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THE RELATIONSHIP BETWEEN PATIENT EXPECTATIONS, FUNCTIONAL OUTCOME, SELF-EFFICACY, AND REHABILITATION ADHERENCE FOLLOWING CARTILAGE REPAIR OF THE KNEE: A SEQUENTIAL EXPLANATORY ANALYSIS

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DISSERTATION

A dissertation submitted in partial fulfillment
of the requirements for the degree of Doctor of Philosophy in the
College of Health Sciences
at the University of Kentucky

By

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ABSTRACT OF DISSERTATION

THE RELATIONSHIP BETWEEN PATIENT EXPECTATIONS, FUNCTIONAL OUTCOME, SELF-EFFICACY, AND REHABILITATION ADHERENCE: A SEQUENTIAL EXPLANATORY ANALYSIS

Patient expectations have been shown to be a major predictor of outcomes. Furthermore, fulfilled expectations have been linked to increased patient satisfaction and rehabilitation adherence. Expectations may be influenced by a variety of factors, including patient characteristics, pre-operative function, or disease characteristics. However, it is currently unknown what factors and to what degree they may influence patient expectations prior to knee surgery. Furthermore, understanding the importance and values of those expectations for recovery using qualitative methods has not previously been conducted in this patient population.

A mixed methods design was used. Twenty-one participants scheduled to undergo cartilage repair of the knee, including autologous chondrocyte implantation, osteochondral allograft transplantation, or meniscal transplant were included. During their pre-operative visit, participants completed an expectations survey (Hospital for Special Surgery (HSS) Knee Surgery Expectations Survey) and the Knee Injury and Osteoarthritis Outcome Score (KOOS) as a measure of functional ability. At their first post-operative visit, patients completed the Self-Efficacy for Rehabilitation Scale (SER). Rehabilitation adherence was collected by the participant's rehabilitation provider. A selected sample of 6 participants participated in a semi-structured interview 6 months following surgery to better understand their expectations for recovery. Pearson correlation coefficients were used to determine relationships between expectations and KOOS scores, SER scores, and measures of adherence.

Results demonstrated that patients have moderate expectations for recovery and these expectations were positively associated with pre-operative pain, activities of daily living, and knee-related quality of life as measured by the KOOS. In addition, a negative relationship was found between patient expectations and adherence with home exercises, use of a brace, and weight-bearing restrictions. Four qualitative themes emerged as participants' described how previous recovery experiences shaped their recovery

following cartilage repair of the knee. Patient education, pre-habilitation, and the use of psychological skills during rehabilitation may help to manage patient expectations, improve rehabilitation adherence, and assist clinicians in providing more focused and individualized patient care.

KEYWORDS: Autologous Chondrocyte Implantation, Osteochondral Allograft, Patient Expectations, Rehabilitation Adherence, Self-Efficacy

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CHAPTER 1: INTRODUCTION AND SYSTEMATIC REVIEW OF EVIDENCE-BASED GUIDELINES FOR REHABILITATION FOLLOWING AUTOLOGOUS CHONDROCYTE IMPLANTATION

Chondral injuries of the knee, when left untreated, can result in significant pain, functional impairments, decreased quality of life and an increased risk for the progression of osteoarthritis.[1,2] The aim of cartilage repair procedures is to restore full function and delay the progression of osteoarthritis. Over the years, a variety of surgical procedures have been developed to address cartilaginous defects in the knee, including osteochondral allograft, microfracture, and autologous chondrocyte implantation (ACI). Regardless of the surgical technique, the recovery period following cartilage repair is a lengthy one and often involves a period of restricted weight-bearing necessary for adequate tissue healing.[3,4] As a result, return to full function is often delayed 6-12 months, with return to unrestricted sport participation as late as 12-24 months.[5] In order to optimize the benefits of cartilage repair surgery, it is crucial that patients are well informed and educated regarding the recovery process and willing to adhere to a lengthy rehabilitation process.

