



Using an E-Health Application for Post-operative Monitoring After Inguinal Hernia Repair: A Feasibility Study

J. L. Faessen¹ · R. van Vugt¹ · R. Veldhuizen¹ · J. H. M. B. Stoot¹

Accepted: 23 April 2022

© The Author(s) under exclusive licence to Société Internationale de Chirurgie 2022

Abstract

Background E-Health care is already well established in some (non-) surgical specialties and is considered as a means of improving patient-centred care. Considering the demand of remote health care changes, especially in the COVID-19 pandemic, it is essential to investigate the feasibility of e-Health care within one of the most performed surgery procedures: inguinal hernia repair.

Methods A total of 60 patients used the e-Health application in this study compliant. Primary objectives were to investigate the accuracy of the “deviating post-operative course” alerting by the e-Health application. Secondary objectives included patient perspective and e-Health costs analysis.

Results Forty-four patients reported no deviation in the post-operative course using the e-Health application of which 93.2% ($n = 41$) was in concordance with the findings during standard follow-up. Within 16 patients reporting a deviating post-operative course, a true complication was found in 25% ($n = 4$). Based on in-hospital costs, a hypothetical e-Health follow-up scenario was more expensive (€59.5 per patient) than current standard follow-up care (€28.2 per patient). Usage of the e-Health application showed a high perceived overall patient satisfaction: 4.2 (on a Likert-scale of 1–5).

Conclusion An e-Health application is a promising tool for identifying patients who require in-person or phone follow-up assessment. Patients’ perspectives surveys revealed high potential and willingness of using this application. A hypothetical e-Health follow-up scenario showed to be more expensive compared to current standard follow-up. If the identified (dis)advantages can be improved, e-Health follow-up care appears to be promising in terms of safety and feasibility. Future studies can leverage on this study and further investigate the use of e-Health within the field of general surgery.

Introduction

Inguinal hernia is a common global health problem. With over 20 million inguinal hernia repairs done worldwide annually, it is one of the most performed general surgery

procedures [1]. Due to improvements in technology and technique, mortality rates are estimated to be lower than 0.22% [2]. Post-operative complications rates including wound complications, surgical site infections, hernia recurrence and chronic post-operative pain (CPIP) are low overall as well [3–6].

Due to the low rates of post-operative complications, as well as a relatively benign post-operative course, the utility of scheduled routine post-operative follow-up for all patients who undergo elective, outpatient inguinal hernia repair has been questioned. The literature shows that

✉ J. L. Faessen
jelle.faessen@gmail.nl

¹ Department of Surgery, Zuyderland Medical Center, Dr. H. van der Hoffplein 1, Sittard-Geleen, 6162 BG Heerlen, The Netherlands

unnecessary outpatient visits may pose a burden to both patients and health care providers [4]. Accordingly, the use of telephone contact to follow-up patients after surgery is widely investigated and is already well established in daily practice after it had been considered safe [3, 5–8]. However, the limitation of telephone follow-up is that it must be performed with both the patient and the surgeon being simultaneously available.

In line with this, e-Health interventions are becoming increasingly popular in medical care within the last decades [9]. These applications give patients the opportunity to get information fast, to self-manage their recovery process and to deliver more patient centred care. In addition, recent studies show that the usage of e-Health tools have advantages in terms of delivering more efficient, effective, and patient-friendly health care [9–20]. However, no study to date has examined the feasibility of e-Health follow-up in elective inguinal hernia repair. Therefore, a pilot study with the objective to analyse the feasibility of an e-Health application in the post-operative course after inguinal hernia repair was conducted.

Methods

Design

All patients who had a primary elective inguinal hernia repair and who were motivated to use the e-Health application additionally to the standard follow-up care at the Zuyderland Medical Centre (The Netherlands) were invited to participate. Enrolment occurred from January 2019 through September 2020. The study period was up to the routine, current standard follow-up at 6–8 weeks after the inguinal hernia repair surgery (in-person or via phone contact by a surgeon). Patients were excluded if they underwent a combined procedure, had a language barrier, or were unable to use the e-Health application.

