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Remote patient monitoring in spine surgery

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ABSTRACT

Objectives: Remote monitoring or telemonitoring is an innovative strategy to improve patient care. This study aimed to present the authors' experience of a remote monitoring platform for post-operative care of patients who have undergone spine surgery.

Methods: A telemonitoring system for patients undergoing spine surgery, centered on a smartphone application named *Wippe Track*, (Brazilian Telemedicine Company BR HomMed, São Paulo, Brazil) compatible with both Android and iOS smartphones. All patients had two Bluetooth devices connected to the smartphone application: Digital scale and wristband activity tracker. The outcomes evaluated were based on patient-related outcome measures (PROMs) using specific disease-oriented questionnaires.

Results: A preliminary study to refine the system based on patient/provider input was performed with 30 patients. The adherence and interaction with the platform were 94%. Patients have provided all the PROMs data inputs and have consistently interacted with monitoring center professionals and the surgeon through the platform. Weight loss was observed in 76% of overweight patients using remote nutritionist support and specific exercises.

Conclusion: The patients were satisfied and felt secure. The remote monitoring could detect and help manage events and warnings related to post-operative issues and reduce the need to travel for non-scheduled care.

Keywords: Multiprofessional, Postoperative, Spine, Surgery, Telehealth, Telemonitoring

INTRODUCTION

Low back pain (LBP) and degenerative disk disease (DDD) are the most common etiological factors behind lumbar pain, being associated with traumatic, lifestyle, genetic, and environmental factors.[1,2] Persistent and severe pain often occurs, along with other sensory and motor deficits. Despite the favorable natural course for most patients, over 20% of them may require surgical care.[3-6] Monitoring and early management of mood disorders, overweight, the lack of physical activity, and complications are necessary to improve post-operative results.

Telemonitoring or remote monitoring is an innovative strategy to improve patient care, facilitating patient-physician contact through the use of many technological tools.[7] There has been a growing interest in telemonitoring strategies, because of increasing access to smartphone apps and the internet over the past years.[7]

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Given the high prevalence rates for LBP and spine surgery attributable to DDD, strategies that target its risk factors and improve post-operative care are of paramount importance. Therefore, the main goal of the present study was to present the experience of a remote monitoring platform for post-operative care of patients who have undergone surgery for lumbar DDD. This is the first type of remote monitoring of post-operative spine surgery performed by a multiprofessional team and capable to collect patient outcomes.

MATERIALS AND METHODS

This is a prospective, non-randomized, and controlled clinical study. It was authorized by the University of Caxias do Sul Ethics Committee under the number 2.677.226/83599818.8.0000.5341.

Study population

Patients were recruited from the author's (AF) private practice. The inclusion criteria were: Patients suffering from lumbar DDD whose diagnosis was supported by an MRI and compatible signs and symptoms, who were refractory to clinical treatment, and able to interact online through a mobile phone. Exclusion criteria were: Clinical-radiological dissociation and patients who were unwilling or unable to undergo spine surgery due to clinical issues.

Remote monitoring platform

The Brazilian Telemedicine Company *BR HomMed* developed a telemonitoring system for patients undergoing spine surgery, centered on a smartphone application named *Wippe Track*, compatible with both Android and iOS smartphones. This application was approved by the Brazilian Federal Council of Medicine. It was categorized as a medical class software, registered under the Food and Drug Administration and the Brazilian National Health Agency (ANVISA) under number 81026159004.

Patient registration

The patients were registered on the monitoring platform. During the registration process, the information collected from the patients was gender, date of birth, weight, height, brief medical history, medications taken, date of entry into the study, date of surgery, type of procedure, E-mail, and how questionnaires will be collected. The code was automatically suggested by the system.

Wireless devices

The smartphone application named *Wippe Track* was downloaded to the patients' mobile phones after their registration. In addition, all patients had two Bluetooth devices connected to the smartphone application: Digital scale and wristband activity tracker. Patients received the devices at no cost and were instructed to use the smartphone app and the Bluetooth devices remotely and the app tutorial.