Successful outcomes following cartilage repair of the knee are dependent on a multitude of factors, including patient history, lesion characteristics, quality of the repair, post-operative rehabilitation, and psychosocial factors. Although it has been suggested that rehabilitation plays a valuable role in achieving successful outcomes following cartilage repair of the knee, guidance for the progression of rehabilitation is based almost entirely on expert opinion, basic science and the biomechanics literature.[6] To date, little

is known about the recovery process following cartilage repair of the knee from the perspective of the patient or the rehabilitation provider. Furthermore, to date, little is known about the expectations of patients undergoing cartilage repair surgery and whether these expectations influence post-operative outcome and adherence to rehabilitation guidelines.

PURPOSE

This study was an investigation of current rehabilitation practices following cartilage repair of the knee in an attempt to better understand the role of rehabilitation and its impact on patient care and outcomes. Therefore, the primary purposes of this dissertation were the following:

1. To systematically review the current evidence for rehabilitation interventions and progressions following ACI.
2. To assess the consistency of the documentation process relative to post-operative rehabilitation in order to provide information and guide initiatives for improving the quality of rehabilitation practices following ACI.
3. To explore and describe patients' experiences during the recovery process following ACI.
4. To explore and describe the experiences of rehabilitation providers' experiences during the rehabilitation process following ACI and to determine what strategies they employ to improve outcomes, encourage rehabilitation adherence, and establish positive therapist-patient relationships.
5. To examine and explore the relationships between patient expectations, functional outcome, self-efficacy, and rehabilitation adherence in patients

undergoing cartilage repair of the knee. *Hypotheses: there will be a positive association between patient expectations and postoperative functional status. There will be a positive association between patient expectations and preoperative functional status. There will be a positive association between patient expectations and rehabilitation adherence. There will be a positive association between patient self-efficacy and rehabilitation adherence.*

OVERVIEW

This dissertation is organized according to the following: Chapter 1 is a systematic review of evidence-based rehabilitation interventions and progressions following ACI**.** This chapter will provide current evidence for the development and progression of rehabilitation programs following ACI. Chapter 2 is a retrospective chart review that examines the role of rehabilitation following ACI. In addition to patient-reported outcome measures and patient demographics, physical therapy records were reviewed to determine what factors influence outcome following ACI. Chapter 3 is a qualitative investigation of patients' experiences during recovery following ACI. This information will provide a deeper understanding of the recovery process from the patient's perspective. Chapter 4 explores the rehabilitation providers' perspective on recovery following ACI from a qualitative perspective. Chapter 5 examines the relationship between patient expectations, functional outcome, rehabilitation adherence, and self-efficacy in patients undergoing ACI. It also seeks to describe patients' expectations for recovery from a qualitative perspective. Chapter 6 will provide a summary of the results of this dissertation and provide implications for clinical practice and future research.

OPERATIONAL DEFINITIONS

Autologous Chondrocyte Implantation:

A two-stage cell-based procedure used for the treatment of articular cartilage injuries. During the first procedure (arthroscopy), chondrocytes are removed from a non-weight-bearing portion of the knee and harvested. Following culture, the chondrocytes are transplanted into the articular cartilage defect(s) during a second procedure.

Osteochondral Allograft:

A surgical procedure used for the treatment of large articular cartilage defects. A cadaveric allograft is obtained and transplanted over the articular cartilage defect using screws.

Meniscal Transplant:

A surgical procedure for the treatment of meniscal injury that cannot be repaired due to the severity of the injury and in which most of the tissue has to be removed. In this procedure, an allograft meniscus is transplanted onto the medial or lateral tibial plateau to replace damaged meniscus.

Patient-reported outcome (PRO):

Self-report questionnaires used to assess patient response to treatment. Measures include health-related quality of life (HRQOL), condition and disease-specific measures, and site/joint-specific measures.

