Smartphone application-based follow-up care of patients after bariatric surgery: A mixed-method study of usability

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Abstract

Objective: Due to potential short-term and long-term complications, adequate lifelong follow-up is crucial for patients after bariatric surgery. However, compliance with postoperative follow-up is poor despite clear national and international guidelines. This feasibility trial aimed to evaluate the usability of a smartphone application-based follow-up program in patients after bariatric surgery.

Methods: Patients were included after having undergone a primary bariatric surgery. Instead of attending meetings in our outpatient clinic, they were followed up using a smartphone application. After 6 months, the System Usability Scale (SUS) was used to measure participant perception. Additional interviews were performed to gain more insight into the usability of the app.

Results: Between August 2020 and February 2021, 52 patients met the inclusion criteria and agreed to participate in the study, of whom 5 (9.6%) dropped out of the study. At the time of analysis, 31 patients have been followed up for 6 months, among whom 26 patients completed the SUS questionnaire. The mean overall score of SUS is 82.1 ± 19.8. In the qualitative analysis, participants were generally positive about the follow-up care and found it easy to use, despite some minor technical problems.

Conclusion: Our smartphone app-based follow-up program was proven to be effective in the aftercare succeeding bariatric surgery. Our data indicates that the satisfaction, efficiency, learnability, and ease of use of the smartphone application were coherent in the acceptance and use of mobile technology by patients.

Keywords

Postoperative monitoring, obesity, mobile health app, telemedicine, handheld device

Introduction

Obesity is an increasing global health challenge and one of the main risk factors for numerous comorbid medical conditions such as cardiovascular disease, type 2 diabetes, and early death.¹⁻⁴ Bariatric surgery has been proven to be the most effective and durable therapy for obesity,⁵ which leads to sustained improvement in comorbidities such as better diabetic remission, lower risks of microvascular and macrovascular disease,⁶ decreased incidence
and long-term progression of chronic kidney disease as well as reduced number of cardiovascular deaths. However, bariatric surgeries are associated with short- and long-term complications. Protein malnutrition and micronutrient deficiency are common despite recommendations for multivitamins and mineral supplements. Dumping syndrome and gastroesophageal reflux disease are potential complications related to the anatomical changes through bariatric surgeries. Thus, adequate lifelong follow-up is crucial for the early detection of postoperative complications. Additionally, adherence to postoperative follow-up has been shown to associate with greater long-term excess weight loss and total weight loss. Unfortunately, the compliance with long-term follow-up after bariatric surgeries is poor despite clear national and international guidelines. Lack of time and long distances are often mentioned as barriers to attend regular follow-ups. The COVID-19 pandemic adds additional barriers to patients by limiting their in-person visits to the out-patient clinic.

With rapidly increasing mobile device usage, smartphone applications (app) present an opportunity to help patients improve the access to health services, adherence to treatment, and behavioral changes as well as ease the communication with health care providers. Mobile health (mHealth) interventions for diabetes and obesity management are promising, but there is limited evidence about their effectiveness in the follow-up of patients after bariatric surgery.

**Methods**

**Study design**

The single-arm, prospective trial was designed as a prospective, single-center analysis observing the usability of a smartphone application for postoperative follow-up after bariatric surgery. The study was approved by the university faculty ethics committee and institutional review board (#2018-643N-MA) and was conducted at the university hospital. The trial is registered in the German Clinical Trials Register (DRKS00016143).

**Inclusion**

Patients underwent bariatric surgeries for poorly managed obesity (body mass index (BMI) ≥35 kg/m² with one or more comorbidities (e.g., diabetes, arterial hypertension, and sleep apnea) or BMI≥40 kg/m²). Two weeks after discharge, patients attended their first postoperative appointment in the outpatient clinic and were included in the study. Exclusion criteria were redo surgeries, language barrier, impaired mental state, serious postoperative complications (grades II, III, and IV according to the Clavien-Dindo classification) up to the first visit, and lack of compliance. Participation for all patients was predicated on their written informed consent.

**Procedures**

The smartphone app MYONCARE™ (OnCare GmbH, Munich, Germany) was used in our investigation. Through constant feedback, we were involved in the development of the smartphone app.

All participants utilized their private smartphones. After informed consent, coauthors NT and MK assisted the participants in installing the app. With a personalized QR code, participants could log in to the app. After being trained until participants were confident with the app operation flow, each participant carried out a “dry run”, involving receiving an example questionnaire and sending back answers.

