

# Improving patient compliance and outcomes after ACL reconstruction?



## There's an app for that!

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Figure #1

It has been 12 weeks since her anterior cruciate ligament (ACL) reconstruction and Avni\* is attending her first physiotherapy assessment. After assessing her knee, it is clear that she has difficulty walking, ascends and descends stairs one at a time, is unable to do a straight leg raise without a quadriceps lag, lacks full knee extension, and her passive knee flexion is 80 degrees with a harsh capsular end feel. Even with aggressive mobilization, Avni is likely going to need another arthroscopic surgery to address her flexion limitation due to arthrofibrosis in her joint. She was an avid soccer player who now has trouble with simple activities of daily living and requires a second surgery which could have been avoided because of delayed post-operative rehabilitation (Fig #1).

Patients like Avni, and others who have poor compliance with post-operative rehabilitation, led me to seek out solutions using mobile health technology. Consider the following facts:

1. As of January 2017, there were 4.92 billion users of mobile devices which represents 66% of the world population<sup>1</sup>;
2. Mobile phones are now the most universal form of technology in human history<sup>2</sup>;
3. The average user spends five hours per day on their mobile device<sup>3</sup>;
4. Text messages are read by 90% of users within three minutes of receiving them.<sup>4</sup>

What if we could take this same addictive and ubiquitous technology that goes everywhere with us, and use it to improve access to rehabilitation? Would this result in increased patient compliance, therefore better patient outcomes?

I worked with a group of engineers in January 2016 to devise a solution. But first we wanted to know the extent and nature of limited access to and poor compliance with post-operative rehabilitation after ACL reconstruction. We conducted semi-structured interviews with four patients who had ACL surgery, two orthopaedic surgeons who perform the surgery, and four physiotherapists who treat patients after orthopaedic surgery.

Based on these 10 interviews, the following themes emerged:

1. Many of the patients pointed to the cost of physiotherapy services being the main barrier to them accessing rehabilitation. As one 23 year-old graduate student said, "I really need physiotherapy, but it's \$80 for 30 minutes and I can't pay."
2. Accessibility of physiotherapy was brought up by both physiotherapists and patients as a barrier. "Some of my patients have a limited number of physiotherapy sessions based on insurance coverage and some have to travel far to see me," said Steve, a physiotherapist at Trent University.
3. Inconvenience was identified by some patients as a challenge to accessing reha-



Figure #3

Figure #2

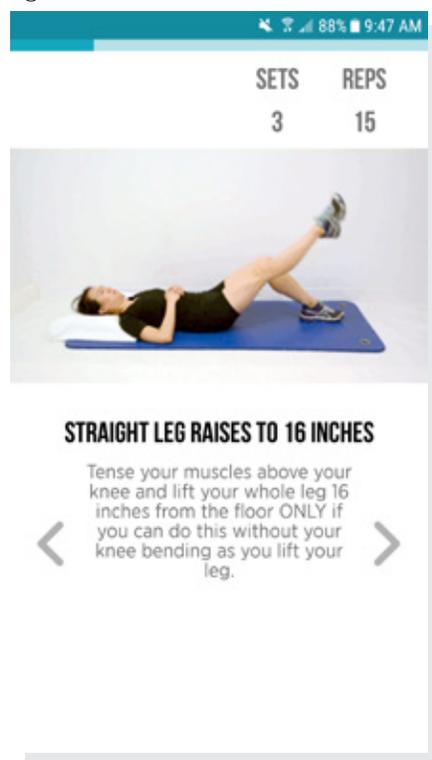
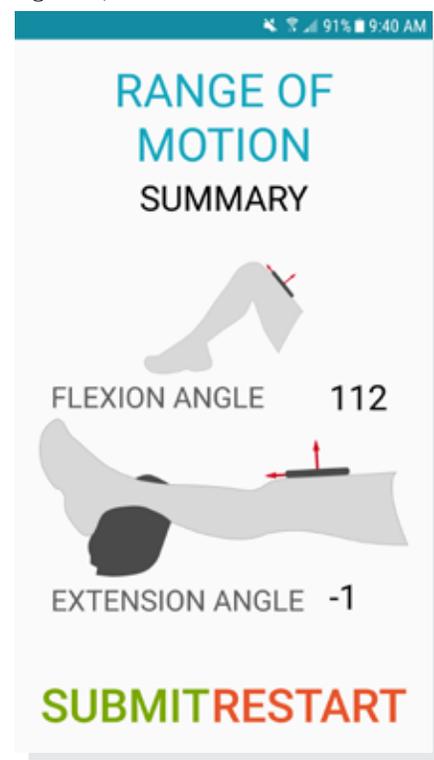


