A smart device application for acute pain service in surgical patients at a tertiary hospital in South Korea: a prospective observational feasibility study

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Background: Pain assessment and patient education are essential for successful postoperative pain management. However, the provision of personnel for performing these tasks is often insufficient. Recently, attempts have been made to implement smartphone applications for educating and monitoring surgical patients. We developed a smartphone application (app) for postoperative pain management, and conducted a feasibility study.

Methods: This single-center prospective observational study included 60 patients aged <70 years who underwent elective surgery. This study evaluated the SmartAPS application, which offers tools for postoperative pain assessment and educational materials for pain management. The primary outcome was the active usage rate, defined as responding at least twice daily on postoperative days (PODs) 1 and 2. Additionally, we investigated patient satisfaction with the app and educational videos as well as any challenges encountered during use.

Results: Sixty patients were enrolled in the study and active app use was achieved in 56.7% of them. Response rates peaked at 85.0% for pain intensity and 83.3% for opioid-related side effects at 14:00 on POD 1 but dropped to 56.7% and 58.3%, respectively, at 18:00 on POD 2. Among the patients who responded to the survey regarding the app usage, 84.0% reported satisfaction with the app and 80% found it beneficial for managing postoperative pain. Furthermore, 92.0% did not encounter difficulties using the app, indicating a generally positive user experience.

Conclusions: Our findings support the utility of the SmartAPS application in acute pain services, highlighting its potential for improving postoperative pain management.

Keywords: Digital health; Digital technology; Mobile applications; Pain measurement; Pain, postoperative; Smartphone; Telemedicine.

INTRODUCTION

Inadequate postoperative pain control not only causes patient discomfort, hinders postoperative recovery, and diminishes patient satisfaction [1-3], but can also lead to longer hospital stays due to complications [4]. Furthermore, it is an
important risk factor for chronic postoperative pain and subsequent opioid use [5]. Despite advancements in minimally invasive surgical techniques and perioperative care, a considerable proportion of patients experience severe postoperative pain [6].

The Acute Pain Service (APS) was introduced in the early 1990s to improve postoperative pain management in the United States and Europe [7]. However, although APS has been widely adopted [8-10] and shown to enhance pain control, increase patient satisfaction, and shorten hospital stays [11], its implementation faces challenges, including reliance on team commitment, limited resources, and institutional funding, particularly in non-academic hospitals [8,12,13]. Evidence of the cost-effectiveness of APS remains limited [14], and its adoption is heavily influenced by institutional policies, healthcare reimbursement rates, and the perceived value of postoperative pain management by healthcare professionals and patients [11]. According to the results of the second comprehensive quality report on anesthesia conducted by the Health Insurance Review and Assessment Service in South Korea, only 49.6% of institutions operate APS teams [15].

To address these challenges, we focused on the role of mobile applications in providing healthcare, which have been gaining an increasingly notable role in the medical field [16]. Recognizing its potential to improve acute pain management [17,18], we aimed to develop a mobile application (app) specifically for postoperative pain management that incorporates pain assessment and patient education. Given the novelty of the app and lack of data on its usage and technical reliability, we initiated this feasibility study to identify app errors, evaluate patient compliance, and investigate areas for further enhancement before proceeding with a randomized controlled trial.

MATERIALS AND METHODS

Study design

This feasibility study used a single-center, prospective, non-randomized observational design. This study received an approval from the Institutional Review Board (IRB) of Seoul National University Hospital (Approval no. 2304-053-1420). The trial was registered with ClinicalTrials.gov (NCT06014918, August 2023) before the recruitment of the first participants and adhered to the Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines [19].

Adult patients aged < 70 years scheduled for elective major surgery were assessed for eligibility. Patients with an American Society of Anesthesiologists physical status of I or II, and a smartphone that could be used met the inclusion criteria. Patients with an American Society of Anesthesiologists physical status of III or higher were excluded from the study because of functional limitations caused by underlying medical conditions, which may make it difficult to use the app and affect the accuracy of patient compliance evaluation. Patients with communication impairments, including cognitive disorders, deafness, and blindness were excluded from the study. Considering that the notification is scheduled for the second day after surgery, we selected two patients from our division who underwent elective major surgery on Tuesdays and Wednesdays, and met the criteria mentioned above. An online random-choice generator (www.microapp.io/random-choice-calculator) was used for the participant selection. Patient recruitment began in August 2023 and continued until February 2024. All patients were fully informed about the study and provided written informed consent.