Collecting patient-generic data

The smartphone application collected the data from the Bluetooth devices regarding steps taken, physical activity, hours of sleep, weight, waist circumference, mood, blood pressure, laboratory tests, and a visual analog scale (VAS) for pain. According to the patient preferences, some of the data were inserted manually, others automatically through Bluetooth devices. For example, physical activity included several options, ranging from climbing upstairs and shopping for groceries to weightlifting and many different sports. Patients would then report the duration of their activities in minutes and their perceived intensity (light, moderate, or intense). For every parameter, patients could also leave notes on anything they believed to be relevant to the information they inserted – for example, "*The pain in my back became more intense during the night, impairing my sleep.*" The app can generate color-oriented graphics in red, orange, yellow, or green, according to the level of pain, allowing both patients and the monitoring team to keep track of these parameters easily. The red color was considered very bad symptoms and disability and green was considered normal, without any unexpected signs and symptoms.

Collecting patient outcome data

The outcomes evaluated were based on patient-related outcome measures (PROMs) using specific disease-oriented questionnaires to evaluate functionality, Oswestry Disability Index (ODI), pain, mood disorders, Hospital Anxiety and Depression Scale, and social activities. PROMs questionnaires were applied during the pre-operative period, at 1 month, 3 months, and 6 months postoperatively. *The database* generated a PDF report based on the inserted data, which the surgeon could share with the patient or export. A dashboard was developed to visualize the score of the questionnaires on charts.

Remote monitoring center

The remote team (RT) actively monitored the patients by analyzing the data received and by synchronous online meetings previously defined. The RT comprised one nurse, one nutritionist, one physiotherapist, and one psychologist. All team members were previously trained to provide information about the pathology and the surgery performed. In addition, the RT actively engages the patient based on the data regarding the other parameters, including mood,

weight, and physical activity. The interaction of the RT was performed at least once a week. Some patients required more interactions to control pain or comorbidities, such as diabetes mellitus and blood hypertension.

Statistical analysis

Means and standard deviations were used to summarize continuous data. Categorical variables were expressed as counts and percentages. A pilot study was performed using a sample of 30 patients.

RESULTS

The pre-operative timeline that the patient goes through is summarized in [Figure 1]. After surgery, the patients keep interacting with the RT and reporting the PROMs. A preliminary study for refinement of the system based on patient/provider input was performed with 30 patients and described in [Table 1]. From the cases analyzed, 40% lived in small towns, hours away from the city where surgery was performed. The surgical goals were spinal nerve decompression, realignment, and fixation of the spine using a minimally invasive technique through the Wiltse approach and small tubular distractors. Most of the cases had one or two levels DDD with listhesis and a length of hospitalization of 48 h [Table 1].

The remote monitoring team worked 8 h a day from Monday to Friday and 900 km away from where patients were recruited. The remote center located at the Caxias do Sul University gave support on weekends and progressively during the weekdays. The multidisciplinary monitoring team that worked on the remote station was trained using six face-to-face meetings and three online meetings for simulations.

Patients were able to provide all the PROMs data inputs and interact with the platform in 94% of the cases in the 1st month of perioperative time. Patients consistently interacted with monitoring center professionals. Surgeons were asked to get in touch with the patients every time the RT detected an unexpected wound problem or a delay in clinical improvement. Over time, the percentage of the subjects who continued to answer the questionnaires and to interact with the platform was 73% in 3 months. The platform inserted 4431 clinical data in 6 months with a mean number of 233 clinical data per patient.

Weight loss of more than 3 kg has been observed in 76% of overweight patients (high body mass index above 25) using remote nutritionist support and specific exercises. In our series, 57% of the patients were doing exercise 6 months after surgery. As soon as the patient began to recover from surgery, more stimulus from RT for interaction was needed.

Table 1: Demographic populations analyzed in the pilot study of 30 cases that underwent to lumbar spine surgery. Data are presented as mean±standard deviation or counts (percentages).

Characteristics	Cases
Age, year	54.8±16.2
Male sex, number. (%)	18 (60.4)
BMI, kg/m^2	28.2±3.2
History of, number (%)	
Hypertension	9 (29.8)
Diabetes mellitus	5 (16.6)
Pulmonary disease	3 (10.0)
Smoking	5 (16.6)
ASA score, number (%)	
1	10 (33.4)
2	16 (53.3)
≥3	4 (13.3)
Level of the disease, number (%)	
L2-L3	2 (9.5)
L3-L4	5 (18.0)
L4-L5	17 (58.2)
L5-S1	16 (56.2)
Number of surgical levels, number (%)	
1	17 (56.6)
2	8 (26.7)
≥3	5 (6.6)
Type of pathology	
Degenerative spondylolisthesis	13 (43.3)
Lumbar spine stenosis	9 (30.0)
Lumbar disc herniation	8 (26.7)
Volume bleeding, milliliters	298±86.2
Length of surgery, minutes	135±44.9

BMI: Body mass index, ASA: American Society of Anesthesiologists Physical Status Classification

Events and alerts involving post-operative pain (n = 32) or the surgical wound (n = 5) were rapidly detected and managed, avoiding the need for non-scheduled care at the office (n = 12) and emergency room (n = 3). From the number of events recorded, in 40% of them, the patient could avoid leaving their home to go to hospital or to the doctor's office.