The use of the e-Health application was completely voluntary, no separate messages were sent to encourage compliance. A patient was considered compliant if they properly used the application more than three times (of which at least 1 time after post-operative day 3), ensuring a reliable assessment of the post-operative course. The Medical Ethics Committee of the Zuyderland Medical Centre approved the study (research nr Z2020277).

Study objectives

The primary objective of this study was to investigate the accuracy of the “deviating post-operative course” alerting by the e-Health application. Secondary objectives included

patients’ perspectives on the e-Health application and cost comparison between e-Health versus standard follow-up.

E-Health application

The e-Health application (SanaCoach) was developed prior to the start of this study by a team of experienced inguinal hernia surgeons (RvV, JS) in collaboration with a company specialized in e-Health applications (Sananet Care, Sittard, The Netherlands). The e-Health application provided the patient with surveys to monitor their post-operative course and, by using an algorithm, gave instructions if this course was deviating. The surveys included symptom-based questions, (pain) medication-related questions and free-text boxes for comments. Consented participants were instructed and assisted in setting up and using the e-Health application. Post-operative questionnaires were sent on days 1–6, 8, 10 and 14. In addition, there was also the possibility to communicate in an accessible way via a message system with their care providers. Patients could use a personal smartphone, digital tablet, or computer to access the online e-Health application.

The patient’s monitored post-operative course and questions were reviewed daily, and if necessary, answered upon by a clinical nurse specialist (CNS) or physician assistant (PA). Additionally, after 8 weeks follow-up, the patients received a survey about their perspectives on the e-Health application and given care.

Data analysis

Patient and operative characteristics associated with patient compliancy of e-Health care; accuracy of e-Health follow-up; and unexpected hospital contacts were analysed using Student’s *t* test and Mann–Whitney *U* test, or the Chi-square test, as appropriate. A two-sided *P* value ≤ 0.05 was considered as statistically significant. Statistical analysis was performed using Statistical Package for the Social Sciences (version 27.0, IBM SPSS Inc.). To identify the feasibility, a hypothetical cost analysis of completely replacing current standard follow-up with e-Health follow-up was conducted.

Results

A total of 128 patients were found to be eligible and consented to participate. Five patients were excluded because they did not undergo the scheduled operation (all related to COVID-19). Among the 123 included participants who used the e-Health application, only 60 patients completed more than three online post-operative surveys and were therefore considered compliant (49%). The

remaining, noncompliant group ($n = 63$, 51%), completed none or less than three post-operative surveys. In this study, the compliant group will be referred to as the “e-Health group” and the noncompliant group will be referred to as the “standard group”. No significant differences in terms of patient or operative characteristics between the e-Health group and the standard group were found (Table 1).

Post-operative course

Unexpected telephone contacting was comparable in the e-Health group (3.3%) and the standard group (1.6%), $P = 0.61$ (Table 2). All unexpected telephone contacts were related to pain and/or analgesic drugs. Unexpected hospital visits occurred two times (3.3%) in the e-Health group and two times (3.2%) in the standard group, $P = 1.0$ (Table 2). One of the patients in the e-Health group had a vasovagal collapse based on a haemorrhage two days post-operative, after one day of hospitalization for observation, this patient was able to return home. The other patient