About SmartAPS

The smartphone app, named SmartAPS, which was developed by the principal investigator (HJL), was designed for compatibility with both the Android (Google) and iOS (Apple Inc.) platforms. The app was not uploaded to each operating system’s software download service, as it was still in the testing phase. Therefore, the researchers installed it on the participants’ smartphones using a USB connection or via the TestFlight app (Apple Inc.). This application was designed to be compatible with Android and iOS platforms using the Unity Engine, ensuring operability across all patient smartphone devices. On the server side, RESTful APIs were implemented using ASP.NET Core MVC. The MySQL database was selected for its reliable and scalable data management. The infrastructure was established through the Naver Cloud Platform (Naver), which offers various cloud services, including virtual servers (EC2), databases, and a Content Delivery Network, thereby enabling high availability, security, and efficient resource management.

The app was designed to enable administrators to customize the questions provided to patients through an accompanying website. This application facilitates pain evaluation using a numerical rating scale (NRS). Two horizontal
bars representing an 11-point NRS (0, no pain; 10, worst imaginable pain) were displayed on the screen to measure each pain intensity level. To help understand the numeric pain scale, we incorporated emoticons that reflected facial expressions of pain. However, if a patient experienced difficulty assessing their pain using the NRS, they were advised to choose from a four-level verbal rating scale (VRS) presented in Korean (“It does not hurt at all,” “The pain is tolerable,” “It hurts a lot,” “It is unbearably painful”) [20]. Opioid-related side effects can be evaluated using binary yes/no responses. Patient satisfaction with postoperative pain management was assessed using a 5-point scale (very satisfied, satisfied, neutral, dissatisfied, and very dissatisfied). In addition, we developed a functionality to evaluate postoperative recovery quality in surgical patients using the Korean version of the Quality of Recovery-15 questionnaire [21], although it was not utilized in this study. The scheduling of these item evaluations was flexible, allowing the researcher to set the timing and frequency, with the possibility of conducting up to five assessments per day. Alarms to prompt assessment were set to appear on the patient's smartphone at times specified by the researcher to ensure timely data collection. These results were accessible in real time by medical personnel over the web integrated with the app. In addition, the researcher could upload videos to the Web and select which of the uploaded videos to provide to individual patients at their discretion.

To ensure anonymity, patients were coded and logged in using only the English initials of their name, sex, ward, room number, and scheduled surgery date. Screenshot images of the app are shown in Fig. 1. The app’s home screen displayed basic patient information, date information with a select function, a list of assessments to be completed, a link to a tab for educational videos on postoperative pain management, and a link to contact the researchers (Fig. 1A). The ‘Surveys’ tab allows the patient to change the date, which defaults to the current date, and displays a list of uncompleted assessments with a reminder, or a history of completed assessments for the selected date. Screenshots of the assessments provided by the app, including the NRS or verbal rating scale (Fig. 1B), opioid-related analgesic side effects, and overall satisfaction with pain management (Fig. 1C) are also presented. The ‘VOD’ tab presents educational videos on postoperative pain management and tapping on each video took the patients to the corresponding YouTube link. The researchers created all the videos, the details of which are provided in Supplementary Table 1. Furthermore, the app provided a ‘Contact us’ tab, where patients could submit questions about their postoperative pain management, and the researchers could view and answer the questions.
Study protocol

Consent for the study was obtained after the patient was admitted to the hospital prior to surgery. When a patient agreed to participate, one of the researchers installed the app on the patient’s smartphone. The participants were subsequently instructed on how to watch the educational video materials and how to complete the assessment of pain intensity, opioid-related side effects, and patient satisfaction. The total number and timing of the assessments were also described. After interviewing the patients, baseline information including demographics, planned surgical procedure, history of chronic pain, smoking status, previous surgical history, history of postoperative nausea and vomiting...
(PONV), and history of motion sickness was registered in a web-based program created alongside the app.