Expectations:

Anticipation that given events are likely to occur during, or as a result of medical care.[7]

Self-Efficacy:

Belief in one's ability to "organize and execute the course of action required to produce given attainments".[8]

Adherence:

An active, voluntary collaborative involvement of the patient in a mutually acceptable course of behavior to produce a desired preventative or therapeutic effect.[9]

ASSUMPTIONS

It will be assumed that:

1. Subjects will understand the KOOS, Self-Efficacy for Rehabilitation Outcome Scale (SER) and HSS Patient Expectations Survey and will provide honest answers that reflect their true functional capacity, expectations, and self-efficacy.
2. Rehabilitation providers will provide honest answers when completing rehabilitation intake forms and measures of patient adherence.
3. Patients will provide honest answers to their treating therapist relative to their home exercise, CPM, brace, and weight-bearing restriction adherence.
4. With respect to qualitative data, it is assumed that the researcher remained objective during the course of the study and that participants provided accurate information regarding their experiences.

DELIMITATIONS

1. Subjects will be males and females between the ages of 12 and 65.
2. Subjects were delimited to those that had undergone cartilage repair surgery of the knee, including autologous chondrocyte implantation (ACI), osteochondral allograft, or meniscal transplant.
3. Physical therapy prescription was not controlled in this study.

LIMITATIONS

1. A number of adherence measures (n=5) were not collected from therapists. Despite multiple attempts to contact these therapists, complete data relative to patient adherence is missing from the results.
2. One patient has not followed up with the surgeon since his first post-operative appointment. Despite multiple attempts to contact this patient, postoperative data including measures of adherence and KOOS scores are missing from the results.
3. Due to the longitudinal nature of the study, KOOS scores at 3 months post-surgery (n=18) and 6 months post-surgery (n=10) are not available for all patients enrolled in the study and is therefore missing from the results.

SYSTEMATIC REVIEW OF EVIDENCE-BASED GUIDELINES FOR REHABILITATION FOLLOWING AUTOLOGOUS CHONDROCYTE IMPLANTATION

INTRODUCTION

Articular cartilage lesions of the knee are common and have been suggested to increase the risk of osteoarthritis.[1,10,11] The exact incidence of cartilage defects of the knee is unknown, but a prevalence as high as 63% has been reported in patients undergoing arthroscopic knee surgery.[12] Partial-thickness lesions are rarely associated with significant clinical symptoms. Full-thickness lesions, however, extend to the subchondral bone and often result in significant pain, effusion, functional impairment, and a reduction in quality of life.[13,14] The most common mechanism of chondral injury remains noncontact trauma (i.e. daily activities);[15] however, acute trauma to the knee, as may occur in athletic activity, is also likely to lead to focal chondral lesions of the

knee.[16,17] Due to its avascular nature, injuries to articular cartilage have a limited potential to self-repair and regenerate.[14,18,19] This inability of articular cartilage to repair presents a significant clinical challenge for physicians and rehabilitation specialists.

Over the years, a variety of restorative and regenerative procedures have been developed to treat chondral lesions of the knee. Autologous chondrocyte implantation (ACI) is a regenerative technique that was first described in the literature by Brittberg et al. and is indicated to produce repair tissue similar in structure to hyaline cartilage through the use of harvested chondrocytes.[20] ACI is a two-step procedure that begins with an arthroscopic evaluation and biopsy of normal hyaline cartilage. Chondrocytes removed during this biopsy are expanded in vitro for a minimum of six weeks. The second stage of the procedure often involves an arthrotomy in which the cultured chondrocytes are injected into the prepared defect and sealed.[21] There are several variations of the current ACI procedure, such as matrix-assisted chondrocyte implantation (MACI) and characterized chondrocyte implantation (CCI), depending on the method used to secure the chondrocytes within the defect.

