Digitalization of the process of postoperative care for a patient on the example of hip replacement

O A Kaplunov¹, M Yu Frolov¹,3, Y A Orlova², A V Zubkov²,3 and N D Sibirny²

¹ Volgograd State Medical University, 1, Pavshikh Bortsov Square, Volgograd, 400131, Russia
² Volgograd State Technical University, 28, Lenina Avenue, Volgograd, 400005, Russia
³ Volgograd Medical Scientific Center, 39, Novorossiysk street, Volgograd, 400087, Russia

E-mail: yulia.orlova@gmail.com

Abstract. The work is devoted to the analysis and improvement of the existing business process of patient patronage during rehabilitation. The article analyses the existing software tools that are currently used in medical practice, and also identifies their shortcomings regarding the process of patient support during the rehabilitation period. A service that includes an app for the Android mobile operating system and a website was developed. The work describes the main functionality of this system, as well as shows the changes that occurred during the integration of the service into the existing process of patient patronage.

1. Introduction

Joint replacement – treatment by surgical intervention, in which the damaged joint is replaced with an endo-prosthesis made of biocompatible materials. After the operation, the patient must go through a difficult period of rehabilitation in order to make a successful recovery.

Postoperative period - the period of time from the end of the operation to recovery or complete stabilization of the patient's condition.

In recent years, there has been a clear trend of dependence of the quality of life of the population on the effectiveness and speed of medical and social rehabilitation of patients, especially those suffering from chronic diseases or undergoing surgical treatment, in particular, endoprosthetics.

Currently, in Russia there are no available and universal tools for monitoring and supporting the patient at the time of outpatient treatment and rehabilitation process in online mode, which leads to a very high percentage of complications during treatment activities.

Thus, it is clear that there is a need to provide patients at the treatment stage with remote medical support and access to informed and individualized guidance on treatment measures.

B2Doc Service: Endo-Prosthetics is designed to solve this problem by optimizing and automating the existing process of patient support in the postoperative period.

2. Materials and methods

Specially organized consultations with relevant specialists in this field were used as materials for
research and optimization of existing business processes during endoprosthesis surgery [1,9,10].

We also reviewed existing services that are analogs of the service being developed within this work and are used in this or similar areas of use. Among them are online services such as Yandex Health, Doc + Online and others.

3. Analogues
It is worth highlighting one common and main drawback of such services – they all provide online consultations on various issues, which does not allow to build an individual rehabilitation plan for the patient. Another drawback is that these services are not based on the clinical recommendations provided by the regulations of the Government of the Russian Federation. In this regard, the answer to the patient’s question often resonates with the recommendations of their doctor, which leads to significant difficulties with the support of the patient.

4. The actual method of patronage
After the operation, the doctor discharges the patient and gives him a list of recommendations for the course of treatment in paper form. During the rehabilitation period the patient is required to daily track and carry out doctor’s instructions, and visit the doctor three times: the first six weeks, second six months and the third within one year after the patient’s discharge. The business process of patronizing a patient for recovery is shown as a diagram in Figure 1.

![Figure 1. The actual business process of patronizing a patient.](image)

5. Optimization
The specified method of patronage contains significant drawbacks in its recovery period process. They are mainly related to recommendations and monitoring their implementation.

The first and main problem is the recommendation form factor caused by the content of doctor’s prescriptions in paper form. Papers are inconvenient to use, can easily be lost and are difficult to analyze. The solution to this problem might be smartphones, thanks to which the service implemented in this work functions. Thus, the described service contains all the necessary documents in one convenient and easily accessible place [6,7,15].
In addition to the problem of form factor, through the use of smartphones, the service is also able to solve the problem of forgetfulness in following recommendations and taking medications by showing daily reminders or notifications to the patient about doctor’s prescriptions [5, 17].

The second main problem is the lack of constant interaction between the patient and their doctor, which can cause unforeseen problems and complications. The service also solves this problem by adding the ability to mark the patient's completed prescriptions and describing their condition. All such actions of the patient will be visible to the doctor, so the doctor can always get fresh information about the implementation of recommendations and, if necessary, change the course of treatment, without rewriting paper recommendations.

At the same time, the patient is given the opportunity to quickly and conveniently read the recommendations for any day of interest to him or to get reference information about the drugs that he takes and the basic concepts associated with his diagnosis.