The app prompted patients to enter pain intensity and opioid-related side effects three times a day from postoperative days (PODs) 1 to 2 at 10:00, 14:00, and 18:00. Owing to the unverified safety of the app, we limited the assessments to regular hours to ensure quick responses to technical issues. For postoperative pain, the patients were instructed to enter the intensity at the time of assessment and the maximum intensity from the last assessment to the time of assessment. The following opioid-related adverse effects were evaluated: nausea, vomiting, dizziness, somnolence, and headache. Researchers consistently monitored patient input via a web interface integrated into the application to identify technical issues. If a patient complained of severe pain (≥ 7 points) or any opioid-related side effects during working hours, one of the researchers (SHY) visited the patient to reassess and act if necessary. All other perioperative management procedures were performed according to the routine protocols of each surgical department. The final assessment, conducted at 18:00 on POD 2, assessed patient satisfaction with postoperative pain control using the app. In addition, after the conclusion of the study, patients completed a five-question survey on a seven-point scale to assess their satisfaction and provide feedback on the app’s use using paper questionnaires (Supplementary Table 2).

Outcomes and measures

At the time of patient enrollment, the following variables were collected: patient demographics (sex, age, weight, and height), American Society of Anesthesiologists physical status, history of chronic pain, history of smoking, history of previous surgery, history of PONV, surgical department, name of surgery, and smartphone operating system (Android or iOS) use.

The primary outcome was the proportion of active users, defined as patients who responded to the assessment of pain intensity and opioid-related side effects by using the app at least twice daily. In other words, users were classified as active if they responded to the assessment of pain intensity and opioid side effects at least twice daily during three scheduled notifications (10:00, 14:00, and 18:00) on both POD 1 and 2. The timing of patient response was not evaluated. The deadline for conducting the assessments was the completion of the final questionnaire. At this point, it was determined whether the user was active and each case was subsequently concluded. The secondary outcome was the response rate to the assessments conducted at each time point using the application, including pain intensity, opioid-related side effects (10:00, 14:00, and 18:00 on POD 1 and 2), and satisfaction with postoperative pain control (only 18:00 on POD 2). We also evaluated the survey results regarding satisfaction with and feedback on the app use, whether the patients watched and found the educational video materials helpful, and any technical errors identified during the study.

Statistical analysis

As this was a feasibility study of a newly developed app with no existing reference values for compliance, we assumed a compliance rate of 80% for this app. The acceptable range of compliance was set at a minimum of 70% with a margin of error of 0.1. Therefore, 60 patients were required to achieve a 95% confidence interval with a lower bound of 0.7 [22]. Furthermore, considering previous research that concluded that a sample size of 50 patients would be sufficient for collecting end-user feedback, we determined that even when considering potential unexpected dropouts, our planned sample size of 60 patients would be adequate [23,24].

Patient characteristics and outcome variables were described as numbers with percentages for categorical variables and as means with standard deviations or medians with interquartile ranges for continuous variables, depending on data normality. Additionally, during the revision process, we conducted a comparative analysis of the clinical characteristics of active and inactive users. Continuous variables were analyzed using t-tests or Mann-Whitney U tests based on normality, whereas categorical variables were assessed using chi-square or Fisher’s exact tests.

RESULTS

Of the 62 patients assessed for eligibility, 60 were successfully enrolled and had the SmartAPS application installed on their smartphones. Two patients were excluded from the study due to temporary expiration of their iOS installation codes.

The baseline patient characteristics are presented in Table 1. The mean age was 48.2 ± 11.6 years, and 43 patients (71.7%) were female. Among them, 56.7% (n = 34) were active users. A comparison of the clinical characteristics of the
active and inactive users is presented in Table 2. Active users were younger (45.4 ± 10.2 vs. 52.0 ± 12.5, P = 0.028) and had a higher proportion of the American Society of Anesthesiologists physical status I (67.6% vs. 30.8%, P = 0.010). Active users were also about twice as likely to watch the educational videos on pain management (76.5% vs. 38.5%, P = 0.007). Over half of the active users reported satisfaction with their pain management, with 8.8% indicating 'Very satisfied' and 47.1% indicating 'Satisfied', whereas the majority of inactive users did not undergo the assessment (84.6%).

Table 3 and Supplementary Fig. 1 presents the results of pain intensity, opioid-related side effects, and patient satisfaction with postoperative pain management recorded using the app. Patients using the app evaluated their pain intensity using the NRS; the VRS was not used. Four patients did not complete any assessment using the app. Two patients did not participate because they did not perceive the need to use the app. Another patient’s smartphone was damaged after being dropped, and the fourth did not receive alarms because of server issues. Response rates were highest at 14:00 on POD 1 for assessments of both pain intensity (n = 51, 85.0%) and opioid-related side effects (n = 50, 83.3%), and lowest at 18:00 on POD 2 (n = 34, 56.7% and n = 35, 58.3%, respectively). Both pain intensity and frequency of opioid-related side effects were greatest at 10:00 on POD 1 and generally decreased over time. A total of 35 patients (58.3%) responded to the satisfaction survey for pain management on SmartAPS with 57.1% (n = 20) of respondents selecting "very satisfied" or "satisfied." Of the 20 patients who reported satisfaction with their pain management, 19 were active users.