The short-and mid-term clinical results of ACI are reported to be good or excellent in 71%-90% of cases.[22,23] Furthermore, rates of patient satisfaction with improved function and pain levels range from 72% to 100%.[24,25] The long-term durability of ACI was demonstrated by Peterson et al, who reported good or excellent results in 84% of patients with an average follow-up of 7.4 years.[26] However, despite improvements in self-reported symptoms, patients undergoing ACI continue to demonstrate functional deficits and weakness in the affected limb postoperatively.[27-29]

These findings suggest the importance of post-operative rehabilitation following ACI for chondral defects of the knee.

Recent reviews have emphasized the importance of post-operative rehabilitation in determining successful return to function following ACI.[3,22,30,31] However, current guidelines and evidence for ACI rehabilitation are unclear, mostly based on a combination of expert opinion and the basic science literature.[32-34] Although post-operative rehabilitation plays a valuable role in patient success, there is no consensus on the content of such a rehabilitation program following ACI. Therefore, the purpose of this systematic review was to provide an evidence-based review of rehabilitation interventions, including specific rehabilitation components following ACI. A secondary aim of this study was to design a rehabilitation protocol to be used following autologous chondrocyte implantation.

METHODS

Search Strategy

Online searches of the databases PubMed, the Cochrane Library, CINAHL, MEDLINE, and SPORTdiscus were searched in August, 2012. The latter three databases were searched using EBSCOhost. Briefly, the terms “autologous chondrocyte implantation”, “articular cartilage repair”, “rehabilitation”, “physical therapy” and “knee joint” were combined without restrictions concerning date of publication. The search was restricted to the English language. Table 1.1 provides a description of the search strategy. The results from on-line databases were searched for controlled trials and reviews and evaluated by hand for eligible studies. The bibliographies of relevant papers were searched for further studies, including a forward search of cited articles.

Study Selection

Randomized controlled trials (RCTs) evaluating specific rehabilitation interventions following ACI were eligible for inclusion. Eligible rehabilitation interventions/guidelines included use of continuous passive motion (CPM), bracing, range-of-motion (ROM) progressions, weight-bearing (WB) progressions, modalities, and strength-training progressions (open kinetic chain, closed kinetic chain). In addition, studies that developed rehabilitation protocols based on an extensive search of the literature were also eligible for inclusion. All generations of ACI (first generation, second generation, MACI, or CCI) were eligible for inclusion. Case-series, non-randomized controlled trials, and studies focusing on rehabilitation following other cartilage repair procedures, such as osteochondral allograft transplantation system (OATS) and mosaicplasty were excluded from further review. Furthermore, studies reporting rehabilitation protocols following ACI that were not based on extensive reviews of the literature were excluded for review but were considered for addition as background information.

Data Extraction

Data relative to ACI rehabilitation, including patients, intervention(s), outcome measures, results of intervention(s), author's conclusion, and/or rehabilitation protocol were systematically extracted. Data extraction was conducted independently by one reviewer. Information from background literature, RCT's, reviews, and soundly based rehabilitation programs were combined to develop an evidence-based rehabilitation protocol following ACI.

Quality Assessment

Level of evidence was assessed for included studies using the Oxford Centre for Evidence-Based Medicine.[35] To assess the methodological quality of the RCT's, the PEDro scale was used.[36] Components of the PEDro scale include use of randomization procedures, blinding of patients, therapists, and outcome assessments, attrition reported and accounted for, and reporting of measures of variability. To assess the methodological quality of the systematic reviews, the PRISMA checklist was used.[37] Items specific to meta-analyses (e.g. effect sizes and measures of consistency) were not considered in the overall score. Methodological quality was not assessed for review articles. All quality assessments were calculated independently.

