The Equitable Design of Post-Operative Knee Rehabilitation Protocol

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Total knee arthroplasty (TKA) and ACL reconstruction surgeries combined make up nearly one million surgeries performed annually in the United States alone (Hewett et al., 2010). After knee surgery, typical rehabilitation protocol works in stages, beginning with completely restricted movement, then progressing to movement with a limited range of motion, finally to a full range of motion with weight unloading on the joint. These post-operative rehabilitation plans are designed to ensure a full and proper recovery for the patient. However, not all rehabilitation plans should look alike, depending on many factors related to the patient and their health. It is important to design a plan for each patient while keeping their age, physical ability, gender, and any other lifestyle or health factors in mind. A recovery plan tailored to the specific needs of the individual patient will make it easier on the physician to accurately monitor progress, while also making it easier on the patient both physically and mentally as they feel that they are making that progress. The STS framework that I will be using to investigate my topic is outlined by Steve Woolgar in his 1990 article "Configuring the user: the case of usability trials" (Woolgar, 1990). The use of this framework will aid me in my analysis to answer this question: How do the current standards of treatment and rehabilitation protocol for patients undergoing knee surgery contribute to an inequitable recovery process for patients of different ages, abilities, and genders, and why is this so when it produces undesirable outcomes for certain individuals? Investigating this question is foundational to the equitable design of the recommendations physicians and physical therapists provide to patients post-operatively.

Knee Recovery Protocol Background

Millions of individuals suffer from daily knee pain, and with the demand for total knee replacements being projected to grow by 673 percent to nearly 3.5 million procedures annually

by the year 2030, the need for a proper rehabilitation protocol is more important than ever before (Kurtz et al., 2007). With the prevalence of TKA on the rise, the complications throughout its recovery process are rising too. One of the most common complications resulting from this procedure is a condition called flexion knee contracture, or flexion deformity, where patients can lose up to 62% of their quadriceps strength due to atrophy of the muscle, and is a result of the long-term immobilization of the joint (Anania et al., 2013). Knee flexion contracture is when the knee can no longer be straightened fully, either actively or passively, and it is estimated that up to 60% of patients undergoing TKA will experience knee flexion contracture throughout their recovery. Although some of these effects are reversible, some knee flexion contractures can be so severe that there is a permanent loss in range of motion, impeding a patient's full recovery and can result in permanent physiological limitations on the knee's range of motion (Su, 2012, Mizner et al., 2005).

After knee surgery, patients will undergo a post-operative rehabilitation plan to ensure a full and proper recovery. However, many factors such as age, gender, and physical ability influence an individual patient's response to such a protocol. This sheds light on the importance of designing proper protocol unique to each individual and developing a set of best practices for patients that fall into unique combinations of these groupings. A custom recovery plan that accounts for a patient's abilities and needs will help inform both physicians and patients of the progress they are making, while avoiding discouragement of the patient and the feeling that they are falling behind. For my STS research paper, I wanted to dive deeper into the current inequities present in the standard rehabilitation protocol for total knee replacement in order to figure out why these inequities are still present.

STS Framework Background

In his 1990 article "Configuring the user: the case of usability trials", Woolgar proposes that the user and a machine or technology is analogous to a reader and a text. Woolgar states that just as different readers interpret the same text in different ways, users interpret and interact with technologies in different ways, due to their background. He mentions that in the design of the technology, machines inherently configure users in such a way that informs the way that they interpret the technology and interact with it. This perspective relies on the assumption that whoever designs the technology– or configures the user– knows what the user needs better than the user themself. Configuring the user then shapes what the future user will need from the technology, therefore defining the technology's requirements (Woolgar, 1990).