The survey results on satisfaction with the app usage are shown in Fig. 2. A total of 50 patients completed the survey, and the reasons for not completing the survey among patients who used the app were as follows: discharge before 18:00 on POD 2 (five patients) and poor medical condition (one patient). Of the patients who responded to the survey conducted at 18:00 on POD2, 84.0% (70% of the total) expressed satisfaction with the app, and 80.0% (68.3% of the total) found it useful for managing postoperative pain. When asked if they had difficulty using the application, 92.0% (76.7% of the total) of respondents disagreed or strongly disagreed. Supplementary Table 3 presents patient feedback on the app, which is organized according to the reasons for being unable to use the app actively, positive comments on the app, and comments on potential improvements.

**DISCUSSION**

In our study, 56.7% of surgical patients actively used SmartAPS on PODs 1 and 2. Additionally, 60.0% of patients watched the educational videos provided. Of the patients who responded to the survey regarding the app, 84.0% expressed satisfaction and 80.0% found it useful in managing their postoperative pain. Moreover, 92.0% reported they did not experience difficulties using the app. Despite these positive indicators, we encountered several challenges with the app during the early postoperative phase, underscoring the need for additional refinement.

Mobile healthcare for postoperative pain management is gaining interest, but reviews of apps for pain management have highlighted the absence of end-user involvement in the development process and a lack of scientific evaluations [25,26]. The objective of our feasibility study was to gather end-user feedback and implement it to enhance the app us-
Table 2. Comparison of Perioperative Variables Between Active and Inactive Users of the App

<table>
<thead>
<tr>
<th>Variable</th>
<th>Active users (N = 34)</th>
<th>Inactive users (N = 26)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>27 (79.4)</td>
<td>16 (61.5)</td>
<td>0.217</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>45.4 ± 10.2</td>
<td>52.0 ± 12.5</td>
<td>0.028</td>
</tr>
<tr>
<td>ASA physical status (I/II)</td>
<td>23 (67.6)/11 (32.4)</td>
<td>8 (30.8)/18 (69.2)</td>
<td>0.010</td>
</tr>
<tr>
<td>History of chronic pain</td>
<td>2 (5.9)</td>
<td>3 (11.5)</td>
<td>0.753</td>
</tr>
<tr>
<td>History of previous surgery</td>
<td>18 (52.9)</td>
<td>16 (61.5)</td>
<td>0.687</td>
</tr>
<tr>
<td>Watching educational videos</td>
<td>26 (76.5)</td>
<td>10 (38.5)</td>
<td>0.007</td>
</tr>
<tr>
<td>Satisfaction on pain management</td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Very satisfied</td>
<td>3 (8.8)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Satisfied</td>
<td>16 (47.1)</td>
<td>1 (3.8)</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>7 (20.6)</td>
<td>1 (3.8)</td>
<td></td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>5 (14.7)</td>
<td>2 (7.7)</td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td>3 (8.8)</td>
<td>22 (84.6)</td>
<td></td>
</tr>
<tr>
<td>Total IV-PCA usage (ml)*</td>
<td>40.4 ± 18.1</td>
<td>44.1 ± 23.7</td>
<td>0.571</td>
</tr>
<tr>
<td>Postoperative nausea and vomiting</td>
<td>20 (58.8)</td>
<td>9 (34.6)</td>
<td>0.110</td>
</tr>
</tbody>
</table>

Values are presented as number (%) or mean ± SD. ASA: American Society of Anesthesiologists, IV-PCA: intravenous patient-controlled analgesia. *These data were obtained from 43 patients. Of these, six patients (four in the active user group and two in the inactive user group) did not undergo IV-PCA. Additionally, the total IV-PCA usage could not be assessed in 11 patients because their devices were removed before the final assessment point. The IV-PCAs were formulated with fentanyl at a concentration of 20 mcg/ml, featuring a bolus of 1 ml and a lockout period of 10 min, without a basal infusion.