RESULTS

The search strategy identified 694 relevant citations. After applying exclusion criteria, a total of 11 rehabilitation reviews and RCT's were included and 21 articles with background information were added (Figure 1.1). Four RCT's were included comparing accelerated weight-bearing to traditional/delayed weight-bearing following MACI.[34,38-40] In addition, two systematic reviews were included evaluating the use and efficacy of CPM following ACI.[41,42] Finally, five review articles that developed soundly based rehabilitation protocols based on an extensive appraisal of the literature were included for review.[32,43-46] Additional background information was obtained from the literature in order to develop an optimal rehabilitation protocol that incorporates basic science, biomechanics, strength progressions, use of modalities, and return-to-play criteria. Table 1.3 provides an overview of the results of the included RCT's and reviews on specific

topics (CPM use, weight-bearing progression, bracing, ROM progression, strength progression, return-to-play).

Quality Assessment

Level of evidence for included studies is provided in Table 1.2. The four included RCT's were evaluated using the PEDro scale. The average PEDro score across RCT's was 6.3/10 (range, 5-7). All four included RCT's did not blind patients or the clinicians who administered the treatment/intervention. Furthermore, three studies did not report blinding of assessors measuring study outcomes.[38,39] Although not included in the final score, two studies did not report eligibility criteria for subject participation in the study.[38,39] The PRISMA checklist was used to evaluate the quality of the two included systematic reviews. The average PRISMA score (out of 20) was 14.5 (range, 12-17). Fazalare et al. did not report their methods for assessing risk of bias within individual studies or across included studies.[41]

Continuous Passive Motion

Six studies provide evidence for the use of CPM following ACI. [32,41-44,46] Fazalare et al. conducted a systematic review to evaluate the clinical evidence of using continuous passive motion following surgery for articular cartilage lesions of the knee. Only four level III clinical studies were included in the review, evaluating the use of CPM following microfracture, abrasion arthroplasty, and periosteal transplant. The author concluded that there is a lack of clinical evidence for the use of CPM following cartilage repair surgery.[41] Similarly, Howard et al. conducted a systematic review examining whether the use of CPM enhances cartilage healing following surgery, and if so, what parameters should be used. Both clinical and basic science studies were included in this review; however, most included studies were level III evidence. It was

concluded that although there is evidence in the basic science literature to support the use of CPM following articular cartilage surgery, there remains a lack of clinical evidence to support its use.[42] Despite the lack of clinical evidence supporting the use of CPM following ACI, the remaining four studies recommend use of CPM following ACI, with similar, but varying parameters, depending on defect location (Table 1.3).

Weight-Bearing Progression

Eight studies provide evidence for weight-bearing progression following cartilage repair. [32,34,38-40,43,44,46] Four RCT's evaluated the effect of accelerated/early weight-bearing (WB) versus traditional/delayed WB following MACI for femoral condyle lesions. Accelerated/early WB parameters ranged from immediate weight-bearing as tolerated (WBAT) progressing to full weight-bearing (FWB) by week 8 postoperatively[38-40] to 20% partial weight-bearing (PWB) for 2 weeks, increasing to 50% PWB between 2-4 weeks, restoring FWB after 6 weeks.[34] Conversely, traditional/delayed WB ranged from toe-touch weight-bearing (TTWB) for 5 weeks progressing to FWB at 11 weeks postoperatively[38-40] to TTWB (20%) for 4 weeks with a progression to FWB between 8-10 weeks.[34] In all four RCT's, there were no significant differences in clinical or self-reported function between patients that underwent an accelerated WB versus patients that underwent a traditional/delayed WB rehabilitation program. The remaining literature reviews provide guidelines for WB progression, with a distinction in WB based on defect location. The consensus is that WBAT is allowed immediately following ACI for patellofemoral lesions, with a goal of FWB within 6-8 weeks. Alternatively, patients remain non-weight bearing (NWB) or begin PWB following ACI for femoral condyle lesions and gradually progress WB with a goal of FWB between 6-12 weeks.