Table 1 Baseline patient and operative characteristics

Characteristics	Compliant group ($n = 60$) (= E-Health group)	Non-compliant group ($n = 63$) (= standard group)	<i>P</i> value
Male (n , %)	54 (90.0)	59 (93.7)	0.523
Age at surgery, years (mean, SD)	56.4 (14.2)	58.3 (16.9)	0.302
ASA class (n , %)			0.411
I	26 (43.3)	34 (54.0)	
II	29 (48.3)	23 (36.5)	
III	5 (8.3)	6 (9.5)	
BMI (kg/m^2) (mean, SD)	25.45 (3.15)	24.49 (2.53)	0.082
Surgery type (n , %)			
TEP	46 (76.7)	40 (63.5)	
Lichtenstein	5 (8.3)	6 (9.5)	0.412
TREPP	2 (3.3)	3 (4.8)	
Shouldice	7 (11.7)	12 (19.0)	
Herniotomy	0 (0)	2 (3.2)	
Hernia side (n , %)			
Left	21 (35.0)	33 (52.4)	
Right	31 (51.7)	25 (39.7)	0.140
Bilateral	8 (13.3)	5 (7.9)	
Type of hernia (n , %)			
Indirect (lateral)	34 (56.7)	38 (60.4)	
Direct (medial)	13 (21.7)	18 (28.6)	0.435
Indirect + direct	10 (16.7)	6 (9.5)	
Femoral	3 (5.0)	1 (1.6)	
Employed (n , %)	40 (66.7)	33 (52.4)	0.107
Smoking (n , %)	7 (11.7)	8 (12.7)	0.861

Table 2 Unexpected hospital contact

	E-Health group* ($n = 60$)	Standard group ($n = 63$)	<i>P</i> value
Telephone contact (n , %)	2 (3.3)	1 (1.6)	0.61
Hospital visit (n , %)			1.0
Outpatient clinic	0 (0.0)	2 (3.2)	
Emergency room	2 (3.3)	0 (0.0)	

*Without prior reporting of a deviating post-operative course in the e-Health application

Table 3 Patient-reported post-operative course in e-Health application

Findings at Standard follow-up	E-Health follow-up (<i>n</i> = 60)		<i>P</i> value
	E-Health no deviation group (<i>n</i> = 44)	E-Health deviation group* (<i>n</i> = 16)	
No abnormality or complication (<i>n</i> , %)	41 (93.2)	12 (75.0)	0.074
Pain (<i>n</i> , %)	2 (4.5)	3 (18.7)	0.112
Swelling (<i>n</i> , %)			0.466
Hematoma	1 (2.3)	0 (0)	
Recurrence	0 (0)	1 (6.3)	
Wound infection (<i>n</i> , %)	0 (0)	0 (0)	1.0

*Any deviation of the post-operative course for which the e-Health application algorithm alerted the PA/CNS, such as a deviant post-operative pain course; swelling after post-operative day three; and other complaints reported via the e-Health message system

Table 4 Cost analysis: an e-Health follow-up scenario versus current standard follow-up

	Hypothetical e-Health follow-up scenario	Current standard follow-up
Average time e-Health follow-up per patient (min)	15 ^b	–
Average time in-person or telephone follow-up per patient (min) ^a	2.9 ^c	12.1
Average costs per patient (in-hospital costs)	€14.5 + €30 + €15 = €59.5 ^d	€28.2 ^e

^aBased on standard follow-up distribution and corresponding average time

^bBased on: application set up, standard support, monitoring of deviating responses, intervening and administration

^cBased on: only patients with a deviating course, thus receiving current standard follow-up

^dBased on: PA/CNS fee per hour: €48.60, platform licensing per patient: €30, hosting costs per patient: €15

^eBased on: surgeon fee per hour: €140

presented with abdominal pain and failure to defecate three days post-operative, after administering macrogol, the patient was discharged swiftly. The two patients in the standard group visited the outpatient clinic with an increasing and persistent swelling, this was diagnosed as a hematoma for which in both cases, no further action was necessary.

Within the e-Health group, 44 patients (73.3%) reported a normal post-operative course without a deviation (e-Health no deviation group) and 16 patients (16.9%) reported a deviation which alerted the PA/CNS (e-Health deviation group) (Table 3).