**Questionnaire**

Instead of regular follow-up visits in the outpatient clinic, a standardized questionnaire was constructed based on the database of the German register for obesity and metabolic surgery and sent to the participants via the app periodically: every 6 weeks in the first 9 months and then 1 year after the surgery. The questionnaire consists of 16 items and accesses the general well-being, pains, weight, dietary habits, gastrointestinal symptoms, physical activity, and supplement of minerals and vitamins of the participants (Figure 1, for questionnaire, see online Appendix). If patients’ answers exceeded a defined threshold and indicated a potential problem (i.e. patients report having severe pain with numerical rating scale (NRS)>5), a warning message was sent to the account of responsible
health care providers. Besides, participants were reminded to take supplements or physical activities with weekly push notifications.

**In-app message service**

Participants were able to contact the health care providers using the in-app message service available in the app (Figure 2). Results of tests, which were undertaken by general physicians or other specialists, could be transmitted via the app. During working hours on weekdays, investigating personnel (also health care providers) would take care of the concerns or questions of the participants. If necessary, surgeons or other physicians would also be involved. However, participants were instructed not to use the app as a communication tool in case of an emergency. On the other hand, investigating personnel communicated with the participants via the message service if problems were recognized after evaluating the questionnaires. For example, if a participant stated that his/her daily protein intake was less than 60 g, an investigating nurse would draw attention to the importance of adequate nutrition and give recommendations to increase protein intake.

**Usability**

Usability is defined as “extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.” The usability of the smartphone app was assessed by applying the mixed-method approach, where the combination and integration of qualitative and quantitative elements, have been used to evaluate the usability of the app. The usability assessment took place after 6 months of using the app.

**Quantitative analysis.** The German translation of the System Usability Scale (SUS) was used to measure participant’s perception of using a smartphone application for follow-up care after surgery. SUS is the most frequently used validated questionnaire accessing usability in mHealth applications. It is a brief questionnaire of 10 items. Each item used a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Ranging from 0 to 100, mean scores of 62.7 was considered acceptable, and 68 or above was regarded as above average.

**Qualitative analysis.** To gain more insight into the usability of the app, semi-structured telephone interviews of maximum 30 minutes were conducted with selected participants. Based on the SUS scores, participants were divided into three groups: satisfied, neutral, and unsatisfied. Two participants were randomly chosen from each group and interviewed by coauthors NT and MK. The interviews were guided by key questions related to learnability, efficiency, and satisfaction. Data collected through hand-written notes and audio recordings were qualitatively analyzed following the steps of thematic analysis: compiling, disassembling, reassembling, interpreting, and concluding.

**Statistical analysis**

All statistical calculations were performed with the R version 3.6.3. For quantitative variables, mean and SDs were assessed. For qualitative factors, absolute and relative frequencies were given. For normally distributed data,

| Characteristics | Value |
|-----------------|-------|
| Age (years), mean (SD) | 41.2 (10.1) |
| Gender, n | |
| Female | 19 |
| Male | 7 |
| Body mass index (BMI) (kg/m²), mean (SD) | 47.2 (7.1) |
| Surgery, n | |
| RYGB | 17 |
| VSG | 9 |

RYGB: Roux-en-Y gastric bypass; VSG: vertical sleeve gastrectomy.
Student’s $t$-test was used. Pearson correlation coefficient measures correlations between two metric variables, Spearman correlation between an ordinal and a metric variable, and Chi-square test between a nominal and an ordinal variable. In general, the result of a statistical test was considered statistically significant with a $p$-value <0.05.

**Results**

**Baseline characteristics of participants**

Between August 2020 and February 2021, of the 75 patients assessed for eligibility, 52 subjects met the inclusion criteria and agreed to participate in the study. Of the 52 participants, 5 (9.6%) dropped out of the study: two of them withdrew their informed consent and two were lost to follow-up. One patient was excluded for her limited reading ability. At the time of analysis, 31 patients have been followed up for 6 months, among whom 26 patients completed the SUS questionnaire. Additionally, 6 patients were interviewed. All demographic information for participants is shown in Table 1.

**Quantitative analysis: SUS**

The mean overall score of SUS is 82.1 with a SD of 19.8. The overall scores did not correlate with the age or the surgical procedure (vertical sleeve gastrectomy (VSG) or Roux-en-Y gastric bypass (RYGB)).

Using the regression equations developed by Sauro and Lewis, the benchmarks for SUS items that correspond with overall SUS benchmarks of 80.8 (a common industrial benchmark which is an A on the Sauro-Lewis curved grading scale) were calculated (Table 2). For example, for consistency with an above-average SUS score of 80.8, the corresponding target for Item 1 would be an average score of at least 3.8 and for Item 3 at most 1.8.