The lumbar spine functionality and quality of life improved at 1 and 6 months after surgery when compared with the baseline.

A high satisfaction index of 84% of 4 or 5 from 0 to 5 scale was observed due to the facilitation of interaction with the remote station and the surgeons, and the decision provided according to the data collected [Figure 2].

DISCUSSION

The authors have designed a remote-based strategy for patients undergoing spine surgery associating the monitoring platform with a multidisciplinary team. Patients received remote comprehensive care throughout the post-operative

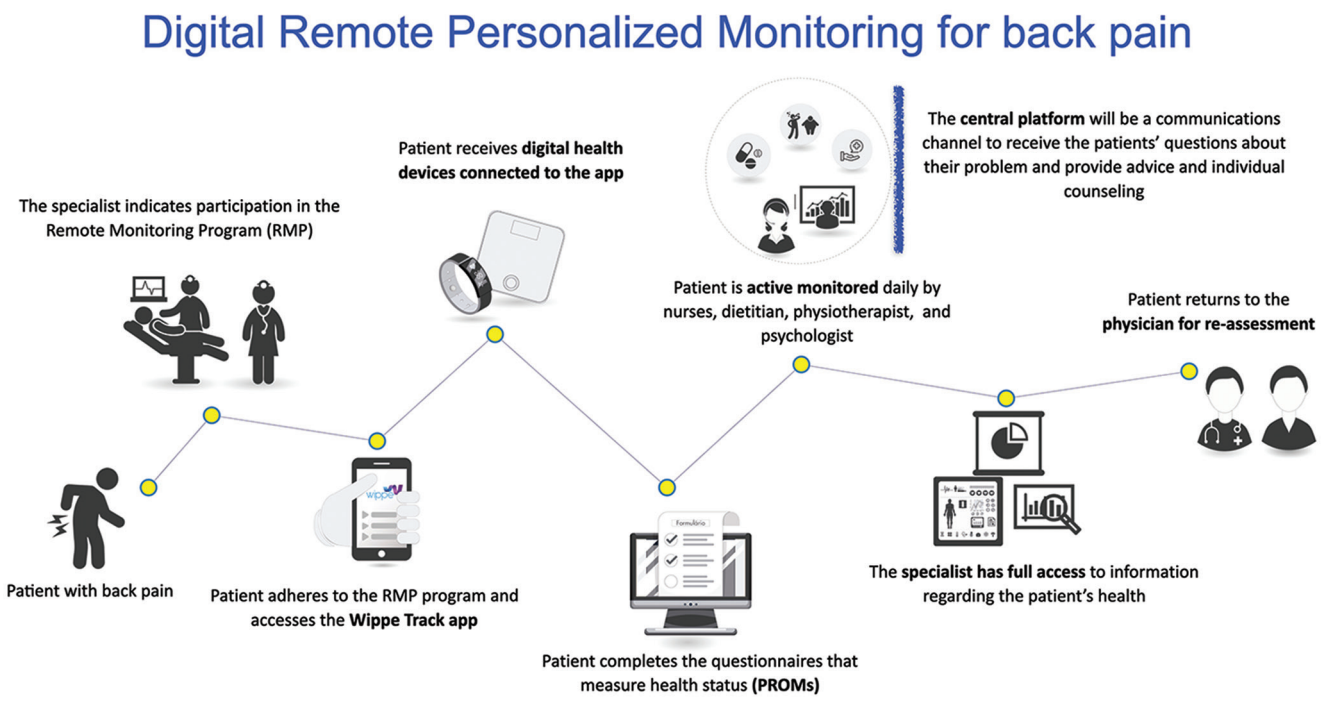

Figure 1: Timeline of the patients during the remote monitoring.