Of the 44 patients who showed a non-deviating post-operative course in the e-Health application, 93.2% (*n* = 41) did also not show complications during the standard follow-up. However, three patients (6.8%) had a complication: two patients reported pain of which one was a small recurrence for which a wait-and-see policy was agreed upon, and one patient reported a swelling which was a hematoma wherefore no further treatment was needed.

In the e-health deviation group, 25% (*n* = 4) of the patients had a complication at standard follow-up. Three (18.8%) of these patients reported pain of which two patients were diagnosed with chronic post-operative pain and were referred to the outpatient pain clinic for

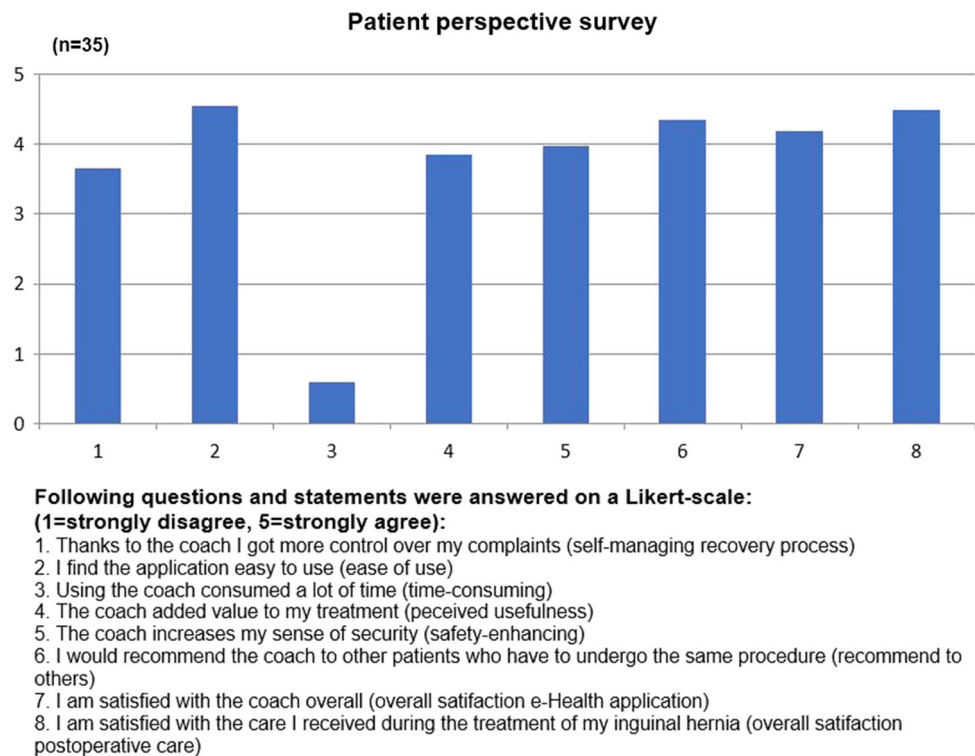
treatment. One patient (6.3%) had a symptomatic recurrence and underwent a successful reintervention.

Cost analysis

Standard follow-up distribution showed that approximately 6.5% of the patients did not show up or were not reachable by phone at standard follow-up, 77.5% received a telephone contact and 16% had an in-person hospital visit.

A cost analysis of a hypothetical scenario in which current standard follow-up is entirely replaced with e-Health follow-up was conducted. In this scenario only in the event of a deviating post-operative course within the e-Health application, a patient would receive an in-person or phone follow-up. This analysis only considers the total costs of medical staff and the costs of the e-Health application, costs incurred by the patient were not included.

The total cost difference in this scenario comparing the e-Health follow-up and the current standard follow-up was €31.2 per patient, with e-Health follow-up being more expensive (€59.5 per patient) than standard follow-up care (€28.2 per patient) (Table 4).