Table 3. Response Rate and Content of Responses to the Assessments on Application

<table>
<thead>
<tr>
<th>Variable</th>
<th>Postoperative day 1</th>
<th>Postoperative day 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10:00 14:00 18:00</td>
<td>10:00 14:00 18:00</td>
</tr>
<tr>
<td>Pain intensity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondent</td>
<td>49 (81.7) 51 (85.0) 47 (78.3)</td>
<td>43 (71.7) 41 (68.3) 34 (56.7)</td>
</tr>
<tr>
<td>Pain at the time</td>
<td>5 (3.6) 5 (3.5) 4 (3.5)</td>
<td>3 (2.5) 3 (2.4) 3 (2.4)</td>
</tr>
<tr>
<td>Maximum pain</td>
<td>7 (5.8) 6 (5.8) 6 (5.7)</td>
<td>4 (3.5) 4 (3.5) 4 (3.5)</td>
</tr>
<tr>
<td>Opioid side effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondent</td>
<td>47 (78.3) 50 (83.3) 43 (71.7)</td>
<td>43 (71.7) 40 (66.7) 35 (58.3)</td>
</tr>
<tr>
<td>Nausea</td>
<td>24 (51.1) 17 (34.0) 11 (25.6)</td>
<td>9 (20.9) 7 (17.5) 3 (8.6)</td>
</tr>
<tr>
<td>Vomiting</td>
<td>8 (17.0) 5 (10.0) 3 (7.0)</td>
<td>0 (0) 0 (0) 0 (0)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>28 (59.6) 26 (52.0) 15 (34.9)</td>
<td>12 (27.9) 11 (27.5) 6 (17.1)</td>
</tr>
<tr>
<td>Somnolence</td>
<td>23 (48.9) 20 (40.0) 14 (32.6)</td>
<td>10 (23.3) 11 (27.5) 6 (17.1)</td>
</tr>
<tr>
<td>Headache</td>
<td>15 (31.9) 14 (28.0) 9 (20.9)</td>
<td>9 (20.9) 10 (25.0) 8 (22.9)</td>
</tr>
<tr>
<td>Satisfaction on overall pain management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondent</td>
<td></td>
<td>35 (58.3)</td>
</tr>
<tr>
<td>Strongly satisfied</td>
<td></td>
<td>3 (8.6)</td>
</tr>
<tr>
<td>Satisfied</td>
<td></td>
<td>17 (48.6)</td>
</tr>
<tr>
<td>Neutral</td>
<td></td>
<td>8 (22.9)</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td></td>
<td>7 (20.0)</td>
</tr>
<tr>
<td>Strongly dissatisfied</td>
<td></td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

Values are presented as number (%) or median (1Q, 3Q).

Moreover, most apps have been developed to target patients with chronic pain but not those with acute postoperative pain. Subsequent studies have highlighted the effectiveness of smartphone apps in managing acute postoperative pain. A feasibility study of 50 surgical inpatients showed 60% satisfaction with the app [23], and a French study of 1,691 patients highlighted the app's usefulness in postoperative
Studies have also indicated that apps can improve post-discharge pain management and reduce the burden on healthcare providers [28,29]. However, our study differs from the previous studies in several respects. First, the SmartAPS can evaluate not only pain intensity but also opioid-related side effects and patient satisfaction with pain management [23,28]. Furthermore, our study included hospitalized patients who underwent major surgeries, unlike previous studies that focused on day surgery patients [27,29], and included patients who received general anesthesia rather than regional anesthesia [28,29], thereby capturing a more diverse patient population. Most importantly, these apps were all developed in their native languages, making them inaccessible to Korean patients; therefore, we decided to develop SmartAPS for Korean surgical patients.

To the best of our knowledge, this study represents the first effort in Korea to use a smartphone app for the comprehensive management of postoperative pain, which differs from previous studies that focused solely on patient education regarding intravenous patient-controlled analgesia [30].