Figure #4



bilitation services. Lyndon, a 32-year old self-employed patient said: *“I rely on my phone for the calendar, email, notifications, and what to do every day. It would be great if I could use my phone to help me with my exercises.”*

4. Reminders about what the patient needs to do in their post-operative care would be very useful for patients as well as health care providers. As one surgeon stated *“...many times patients come back to ask about what they can do, even though it says it in their protocol.”*
5. The ability to track progress and outcomes was clearly important to patients, physiotherapists, and surgeons. When one surgeon was asked ‘what is your patients’ compliance rate with rehabilitation after surgery?’ He said, it is *“very hard to know, [and] changes based on the patient. I would be guessing if I gave you a number.”* Relatedly, patients wanted a way to measure their knee range of motion on their own. As Nirav said *“if I could measure my knee [knee flexion and extension range of motion], I would do it every day to see if I am achieving my goals or not.”*
6. Physiotherapists and patients have expressed their desire to have proper exercise technique demonstrated to the patient outside of the physiotherapy clinic. Physiotherapists expressed frustration with the current process of constantly

printing off new exercises at every session and using up some of their treatment time on this administrative task. Patients had difficulty remembering all of the exercises they were prescribed, and struggled with proper exercise technique.

Using these themes as guidelines, I formed a company with four engineers through the Hatchery which is a University of Toronto startup incubator. I worked with Harris Chan, Annie Mao, Sherry Shi (EngSci ECE graduates from UofT) Fionna Gan (EngSci BioMed graduate from UofT) and our advisors Professors Jonathan Rose and Joseph Orozco to create an app for ACL rehabilitation after injury or surgery. By drawing on the growing field of mobile health technology, we hoped to address the barrier of cost, access, and inconvenience. The app, called Curovate, is available in the Google Play Store and can be downloaded here: (<https://goo.gl/x2jV8X>) by anyone with an Android device; we are currently working on a version for the iPhone.

Once patients input their injury or surgery date as well as their graft site for their ACL reconstruction, Curovate provides them with a video-guided daily protocol for six months. Each day in the app starts with video instructions of every single exercise for rehabilitation and as the video plays, the app counts every repetition and set for the patient so there is no need to remember which exercises were completed or count reps and sets (Fig #2). To address the identified need to

track progress, the app also allows patients to measure their knee flexion and extension range of motion with nothing more than their cell phone (Fig #3). These measures are also tracked over time so that patients can identify if their range of motion is improving. (Fig #4)

All of the completed exercises, the range of motion measured, and patients’ overall compliance rate are tracked by the app and presented to the patient in a simple manner which acts to gamify the process of rehabilitation. The patient can earn badges within the app to motivate them to be consistent with their exercises and rehabilitation. The app also has a daily check list of items to help with medication adherence, ice, compression and elevation, biking duration, and specific time sensitive instructions to improve the function of the knee (Fig #5).

The app comes pre-set with reminders to help the patient complete their exercises and these can be customized by each patient. The app has four versions or protocols specific for patellar tendon reconstruction, hamstring tendon reconstruction, immediately following injury to the ACL or ACL rehabilitation without surgery. Every protocol is based on evidence-informed rehabilitation, my professional experience as a physiotherapist over the past 17 years, and helpful tips and suggestions from my patients. There is a list of clearly stated references within the app.

We all know that despite our best efforts sometimes patients fall behind on their rehabilitation. They may miss a day, a week or come back after a month and state they have

not been able to do most of their exercises. The app allows a patient or a physiotherapist to move the patient back a day, a week or a month in the protocol. Everything in the app is set up in stages of rehabilitation so a patient can move back as many stages as necessary to match their current abilities.

The app, released on Google Play in August 2016, has received some feedback from patients who have used it as part of their rehabilitation.