**Qualitative analysis: Interviews**

A total of 26 participants were divided into 3 groups according to the SUS overall scores (satisfied, neutral, and unsatisfied). Two participants were randomly selected from each group and six participants were approached for a telephone interview. Table 3 presents the characteristics of the interviewees.

The qualitative results are described according to the key questions.

**Quality of follow-up care with the questionnaires in the app.**

A standardized questionnaire was sent to participants in each follow-up session. Most participants had no problem in understanding the questionnaire and the follow-up with the questionnaire was sufficient in their opinion.

Everything is actually perfect the way it is. I get along very well with the questions.

[patient 20]

The questions were okay in principle, it (the follow-up care using the app) was actually enough for me. For me that is enough as follow-up. It’s very user friendly.

[patient 19]

It was much appreciated that caregivers contacted the patients actively by sending a questionnaire regularly and gave feedback to their answers within a short time. If patients’ answers exceeded a defined threshold and indicate a potential problem (i.e. patients report having severe pain with NRS>5 or vomiting after meals), a warning message was sent to the account of responsible health care providers.

| Item                      | Score       | Target for SUS≥ 80.8 |
|---------------------------|-------------|----------------------|
| **Satisfaction**: I think that I would like to use this system frequently. | 4.1 ± 1.4  | ≥ 3.8                |
| **Efficiency**: I found the system unnecessarily complex. | 1.4 ± 0.9 | ≤ 1.8                |
| **Ease of use**: I thought the system was easy to use. | 4.5 ± 1.1 | ≥ 4.3                |
| **Learnability**: I think that I would need the support of a technical person to be able to use this system. | 1.4 ± 0.8 | ≤ 1.5                |

SUS: System Usability Scale.

| Number | Group | Gender | Age | Surgery | SUS score |
|--------|-------|--------|-----|---------|-----------|
| 20     | High  | Male   | 53  | RYGB    | 100       |
| 10     | High  | Female | 32  | VSG     | 97.5      |
| 19     | Medium| Male   | 37  | RYGB    | 85        |
| 26     | Medium| Female | 42  | RYGB    | 75        |
| 1      | Low   | Female | 62  | VSG     | 55        |
| 33     | Low   | Female | 40  | RYGB    | 42.5      |

RYGB: Roux-en-Y gastric bypass; SUS: System Usability Scale; VSG: vertical sleeve gastrectomy.
Patients were contacted with the in-app message service or called depending on the degree of severity as soon as possible.

It is nice that I am being contacted regularly and asked, how I am doing.
[patient 33]

I was really grateful that there was always feedback, I always got a response. I felt really well supported and taken care of. That was good.
[patient 1]

The standardized questionnaire is for some interviewees not personal enough, a more patient-centered approach is desirable. Few patients were concerned that the follow-up care would not be sufficient for patients with more severe problems.

I hadn’t had any great problems. So it was enough for me. But maybe for someone who has more problems, it could be that it is not enough (as follow-up care)... The choices (of multiple-choice questions) were sometimes very superficial. It might be a bit easier for us if you would give more individual choices.
[patient 19]

It would be helpful if, for example, you could see in the app which substitutions you should take. A personal conversation would also be nice.
[patient 33]

Interviewees think it is a great advantage that they are able to answer the questionnaire according to their schedules.

When I got a pop-up message that a questionnaire has to be answered again. Sometimes I don’t see it right away. And then the next day and I still could click that and answer the questions.
[patient 20]

Repetitive questionnaires are well accepted and only one patient felt that disturbing.

No, it is not annoying when the same question is asked over and over again, because the answers could be different in the next appointment.
[patient 20]

I don’t really have to answer some questions every couple of weeks.
[patient 1]

Contact with health care providers via this app. Participants were able to contact health care providers using the message service in the app. All interviewees were delighted by the uncomplicated and direct access to health care providers.

It always went very quickly. When I had questions, I always got the best possible answer. That’s positive.
[patient 33]

I asked a question in the app and got an answer to my problems relatively quickly. That was very good. The direct contact.
[patient 10]

Difficulty in using the app. For the majority of the interviewees, the app was easy to use. The assistance of installation and initial log-in procedure was admired and considered necessary. After that, technical assistance was seldom necessary.

I didn’t install the app myself. That was installed in the outpatient clinic. After that I could use the app myself.
[patient 26]

I guess even for someone who is not very technically gifted, the app is actually so simple that it could be used by everyone.
[patient 19]

Technical issues. Some minor technical problems were reported by the interviewees, which reduced the comfort of using the app and were reported as disturbing.

