports Traumatol Arthrosc. 2025;1–7. https://doi.org/10.1002/ksa.70061