Fig. 1 Patient perspective survey ($n = 5$)**Table 5** Messages via e-Health application

Message regarding	Messages send	Resolved via e-Health message	Resolved via in-person contact	Resolved via telephone contact
Technical issues (<i>n, %</i>)	14 (27.5)	14	–	–
Pain (<i>n, %</i>)	4 (7.8)	3	1	–
Swelling or lump (<i>n, %</i>)	2 (3.9)	1	–	1
Medication (<i>n, %</i>)	3 (5.9)	3	–	–
Pre-operative preparation (<i>n, %</i>)	12 (23.5)	12	–	–
Surgical procedure (<i>n, %</i>)	3 (5.9)	3	–	–
Postoperative restrictions and expected course (<i>n, %</i>)	13 (25.5)	11	2	–
Total (<i>n</i>)	51	47	3	1

Patient perspective and use of the e-health application

Questionnaires about the patient perspectives on the e-Health application were completed by 35 patients (58.3%) of the e-Health group (Fig. 1). The average scoring on the following aspects of the e-Health application (all on a Likert-scale of 1–5) was self-managing the recovery process: 3.7, ease of use: 4.5, time-consuming: 0.6, perceived usefulness: 3.9, safety-enhancing: 4.3, recommend to others: 4.2, overall satisfaction e-Health application: 4.2, and overall satisfaction post-operative care: 4.5

Fifty-one questions were asked by patients via the e-Health application, of these the majority (92%) could be answered and solved directly, three (6%) could be resolved by phone and one (2%) had to get an outpatient appointment (Table 5). These questions were mostly related to technical problems (27.5%); pre-operative preparation (23.5%); and post-operative restrictions and expected course (25.5%).

Discussion

The concept of remote health care is already well established in non-surgical specialties and is considered as a means of improving: patients' access to care, personal autonomy and patient-centered care [16, 17]. This study investigated the novel use of an e-Health application to provide pre- and post-operative care to, low-risk, inguinal hernia patients.

Safety and accuracy

Concordance of patient-reported and physician-reported outcome, especially when it is deviant, is critical to ensure safety of implementing an e-Health tool instead of a traditional follow-up in the post-operative course [12, 17–19].

In this study, it was shown that when patients did report a non-deviating post-operative course, in more than 90% of the cases, this matched the findings at current standard follow-up. In the three patients where a complication was not detected, only one complication was found to be clinically relevant, concerning a recurrence. Within the group of patients where the e-Health tool reported a deviating post-operative course, one out of four cases (25%) had a true complication at standard follow-up. These findings show that the e-Health application has a high concordance with current standard follow-up. It is estimated that, when adjusting the options in the application, the concordance can come close to 100%. However, since any missed complication after routine inguinal hernia repair can lead to unacceptable outcomes, this needs to be addressed in a future study.

Furthermore, an e-Health application should not only be accurate, but it must also detect complications in time so that proper interventions can be undertaken. It was found that there were two patients who came to the emergency room without the application detecting problems and preventing this in an earlier stage. However, because these were acute events, it can be argued that the application could not have detected nor prevented it in time.

Cost analysis

Results from demonstrating total in-hospital costs show that a hypothetical e-Health follow-up scenario is more expensive when compared to current standard follow-up from a health care system perspective (€59.5 vs. €28.2 per patient). The costs of the application (platform licensing: €30 and hosting: €15) in particular are responsible for these higher costs per patient in the e-Health scenario. If these costs were to be eliminated, or at least significantly

reduced, the e-Health application would become a more financially interesting choice.

Furthermore, decreasing the total number of phone and in-person follow-up visits required has the potential to free up time for surgeons and clinic resources, which can be used to improve and maximize quality care for other patients.

It is important to state that the calculations in this study are only based on the costs of the health care providers and the costs of the application. The analysis does not consider the patient-related costs such as patient leisure time, travelling, and parking. Previous studies report that these patient costs are significantly reduced by using an e-Health tool and are a major part of the total societal costs [15]. Therefore, the results of this study can be misrepresented to the disadvantage of the e-Health application. Despite this, a cost-effectiveness analysis including patient costs was beyond the scope of this study and future research should certainly examine this topic.