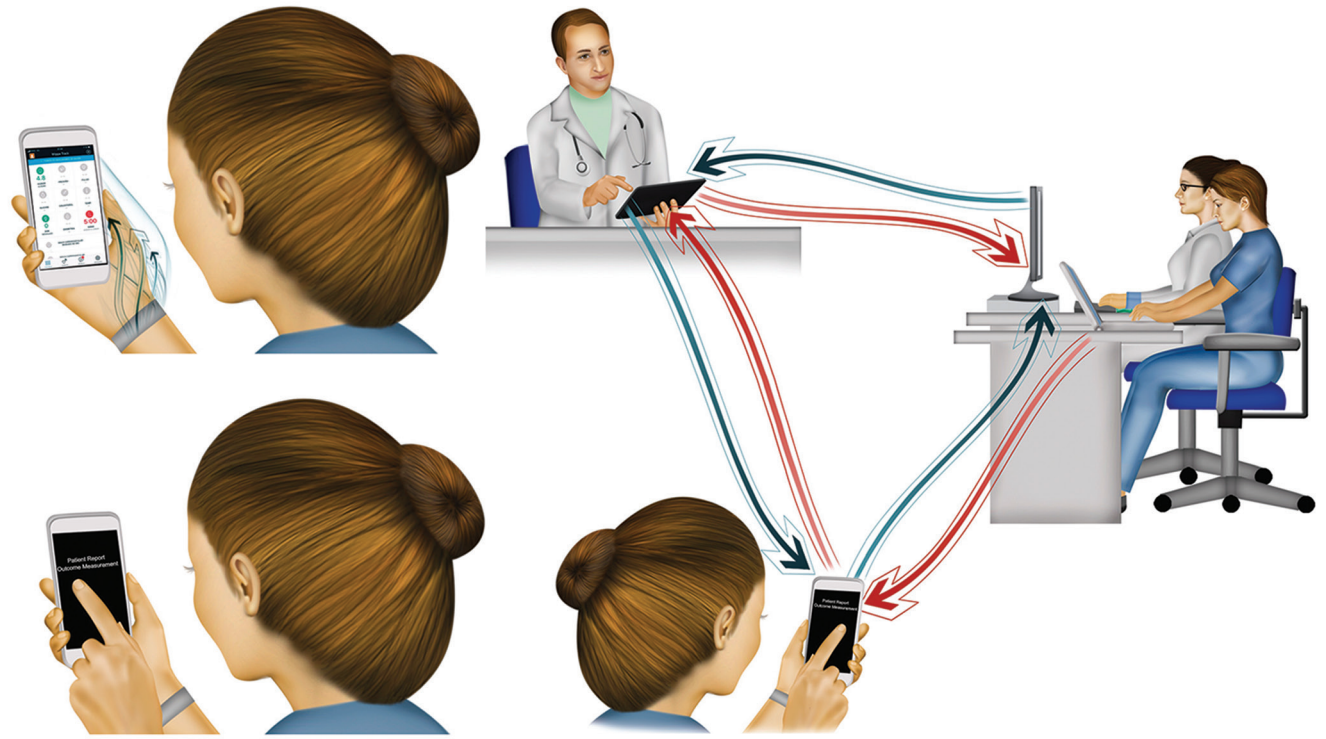

Figure 2: Interaction afforded by the telemedicine platform and smartphone application. The APP transmits the information to the remote station and communication between the multidisciplinary team and the patient begins.

period, delivered to their homes through the remote platform. The remote interdisciplinary team was composed of nursing, nutrition, and psychology professionals, a configuration which is, unfortunately, not always available to patients

through traditional means. Outcomes were evaluated by PROMs questionnaires delivered by the mobile application.

Financial aspects and reducing hospitalizations

One major aspect of our platform was the alarm system designed to trigger remote nursing care. The remote center received events and warnings related to post-operative pain and surgical wound. A positive result was also observed to avoid non-scheduled consultations in the surgeon's office and the emergency room. A study conducted in France evaluated the use of a mobile app for post-operative monitoring of outpatient lumbar discectomy.[8] During the 15-day period evaluated, there were a total of 29 relevant alarms (defined by the colors orange and red) from 19 patients, all of which were managed remotely by the nursing team, avoiding emergency consultations at hospitals.[8] The ability to use telemonitoring to reduce hospitalizations or emergency department visits may prove immensely useful in making health systems more effective by reducing the costs of unnecessary care – which have been estimated as 210 billion dollars in the United States alone in 2013.[9]