I believe that this principle can be applied to investigating the post-operative rehabilitation protocol. I will apply the concepts of user configuration to different patients' experiences with post-operative knee braces and recovery programs. Woolgar writes, "users can't help the way they behave; they just need to be educated to understand what we are trying to achieve here. Readers can't help the way they interpret the text; they just need to be educated" (Woolgar, 1990, p. 89-90). This analogy can be further extended to the field of orthopedics and rehabilitation in that the design of protocol contains inherent bias and the way that patients react is dependent on the individual patient and their needs. There are a lot of factors that play into how any given person will interpret a text: do they have background knowledge on the subject, do they have a personal connection to the subject, what do they think other people's perception of the subject is? Another factor comes from the author's side; that is, who wrote the text? Who designed the rehabilitation plan? These same things, or analogies of them, could impact the way that a patient reacts to their rehabilitation plan both physiologically and psychologically. Viewing

different patients' experiences through this lens will help me to investigate why there are these discrepancies and inequities in rehabilitation programs.

Other authors have built upon this framework and some have even begun to challenge it. Oudshoon and Pinch argue that in order to apply this framework, an important question must be asked: How are these users defined, and by whom are they defined? Further, how do designers think of users and how do users speak and communicate with these designers? They critique Woolgar in mentioning that he limits the framework to "design processes that delimit the flexibility of machines rather than on the negotiations between relevant social groups" (designers and users). They argue that the framework should be broadened to include the complexities of such designer user relations and communications (*How Users Matter*, 2003).

Research Question & Methods

The goal of my research is to answer this question: How do the current standards of treatment and rehabilitation protocol for patients undergoing knee surgery contribute to an inequitable recovery process for patients of different ages, abilities, and genders, and why is this so when it produces undesirable outcomes for certain individuals? I conducted my research by studying orthopedic journals to investigate different types of patients' experiences with the recovery process for total knee arthroplasty (TKA). I split my analysis into three categories: age, physical ability and biomechanics, and psychological and emotional factors. This helped me to uncover disparities in different groups of patients based on these individual factors in order to fully uncover disparities in the standard of care provided to different types of patients with different needs.

Results / Discussion

Throughout the next section of this paper, three categories of characteristics that make patients unique in their recovery needs will be discussed: age, physical ability and biomechanics, and psychological and emotional factors. For each factor, I looked into different studies analyzing how that factor influenced a patient's ability to recover successfully after TKA surgery. Following the three factors, a discussion section addresses the connections my research and analysis has with the User Configuration STS framework.

Age

The mean age for total knee arthroplasty (TKA), or total knee replacement is 67.2 years, but the range of ages for this procedure is getting larger with younger patients opting into it each year. A study done by the American Academy of Orthopaedic Surgeons titled "Age-Related Differences in Pain, Function, and Quality of Life Following Primary Total Knee Arthroplasty" investigates the differences in patients of varying age groups before and after total knee arthroplasty (TKA). They studied 11.602 patients ranging from younger than 55 years to older than 75 years and assessed multiple factors related to the patients' physical and emotional health both pre- and post-operatively. These factors are as follows: patient demographics, comorbidities, patient reported outcome measures such as the Knee Injury and Osteoarthritis Outcomes Scores (KOOS), and physical and mental composite scores. Patients were divided by age into cohorts: 55 years and younger, 55-64 years, 65-74 years, and 75 years and older (American Academy of Orthopaedic Surgeons, 2023).

The study found that prior to TKA, younger patients reported worse pain, function, and quality of life compared to older patient groups. A year post-operatively the same metrics were collected from the same patient population, and it was found that younger patients still reported

slightly worse pain and quality of life, but they had better function scores, as compared to older groups. These findings seem to suggest that a younger age is associated with a less successful recovery from TKA. However, a disconnect is present due to a common misconception about younger patients: that they are healthy and active individuals who require this procedure due to a sudden injury. This is not the case, as it was uncovered in the study that the younger populations had higher incidences of obesity and more medical comorbidities that potentially led to early onset arthritis. The conclusions made from this study were that a patient's medical fitness level was a better predictor of success for recovery and that age had less to do with success than they had originally thought (American Academy of Orthopaedic Surgeons, 2023).