Patient perspective

Prior studies suggested that most patients would be willing to use e-Health tools for pre- and post-operative monitoring [10, 12, 18, 20]. In concordance, this pilot study supports the acceptance and willingness to use e-Health monitoring in a pre- and post-operative setting. The patients' impressions of using an e-Health tool were positive, they reported that the app was easy to use, was not time-consuming, and contributed to an increased sense of safety. Furthermore, the numerous messages sent by users of the app to the care providers indicate the desire to ask questions pre- and post-operatively. This finding has been confirmed by other studies who reported that, especially in the first five days after surgery, patients have symptoms and recovery-related questions that need attention [21, 22]. As it is accessible to ask these questions via an e-Health application, patients were potentially more willingly to do so. This ensures better knowledge and understanding of what constitutes the normal range in recovery and how to manage self-care, which leads to improved recovery [23–26].

Limitations

First, it should be noted that the present study is a single centre pilot study which main goal was to define if an e-Health application was feasible in inguinal hernia surgery. It is not certain whether these findings could be applied in other settings and with other e-Health applications. As with the majority of studies, the design of the current study is subject to limitations. An e-Health application with locally developed surveys and algorithm was

used, yet the basic functionality and surveys are based on widely used commercial products and validated inguinal hernia questionnaires. Therefore, this application could be considered as a generalizable tool for post-operative care.

The vast majority of the study population was male, which can be well explained by the fact that more men undergo inguinal hernia repair annually. However, as a result, the effect of the e-Health application on female patients cannot be extrapolated. Furthermore, the proportion of compliant e-Health use among eligible participants was poor, an explanation is that the use of the application was completely voluntary and was offered in addition to the standard follow-up. Because patients knew that they would get a phone or in-person follow-up control, they may have been less motivated to address all questions and concerns via the e-Health app. Compliance is a potential concern that will need to be investigated in a future cohort with patients receiving only e-Health follow-up.

Another study limitation is the fact that only 58% of the compliant patients completed the patient perspective questionnaires, as well, each patient underwent a routine standard follow-up. Thus, in addition to a less reliable analysis due to this low percentage of respondents, patients may have given a higher score because they were also satisfied that they were able to meet their practitioner in person.

An additional limitation relates to the fact that the study was not adequately powered to analyse concordance of patient-reported and physician-reported outcomes given the low incidence of complications in this population of patients undergoing low risk, elective inguinal hernia operations. These limitations will be addressed in further research and evaluation of the application.

Conclusion

This study demonstrates the utility of an e-Health application as a promising triage tool for identifying patients who require in-person or phone follow-up assessment after inguinal hernia repair. A hypothetical e-Health follow-up scenario was found to be more expensive compared to current standard follow-up, however, saved patient costs were not considered in this analysis. If the identified (dis)advantages can be improved, e-Health follow-up care appears to be safe and feasible and may contribute to an improvement of post-operative outcomes, cost-efficiency, and patient satisfaction. Future studies can leverage on this pilot study and further investigate the possibility of e-Health within the field of surgery to support the current transformation of traditional to digital health care.

Funding This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Declarations

Conflict of interest All authors declare no conflicts of interest.

Ethical approval In view of the retrospective nature of the study, all the procedures being performed were part of the routine care. The Medical Ethics Committee of the Zuyderland Medical Centre approved the study.

Informed consent All patients gave informed consent for surgery and use of data for research purposes.