You can see a variant of implementing such changes in the existing business process of patient patronage as a diagram in Figure 2.

![Figure 2. Diagram of service’s business processes.](image)

6. The presentation of the service
From the point of view of internal implementation, the service consists of 4 components:
- Android application – implemented on the Kotlin SDK [14, 16] and intended for use by patient-users of the service;
Website – implemented using React.js [11, 12, 16] and intended for use by doctor-users of the service;
- Server—a resource server implemented in Java using the Spring Boot [2, 3] environment;
- Database – MySql DBMS.

REST (representative State Transfer [4, 8]) was chosen as the architectural style of interaction between service’s components. It is a set of architectural principles for creating scalable and flexible network services. The service structure is shown in Figure 3.

Figure 3. Service structure.

From the user’s point of view, the service is presented as two different platforms – a mobile application designed for patients undergoing rehabilitation, and a WEB application [11, 12] for doctors in which they can track the progress of rehabilitation and edit or supplement the content of the mobile application. This solution is based on the principle of both creating maximum comfort for doctors and developing maximum patient convenience.

The mobile app provides patients with the following features:
- authorization;
- view of doctor’s prescribed medications;
- view doctor’s recommendations;
- view reference information.

The WEB application provides doctors with the following features::
- registration and deletion of patients in the system;
- view patient's rehabilitation progress;
- edit existing recommendations or create new ones;
- edit existing or create new medicines;
- the appointment or abolition of recommendations patients;
- the appointment or abolition of drugs to patients.

The full diagram of the service's business processes is shown in Figure 2.

Let’s look at the process of using the service by the patient. First of all, the patient must register in the system through a doctor. After that, they will start receiving daily notifications containing their doctor’s prescriptions/recommendations. The patient follows the recommendations and takes medication during the course of treatment. If complications occur, the patient should consult a doctor to get a new course of treatment or adjust the current one. After the end of the treatment course, the patient stops using the service.

The role of the doctor in this process is to monitor the patient's condition, their follow process of recommendations and to prescribe or adjust the patient's treatment course.
7. Integration

In order to assess the impact of the developed service on the rehabilitation process, we selected 2 groups of patients operated from 2018 to 2019 on the basis of the orthopedic center of the FGBU SDMIK FMBA of Russia. The first group consisted of 24 people who used the developed service, and 82 people with the standard method of rehabilitation. Thus, 106 people participated in the study, among which women over 55 years of age with idiopathic coxarthrosis prevailed.

As a result of the analysis of the second group, 4 patients had complications. 2 patients developed edema of the lower leg and foot of the operated limb, which persisted for a long time. Another patient had a single dislocation of the hip as a result of movement disorders in the 4th week after surgery. This patient asked for help only on the 6th day, and therefore the dislocation had to be removed openly, followed by immobilization of the limb for 4 weeks. One patient also developed a thromboembolism of large branches of the pulmonary vascular tree, which led to a fatal outcome.

The first group performed much better. During the follow-up, no dislocations were recorded, and only one patient with concomitant pathology in the form of type 2 diabetes and paroxysmal atrial fibrillation developed sural vein thrombosis of the non-operated limb.

According to the results of an anonymous survey of all participants in the first group, in terms of their satisfaction with the service, it can be stated that positive reviews prevail, namely, 20 people answered that they were satisfied, 2 people were more satisfied than not, one was dissatisfied and one abstained.

Thus, the placement of the developed service [3, 4] with recommendations after surgery on mobile platforms made it possible to inform the patient in a timely manner about the necessary actions and behavior at the stage of rehabilitation after surgical treatment, and also gave access to all the necessary reference information about the treatment that was prescribed to the patient by his / her doctor. Another important advantage is a reduction in the frequency of unscheduled visits to the clinic for consultation with the attending doctor.

8. Conclusion

The result of this work is a service developed on the basis of clinical recommendations for monitoring and managing the patient's rehabilitation process in the form of an application for the Android mobile platform and a website.

The study of the effectiveness of the developed service was conducted based on an anonymous survey of patient satisfaction with the use of the mobile app and a comparative analysis of the number of complications, which showed a noticeable improvement in the entire rehabilitation process provided that the service is used.

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