Postoperative Bracing

Four studies provide evidence for the use of prophylactic braces following ACI.[40,44-46] Currently, there are no RCT's evaluating the efficacy of post-operative bracing on ACI patients; rather, all four studies are level 5 evidence. These included studies report parameters on post-operative bracing which are derived from the basic science and knee biomechanics literature. There is a consensus among authors that patients undergoing ACI for patellofemoral lesions should be placed in a knee brace locked in extension following surgery for 4-6 weeks, with a gradual opening at that time. Authors recommend a brace locked in extension or opening up to 30° for 2 weeks, followed by a gradual increase in knee flexion, with a goal of full flexion between 6-12 weeks for patients undergoing ACI for femoral condyle lesions. While most authors recommend the use of a postoperative brace for 6-12 weeks, Nho et al. recommend use of postoperative bracing until patients have achieved adequate quadriceps control[46] (Table 1.3).

ROM Progression

Four studies provide evidence for ROM progression following ACI[27,32,43,44] (Table 1.3). Based on defect location, two authors recommend a restriction of ROM for patellofemoral lesions from 0°-30° for six weeks followed by a gradual increase in ROM.[32,43] Gillogly et al. recommends a goal of 90° of knee flexion for patellofemoral defects by week 3 with a goal of full ROM by week 6.[44] Recommendations for ROM in patients with femoral condyle lesions are less restrictive. These recommendations range from 0°-90° for six weeks[44] to full ROM as tolerated following surgery.[43] Ebert et al. did not provide recommendations for ROM progressions based on defect location, although

the authors do recommend a restriction to 30° of knee flexion for two weeks following MACI.[40]

Strength Progression

Four studies provide evidence for strength progression following ACI[27,32,43,44] (Table 1.3). Following repair of patellofemoral lesions, three authors recommend avoiding open-kinetic chain (OKC) exercises; however, the duration of these restrictions differ, with avoidance of OKC exercises for 3 weeks[43], 6 weeks[44], or 10-12 weeks postoperatively.[46] A significant variation relative to strength progression following repair of femoral condyle lesions was noted among included studies. Bailey et al. recommend OKC between 60°-75° without resistance for three weeks[43], while Nho et al. do not permit OKC exercises for 6-10 weeks.[46] Furthermore, the initiation of closed-kinetic chain (CKC) exercises varies between authors. Nho et al. allow CKC exercises as early as 2-6 weeks postoperatively[46] while Ebert et al. restrict CKC exercises to 7-12 weeks postoperatively.[27] Bailey et al. provide less specific recommendations for initiation of CKC exercises, suggesting patients begin CKC exercises as weight-bearing allows.[43]

Return-to-Sport

Four studies provide guidelines for return to sport following ACI[27,43,44,46] (Table 1.3). Low-impact activities, such as jogging, swimming, and cycling may begin around 6 months postoperatively.[40,43] Running progressions vary among studies, with authors recommending a return to running as early as 6 months[40,46] but as late as 12 months for larger lesions.[44] Three of the four studies report guidelines for return to agility training; all studies are in consensus that agility training should not begin until at least 9 months postoperatively.[40,43,46] Finally, return to high-impact activities, such as basketball and

tennis, is variable between included studies. Two studies recommend earliest return to activity at 12 months postoperatively.[40,43] However, Gillogly et al. recommend a return to high-impact activity between 12-18 months[44] while Nho et al. recommend an earliest return to competitive activity at 16 months postoperatively.[46]

DISCUSSION

The objective of this systematic review was to provide an evidence-based review of rehabilitation interventions following ACI for chondral defects of the knee. While level I evidence exists for weight-bearing progressions following MACI, little clinical evidence exists for the use of other therapeutic interventions, such as ROM and strength progressions, use of continuous passive motion, postoperative braces, and modalities. Until further evidence becomes available, it will be necessary for rehabilitation specialists to depend on a thorough understanding of articular cartilage healing and maturation, biomechanics, principles of therapeutic exercise and progression, and individual characteristics such as lesion size, location, and any concomitant procedures performed when designing a rehabilitation program.