Providing care in resource limited settings

Our telemonitoring platform provided patients with interdisciplinary care from a team composed of psychology, nursing, and spine surgery professionals. It is worth noting that 40% of the patients in our study lived in smaller cities (population <100,000), hours away from the place where surgeries were performed. Hou *et al.* evaluated a mobile application-based program for rehabilitation after lumbar spinal surgery, in China.[10] Patients enrolled lived at least 2 h or 100 km away from the hospital at which surgery was performed. Patients enrolled in the remote-based program presented significantly better spinal function (−30.43 change in ODI from baseline for remote care vs. −23.41 for usual care, $P = 0.03$) and less pain (−29.95 change in VAS from baseline for remote care vs. −22.36 for usual care, $P = 0.03$) at 24-month post-surgery.[10]

Satisfaction index and spine apps

A study conducted in 2014 identified 78 apps related to spinal surgery or surgical spine conditions and only 40 had documented involvement from a medical professional.[11] The telerehabilitation system for lumbar spine surgery is described by Hou *et al.*[10] obtained an average of 3.5 out of four scores regarding patient satisfaction index. Similar results were obtained regarding patient satisfaction in remote monitoring protocols for orthopedic, breast reconstruction, and colorectal surgery.[12,13] A high satisfaction index of 4 or 5 from 0 to 5 scale was observed in 84% of the patients. The mean time that the patient was engaged with the platform was 3–4 months. The present result shows that platform interaction with the remote multidisciplinary people in post-operative cases could be interrupted in 3 months.

Tele-education and habits

The most widely studied field in telemonitoring is that of cardiovascular disease and its risk factors,[7] with generally positive results, especially regarding treatment adherence and blood pressure control.[14-16] Numerous trials have demonstrated the effectiveness of telemonitoring for weight loss,[17,18] adoption of healthy dietary habits,[19,20] and smoking cessation,[21,22] as well as treatment adherence.[23] The use of remote platforms and wearable devices employed in the present study has shown itself useful in increasing physical activity and weight loss. Smoking and overweight/obesity are significant risk factors and predictors of surgical complications and outcomes.[24-27] Telemedicine interventions that promote physical activity, smoking cessation, healthy dietary habits, and weight loss, like the one designed for this study, can play an important part in improving outcomes after spine surgery.

Telemedicine as an investigational tool and PROMs

Most studies regarding telemonitoring have used clinical or cost-benefit outcomes to evaluate their effectiveness.[7] It is worth noting that telemonitoring has also proved to be an extremely valuable research tool. PROMs are widely recognized as valuable tools in daily clinical practice as well as in research scenarios for quantifying the patient experience with a particular symptom or subjective concern.[28,29] A survey regarding the use of PROMs in spine surgery conducted by our team demonstrated that up to 31.9% of spine surgeons do not use PROMs routinely.[30] The main barriers to PROM implementation described by responders were lack of time (57%), lack of staff (55%), and the long time (46%) needed to fill out the questionnaires.[30] Electronic databases are developed to overcome those drawbacks, making it easier and friendly on both sides, physicians and patients.

Strengths and limitations

The strengths of this study were the clinical experience of comprehensive system design to be used in spine care, highlighting the importance of multidisciplinary care and the digital PROMS questionnaire collections. There is no study without limitations. The limitations observed were the lack of randomization during patient selection, the lack of a control group, patients selected from a single-center, and a small sample size.

CONCLUSION

The platform allowed for real-time interaction among patients, multidisciplinary staff at the remote center, and the surgeon. High patient satisfaction index and adherence rates on telemonitoring with relevant changes in weight and quality of life have been shown during the follow-up. Telemonitoring has excellent potential for immediate and accurate identification of post-operative complications.

Future directions

The future perspective of the group is to start a prospective study taking into consideration a new strategic approach on the digital platform to further expand the Education, Care, and Outcome (ECO) Project, which personalized the ECO of the patient.

AUTHORS' CONTRIBUTIONS

FACF: Literature review, data collection, and scientific writing. VFF: Literature review, and scientific writing. MELV: Literature review, and scientific writing. AF: Planning and executing the study, and scientific writing. All authors have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

ETHICAL APPROVAL

Caxias do Sul University Ethics Committee approval is under number 2.677.226/83599818.8.0000.5341. Approved on May 25th, 2018.

DECLARATION OF PATIENT CONSENT

The authors certify that they have obtained all appropriate participants consent forms. In the form, the participants have given their consent for their images and other clinical information to be reported in the journal. The participants understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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