Jalen (age 23) said, *"It feels like I have a companion for my daily routine. I look at the compliance rate and try to improve it and this makes me more likely to do my exercises."* This is promising as we had hoped that the app would have an influence on patients' compliance after surgery. I have also noticed that some patients were unhappy with the brief paper protocols given to them by their surgeons and found them full of medical jargon and not user friendly. Michael echoed these thoughts when he said, *"I love the app. I think it is much more useful than the information provided by my surgeon."*

Some patients struggle in the first few days post-surgery, particularly if they are alone or don't have guidance on next steps. Patients may then exhibit significant pain avoidance behaviour. They come to see us unwilling to move their knee and this presents an early challenge to knee range of motion. Melanie found this problem was alleviated with guidance from the app: *"I found the app really helpful, especially in the first few days after surgery when I was at home and wanted to do something to get started but also be safe. It was very thorough and the videos were very helpful."*

Another goal was to make the process of rehabilitation more accessible and convenient; I was hoping to make an impact on rehabilitation both locally and globally. A few months ago I received an email from a woman in Prague named Sorin who said the following about the app: *"It's been one month since I had ACL surgery so I will continue with the exercises described in the Curovate application. The app is GREAT! I really love it. Now I have structured rehabilitation. Of course I discuss everything with my physiotherapist, but it is much better to have an app: to watch the exercises and to measure the progress. I really like the easy-to-use design of the app. I found it accidentally on the app store while I was searching desperately for something to help me do my exercises. I have already recommended your app to a work colleague [whose] flatmate had ACL surgery 14 days ago."*

Indeed, the global nature of the app marketplace has surprised me. We have yet to advertise our app and yet through organic searches, we have had users from all over the world. As of this writing, the top countries

that are using our app over the past seven days are Canada, India, Germany, United Kingdom, and Spain. I am also hoping to reach the global audience through my blog about everything from how to use crutches, to research on graft site outcomes and patient personal experiences with surgery. The blog can be found here: <https://goo.gl/aoFCgk>

To follow up on this patient feedback, I am currently conducting two research studies. The first is to investigate whether using our app results in better patient engagement and outcomes? What we know thus far from our app analytics is that people spend between 12-20 minutes per session using our app. This is significant since health-related app use tends to be a few seconds to a few minutes. In comparison, time spent using our app represents high user engagement which we are hoping will translate to better patient outcomes. I am also conducting a long term study to investigate the cost and efficacy of using mobile health technology along with subjective and objective outcomes after surgery.

### Conclusion

My long term vision is to make rehabilitation accessible to everyone who needs it, to improve patient outcomes and increase compliance with pre- and post-operative rehabilitation. I hope to do this in a manner that is patient-centric, affordable, and convenient. My plan is to take what we have learned from deploying the ACL app and do the same for total knee and hip replacements, and other orthopaedic surgeries and injuries. I want to partner with both hospitals and physiotherapy clinics to deploy mobile health technology as a step towards addressing problems of physiotherapy access and patient compliance. If you are interested in working with us to help your patients recover and ultimately improve their outcomes, or are interested in being involved with our research mentioned above, please contact me. 📧

*\*Patient names changed to protect privacy.*

### About Nirtal:

Nirtal Shah is a physiotherapist at the University of Toronto's David L. MacIntosh Sport Medicine Clinic. Nirtal is also an Adjunct Lecturer at the Dalla Lana School of Public Health at the University of Toronto. He has four peer reviewed publications and three mobile health apps (Curovate, myAnkle and myKnee) that are all available on the Google Play Store. Nirtal can be reached at [nirtal.shah@utoronto.ca](mailto:nirtal.shah@utoronto.ca).

[www.curovate.com](http://www.curovate.com)

 @curovate

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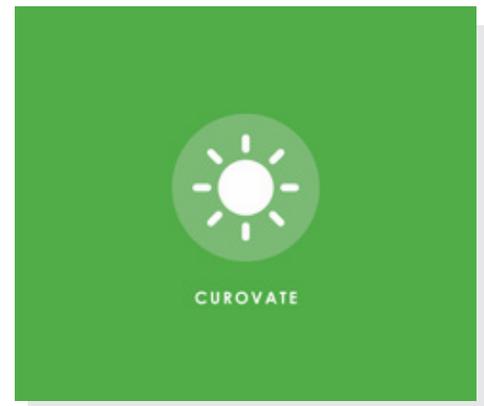


Figure #5