Physical Ability and Biomechanics: Severe Other Joint Diseases, Obesity, and Gender

Many different physical conditions have the ability to impact an individual's recovery post TKA surgery. Pre-operative knee stiffness is known to be a strong indicator of stiffness even three years post-TKA, and pre-operative quadriceps strength is a strong indicator of performance on common functional assessments post-TKA. Multijoint dysfunction is common amongst TKA patients and they have an increased 10 year risk for the need to replace the other knee later on. Other joint diseases can impede the recovery process post TKA, and a study done in 2008 aimed to evaluate the effect of other severe joint disease as well as obesity on outcomes following joint replacement surgery (Naylor et al., 2008).

The effect of obesity on patients' recovery process is less straightforward. In past studies, there have been similar relative improvements in pain and function for both obese and non-obese individuals, and the effect of BMI on prosthesis longevity is also ambiguous. This study compared the 15 meter walk test, the timed up and go test, and whether or not the patient used a walking aid at 52 weeks post operation for control groups and groups with higher BMIs and

incidences of severe other joint disease to determine how well patients of the different groups recovered. It was found that patients with severe other joint disease recovered more slowly than the non-severe group in terms of mobility: they walked more slowly on the 15 meter walk test, took 4 seconds longer on the timed up and go test, and had a 6.8 times greater chance of using a walking aid. This profile was similar when comparing the non-obese versus obese populations. The conclusions from this study further illuminate the need to develop more customized recovery plans for patients with these predisposing conditions (Naylor et al., 2008).

Although TKA is effective in reducing pain and improving function, patients with end-stage osteoarthritis have been found to still experience functional limitations and quadriceps strength deficits even 1 year post surgery. Higher BMI is a risk factor for osteoarthritis and the need for TKA, but previous analyses of the effects of a higher BMI on post-operative recovery from TKA have been unclear. Due to this ambiguity, another study conducted in 2015 investigated a large sample of patients to determine knee range of motion, quadriceps strength, and gait speed post TKA. This was aimed at assessing whether sex or BMI influenced the recovery of these measures post-operatively. They found that over the course of a 16 week observational period that male sex and lower BMI were independently associated with greater knee flexion range of motion. The results were statistically significant, but not large enough to be extremely meaningful clinically (Pua et al., 2015). This is interesting to think about in the context of how it may impact the other two factors (gait speed and quadriceps strength) and how a small difference here may have compounding effects for these other outputs.

As for quadriceps strength, they found that women gained quadriceps strength back more slowly than men, as did shorter patients or patients with a higher BMI. In their gait speed analysis, they found that it was consistently lower in women than men, but an appreciable

negative association due to BMI was only noticeable past 30 kg/m^2. Overall, this study emphasizes the need for a better understanding of the different types of human bodies from a biomechanical perspective and better planning for different patient subgroups (Pua et al., 2015).

As the prevalence of obesity and higher BMI is increasing globally, so is the prevalence of osteoarthritis, subsequent knee joint pain, and subsequent physical disability. In these instances, obesity can be the trigger for the osteoarthritis that leads to TKA surgery. Following surgery, patients benefit from inpatient rehabilitation services that assist in improving their functional independence prior to discharging them to their homes. The Centers for Medicare Services recently developed a reimbursement plan for patients with a lower BMI, assuming that excessive adiposity in patients with a higher BMI lowers their mobility and results in more inpatient rehabilitation services and higher costs. A higher BMI is also associated with more instances of revision TKA procedures, which are associated with lower functional gains and greater length of stay than an initial TKA procedure (Vincent & Vincent, 2008).

A study done in 2008 aimed to uncover whether or not inpatient rehabilitation outcomes following TKA were influenced at all by BMI. The study separated patients into four groups ranging from non-obese to severely obese based on BMI, and all of the patients completed an interdisciplinary inpatient rehabilitation program post-TKA. Total and individual functional independence measure (FIM) scores, length of stay (LOS), FIM efficiency scores, hospital charges, and discharge disposition location were collected from all patients to determine whether the combination of a higher BMI and revision TKA surgery were actually associated with lower functional gains, a longer LOS, and higher hospital charges than lower BMI and primary TKA. It was found that the percent of FIM was 7.5% greater in non-obese compared to severely obese, that FIM efficiency was the lowest in the severely obese, and that changes in FIM motor score

from admission to discharge was 6.7 – 15.6% greater in the non-obese group. Changes in cognition FIM, toilet transfer, and walking without assistance scores were also higher in the non-obese group compared to the severely obese group. The severely obese group also had higher total physical and occupational therapy and pharmacy charges than all other groups. The takeaway from this study was that a higher BMI and revision TKA doesn't prevent functional gains or good outcomes during rehabilitation, but it makes the process less efficient and more costly to the patient (Vincent & Vincent, 2008).