Despite the potential benefits of smartphone apps for postoperative pain management, the low adherence emerged as a significant challenge in this preliminary study, with active user rates falling below the expected 80%. From the feedback of the participating patients, we identified the main reasons for our app’s lower than expected active user rate among surgical patients. First, common postoperative symptoms such as pain, nausea and vomiting, dizziness, somnolence, and fever may have made it difficult for patients to use their smartphones. Additionally, some patients reported that they did not feel the need to watch preoperative educational videos or assess postoperative pain and opioid-related side effects. In a feasibility study that monitored patients discharged after colorectal surgery via a

**Fig. 2.** Survey results on satisfaction with application usage.
smartphone app, those who did not use the app daily cited similar aspects, including physical issues such as postoperative pain and fatigue, and behavioral factors such as time constraints and forgetfulness [31]. On the other hand, daily users were motivated with the connection to healthcare providers and benefits from using the app [31]. Therefore, it is necessary to provide education regarding the importance of patient education and assessment in postoperative pain management to increase patient accessibility. Providing educational materials to patients through the app before hospitalization to increase their familiarity with it may also be beneficial. Second, technical stability issues are associated with the app. Some patients experienced a lack of alarms at preset times or could not undergo the planned assessments due to server downtimes. According to a survey of the public’s perception of barriers to employing mobile health technologies after surgery, technical difficulties and lack of usefulness were identified as the second most frequently cited anticipated barriers [32]. We have resolved the technical issues identified in this study; however, we must continue our efforts to ensure the stability of these solutions in the future. Finally, offering customized feedback in the app, based on patient input and integrating an alert system for healthcare professionals regarding critical conditions, can enhance patient engagement and ensure timely care, potentially increasing the app usage. A previous feasibility study indicated that the incorporation of an app into the treatment pathway affected patients’ perceptions and attitudes towards the app, which, in turn, affected their usage [31]. Additionally, a systematic review of smartphone apps for communication with surgical patients showed that offering feedback on submitted information is an essential feature of an ideal mobile health app [33]. Furthermore, in the future, if patients are able to record audio or video when needed, and clinicians can utilize this multimedia platform to thoroughly assess postoperative pain, SmartAPS could deliver more personalized and refined feedback.

Our study had several limitations. First, it encompassed a diverse group of surgical patients, where disparities in smartphone app utilization may have arisen from demographic variations and postoperative conditions. Anticipating lower app usability among older patients, we limited enrollment to patients aged < 70 years. This approach may not fully represent adherence levels in older populations who may find smartphone technology more challenging. Even within similar age groups, bias may exist due to the skewness of self-reported data, as responses from individuals who are more adaptable to digital devices may be dominant. Furthermore, the degree of postoperative pain could influence app usage. Those experiencing minimal pain may perceive a lower need for the application, which leads to reduced engagement.

Conversely, patients experiencing severe pain requiring intervention may find it difficult to use the app. To enhance the usage rate of this app, further research on the factors that could influence its usage is required. In addition, all patients were notified of the assessments at fixed time points (10:00, 14:00, and 18:00 on POD 1 and 2); thus, the different end-of-surgery times of the patients could also influence app usage. Second, the use of the app for pain assessment did not instantly alter pain management practices. Reporting severe pain through the app does not always lead to additional analgesic interventions, potentially fostering doubts regarding its effectiveness and diminishing patient satisfaction. To improve adherence and ensure timely intervention, a support system that enables real-time communication of uncontrolled pain or opioid-related side effects to healthcare providers is essential. Third, this study introduced SmartAPS to address technical challenges. Any technical issues encountered can negatively affect patient satisfaction and the frequency of app usage. For an app to be effective in real-world clinical settings, it must operate reliably across various smartphone types. Finally, because this was a planned feasibility study, a holistic evaluation of the clinical impact of the app was impossible. In this context, a sample size of 60 patients, even for a feasibility study, may be insufficient to ensure the reliability of the metrics produced. However, a previous feasibility study on the clinical use of a smartphone app for postoperative pain involved a cohort of 50 patients [23]. Furthermore, a systematic review of feasibility studies involving mobile technology in clinical research indicated that the median number of patients was 33 [34]. Therefore, the 60 patients included in our study were an acceptable sample size. Furthermore, a larger prospective randomized study based on the results of this study is planned in the future.

In conclusion, our feasibility study identified that 56.7% of patients actively used SmartAPS after surgery and 70% were satisfied with its use, anticipating its role in future postsurgical pain management. However, the proportion of active users did not meet initial expectations, underscoring the need for ongoing initiatives to enhance user engagement. Moreover, considering the scalability of SmartAPS, further research is imperative to extend its application across diverse surgical cohorts, thereby determining its efficacy and opti-
mization for various surgical patient groups. This endeavor will refine its usability and broaden its impact on improving postoperative pain management strategies.

SUPPLEMENTARY MATERIALS

Supplementary data is available at https://doi.org/10.17085/apm.24059.

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS


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