References

- HerniaSurge G (2018) International guidelines for groin hernia management. *Hernia* 22(1):1–165
- Nilsson H et al (2007) Mortality after groin hernia surgery. *Ann Surg* 245(4):656–660
- Liu N et al (2020) Phone follow-up after inguinal hernia repair. *Surg Endosc* 35(9):5159–5166
- Adamu-Biu F, Akoh JA (2020) Survey of patients regarding experience following repair of inguinal hernias. *Hernia* 24(1):187–195
- Bakker WJ et al (2019) Experience with the PINQ-PHONE telephone questionnaire for detection of recurrences after endoscopic inguinal hernia repair. *Hernia* 23(4):685–691
- Ma Y et al (2018) Post-operative telephone review is safe and effective: prospective study—Monash outpatient review by phone trial. *ANZ J Surg* 88(5):434–439
- Eisenberg D, Hwa K, Wren SM (2015) Telephone follow-up by a midlevel provider after laparoscopic inguinal hernia repair instead of face-to-face clinic visit. *J Soc Laparoendosc Surg* 19(1):e2014.00205
- van den Heuvel B et al (2015) Follow-up after laparoscopic inguinal hernia repair, can it be done by phone? A prospective study in 300 patients, the PINQ-PHONE. *Surg Endosc* 29(11):3292–3297
- van der Meij E et al (2016) The effect of perioperative e-Health interventions on the postoperative course: a systematic review of randomised and non-randomised controlled trials. *PLoS ONE* 11(7):e0158612–e0158612
- van Hout L et al (2020) Perioperative monitoring of inguinal hernia patients with a smartphone application. *Hernia* 24(1):179–185
- Waller A et al (2015) Optimizing patient preparation and surgical experience using eHealth technology. *JMIR Med Inform* 3(3):e29
- Semple JL et al (2015) Using a mobile app for monitoring post-operative quality of recovery of patients at home: a feasibility study. *JMIR mHealth uHealth* 3(1):e18
- Semple JL, Armstrong KA (2017) Mobile applications for post-operative monitoring after discharge. *Can Med Assoc J* 189(1):E22
- Russell TG et al (2011) Internet-based outpatient telerehabilitation for patients following total knee arthroplasty: a randomized controlled trial. *JBJS* 93(2):113–120
- Armstrong KA, Semple JL, Coyte PC (2014) Replacing ambulatory surgical follow-up visits with mobile app home monitoring: modeling cost-effective scenarios. *J Med Internet Res* 16(9):e213

16. Currell R et al (2001) Telemedicine versus face to face patient care: effects on professional practice and health care outcomes. *Nurs Times* 97(35):35
17. Kummerow Broman K et al (2015) Postoperative care Using a secure online patient portal: changing the (Inter) face of general surgery. *J Am Coll Surg* 221(6):1057–1066
18. Scheper H et al (2019) A mobile app for postoperative wound care after arthroplasty: ease of use and perceived usefulness. *Int J Med Inf* 129:75–80
19. Sharareh B, Schwarzkopf R (2014) Effectiveness of telemedical applications in postoperative follow-up after total joint arthroplasty. *J Arthroplast* 29(5):918–922.e1
20. Wiseman JT et al (2015) Conceptualizing smartphone use in outpatient wound assessment: patients' and caregivers' willingness to use technology. *J Surg Res* 198(1):245–251
21. Dewar A, Scott J, Muir J (2004) Telephone follow-up for day surgery patients: patient perceptions and nurses' experiences. *J Perianesth Nurs* 19(4):234–241
22. Flanagan J (2009) Postoperative telephone calls: timing is everything. *Aorn J* 90(1):41–51
23. Hodgins MJ et al (2008) Effect of telephone follow-up on surgical orthopedic recovery. *Appl Nurs Res* 21(4):218–226
24. Svensson M, Nilsson U, Svantesson M (2016) Patients' experience of mood while waiting for day surgery. *J Clin Nurs* 25(17–18):2600–2608
25. Berg K, Arestedt K, Kjellgren K (2013) Postoperative recovery from the perspective of day surgery patients: a phenomenographic study. *Int J Nurs Stud* 50(12):1630–1638
26. Renholm M et al (2009) Continuity of care in ambulatory surgery critical pathways: the patients' perceptions. *Medsurg Nurs* 18(3):169–173

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.