Psychological & Emotional Factors

Across the board, many patients post-TKA report a substantial improvement in pain, function, and general quality of life, but a good 15 – 25% still report unsatisfactory improvements in these three areas. There are many factors associated with poor outcomes post TKA, some of which have been previously discussed in this paper: sociodemographic factors, pre-operative status, intraoperative factors, and post-operative factors. Several studies have reported that patients with pre-operative psychosocial dysfunction, such as dysfunctional coping, stress, depression, or anxiety, may experience unsatisfactory outcomes post-TKA. However, previous studies are limited due to the fact that they failed to include some important factors such as coping, social support, and stress (Lopez‐Olivo et al., 2020).

A study done in 2020 aimed to uncover whether or not these factors are associated with less overall improvements in patients' pain, physical function, and quality of life 24 months post-TKA. They measured the following outcomes at baseline and at 24 months post-TKA for 178 patients: Western Ontario and McMaster Universities Index (WOMAC), Short Form 36 (SF-36), and patient satisfaction with TKA just at 24 months. Linear regression models were used to evaluate the association of multiple preoperative psychosocial factors with these

outcomes. It was found that low tangible social support and low optimism in patients pre-operatively were associated with higher levels of pain and worse function. They also determined that having a dysfunctional coping mechanism was associated with lower satisfaction with the surgery after 24 months. This study brings to light the importance of not only considering physical factors that make patients unique, but also psychological and social factors. This illuminates the need to screen for such psychosocial factors pre-operatively and proactively develop a recovery program that will accommodate for the individual patient's needs psychologically as well (Lopez‐Olivo et al., 2020).

Discussion

Throughout the course of my research and analysis, one conclusion has stuck out: that it is crucial for physicians to consider all of the potential factors that make a patient unique (i.e. physical, psychological, emotional, other demographics) in order to most equitably provide a treatment and recovery plan post TKA surgery. Woolgar's concept of User Configuration states that whoever is designing the technology is inherently configuring the user, and that this configuration then determines how the user will interact with the technology (Woolgar, 1990). The same can be said in the context of a physician and a patient in terms of their treatment and recovery plan. If we configure all patients to interact with the recovery plan in the same manner by prescribing a one-size fits all plan of treatment, then it is naturally the case that some users will be predisposed to find a natural alignment with the plan, and some users will not.

Limitations & Future Work

One limitation of my research is that I could have included more factors that make a patient unique, including some demographic factors such as socioeconomic status. Future work should continue to investigate different types of patients and their respective experiences with the

TKA procedure and their recovery. Another limitation is that I kept my analysis focused on the recovery process, that is post-operative. However, I think that many factors involved in what goes on in the operating room (materials for prosthesis, surgical tools/instruments, etc.) could also have just as large of an impact on a patient's overall satisfaction with this procedure. Other future work should include more research about the decision making process for the surgical process and specifications.

Conclusion

Over the course of my analysis, I looked into a few different patient subgroups with different factors that I hypothesized would predispose them to an unsatisfactory experience post-TKA surgery. I found that a few of these different factors were directly associated with poorer outcomes, and that TKA revisions could lead to even further worsening of a patient's function, pain, and quality of life. The largest takeaway from my research was that physicians need to develop treatment and recovery plans for TKA patients on a more individual basis, taking into consideration all of the factors that could potentially inhibit their ability to recover. In the future, as the prevalence of TKA is on the rise, I hope that these case-by-case decisions are made in order to improve the quality of life and surgical outcomes for all patients.

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