I sometimes got pop-up messages, although no questionnaire was sent yet.
[patient 19]

Sometimes, it seems that my answers did not arrive, so that I have to send the answer again. Once, I sent it back three times!
[patient 1]

Discussion

Principal findings

This pilot study aimed to investigate the usability of a smartphone application as a follow-up tool for patients after bariatric surgery. Quantitative as well as qualitative data confirmed the usability of the smartphone app: the well above average SUS scores supported that the app has good to excellent usability for patients. Individual aspects such as satisfaction, efficiency, ease of use, and learnability scored well, which were supported by the qualitative data. Also, the qualitative analysis of
the interviews provided insight into technical problems and personal preferences of patients, which could be implemented to improve the health support for patients.

Our data analysis suggests that the smartphone app is sufficient for follow-up care in patients without serious initial complications after bariatric surgery. The monitoring of nutrition, surgical complications, and weight loss response are ensured in the investigated period of time. This is in line with the results in previous studies that smartphone apps resulted in high perceived usefulness and ease of use in monitoring postoperative wound, tracking pain and managing medication, day-to-day education after total knee replacement, and rehabilitation after lumbar spinal surgery. The digital transformation plays an essential role in our daily life and is becoming increasingly important, especially in medical care. Many people, especially the younger population, have already various wearables or smartphone apps that could track their daily behavior. However, the use of these devices in healthcare is not yet widespread, although the potential benefits could be immense. After bariatric surgery, a latent malnutrition could lead to serious complications if patients do not attend their follow-up regularly. Therefore, a simple smartphone app could be useful especially for these patients. The great acceptance of the app could be partially explained by the young population of our study (24–62 years old), who are used to smartphone devices and applications in their daily lives. Implementation difficulties and low percentage of app downloads described in the previous investigation were not noted in our study. The chosen app was proven to be easy to learn and use even with elderly cancer patients (61–78 years old). The assistance provided to patients to download and install the smartphone app, as well as the initial training, helped participants overcome implementation difficulties in our investigation.

In general, participants who used the app were satisfied with the flexibility of the home-based follow-up since they do not have to take a leave from work or spend time to visit the outpatient clinic or wait in the waiting room. Furthermore, the app enables the participants to react to findings provided by the smartphone app, as well as the initial training, helped participants overcome implementation difficulties in our investigation.

Despite the positive feedback in our quantitative and qualitative data, some shortcomings and technical problems were detected, which could obstruct a long-term follow-up. Minor technical problems such as unintended pop-up messages and health care providers not being able to receive the answered questionnaires at the right time may discourage further use of the app. The use of the standardized questionnaire did not meet the individual needs of some patients. Participants preferred a more personalized postoperative care after bariatric surgery, although, they could use the in-app chat function to communicate with healthcare providers about further health issues that are not interrogated in the questionnaire. Therefore, an additional input field that is discrete should be made available in the app for an individualized experience.

**Future development of an app-based follow-up program**

In the current investigation, questionnaires were programmed and sent to the participants at certain intervals. When patients sent back their responses, they needed to be evaluated manually by the investigating personnel. This is time- and personnel consuming. In future development, the answers of patients should be evaluated automatically by some algorithm, and instant feedback should be generated and sent back to patients. In case of complicated or severe problems, warnings would help health care professionals filter patients, who might need individual attention. This would decrease the workload of health care professionals so that they could focus on patients who need special help. Furthermore, a medication plan including recommended medications and medications that are taken by the patients should be implemented in the app. For patients, it would be a reminder to take their medications and supplements; whereas, for health care professionals, compliance and changes in medications could be monitored through telemedicine.

**Limitations**

Our study has some limitations. First, the study was conducted during the COVID-19 pandemic during which the patients were not able to visit in person at the outpatient clinic for their follow-up after surgery. It is unclear if the acceptance of mobile technology will continue to be the same post-pandemic. Second, due to the feasibility character of the study, the sample size was small, no control group was introduced, and the clinical efficacy endpoints were not yet analyzed. Moreover, the 6-month follow-up may not reflect problems in the long term. Despite these weaknesses, our data clearly validates the usability of the smartphone app in postoperative follow-up after bariatric surgery. Based on the current study, a further study would be able to remove the ambiguity mentioned above.

**Conclusions**

To our best knowledge, this is the first report on the usability of a smartphone app-based follow-up program for patients after bariatric surgery. Our data indicate that the acceptance, satisfaction, efficiency, learnability, and ease to use were excellent in this patient population.
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