The benefits of using continuous passive motion following articular cartilage repair are based almost entirely on basic science and empirical practice. Howard et al. sought to assess the efficacy of CPM use following articular cartilage repair, including parameters for use. Within this systematic review, six relevant level III basic science studies were included for review.[42] Following induced articular cartilage injury, it was demonstrated that CPM use stimulated chondrocyte synthesis, had anti-inflammatory effects, and resulted in significantly better defect healing than in animals that were immobilized.[47-52] However, limitations exist within these studies that make it difficult to

translate their results into clinical practice. First, most of the studies compared CPM use to immobilization. The practice of immobilization following injury is out-dated, particularly following articular cartilage repair. Secondly, these studies assessed cartilage repair following induction of a chondral injury, rather than following repair of that injury. Further studies in basic science are warranted to evaluate the efficacy of CPM use following articular cartilage repair, specifically ACI. Although excluded from this study, Salter provides a historical assessment of rest and motion in advocating the use of early continuous passive motion. He argues that synovial joints were designed to move, and articular cartilage nutrition is enhanced with joint motion. Continuous passive motion seeks to accelerate the healing of articular cartilage by enhancing the metabolic activity of cartilage; furthermore, CPM use helps to stimulate mesenchymal cells, which assist in the regeneration of articular cartilage.[53]

The limited clinical evidence for the use of CPM following articular cartilage repair is demonstrated in studies by Marder et al. and Rodrigo et al. Marder et al. retrospectively evaluated differences in self-reported measures, such as the Tegner activity scale and the Lysholm scale, along with disease-oriented measures, including radiographs and ROM testing among patients undergoing microfracture for femoral condyle defects. There were no differences between patients using the CPM for 6 weeks compared to patients not using the CPM. Rodrigo et al. also assessed the effects of CPM use on patients following microfracture for femoral condyle lesions.[54] Also a retrospective study, Rodrigo et al. performed second-look arthroscopies in symptomatic patients. Of those 77 patients, 46 had used a CPM postoperatively compared to 31 patients that did not report using a CPM following microfracture. Although patients who

used a CPM postoperatively had significantly greater improvements in lesion grading than patients that did not use a CPM, the groups had significant differences in age and lesion size.[55] Given the retrospective nature of both of these clinical studies, it is difficult to make clinical recommendations for the use of CPM following articular cartilage repair. Parameters of CPM use following articular cartilage repair is also based mostly on empirical evidence and expert opinion. Although evidence in the basic science literature supports the use of CPM for 6-8 hours per day[51], there is no current evidence that provides guidelines for duration of CPM use following surgery. Randomized clinical trials evaluating CPM dosage on patient and disease-oriented measures are warranted.

Progressive and gradual progression in loading following articular cartilage repair is an important concept. When articular cartilage is unloaded, a change in the mechanical properties of the tissue occurs, thus making the cartilage more vulnerable to injury. Loading of the tissue helps to maintain the properties of articular cartilage and it has been suggested that loading following articular cartilage injury may be more important than mobilization.[56] However, excessive loading may lead to cartilage degeneration.[57] Weight-bearing following ACI must be implemented in order to optimize the benefits of gradual loading without causing damage to the repair site by overloading the joint with compressive and shear forces. An understanding of the size and location of the lesion is necessary to optimize this healing. Although weight-bearing restrictions are advocated following ACI, there is significant variability in how weight-bearing progressions are implemented.[3]

This review identified four RCT's evaluating accelerated weight-bearing following MACI. Overall, two studies concluded that there were no differences in

patient-reported function or pain between groups that progressively increased weight-bearing over a shorter period of time compared to patients that had a slower progression to FWB.[34,40] Ebert et al. observed improvements in pain and function in patients that underwent an accelerated weight-bearing program.[38] However, these results were noted only three months postoperatively so it is difficult to make recommendations based on short-term clinical improvements. Furthermore, in another study by Ebert et al., patients that underwent a traditional/delayed weight-bearing program demonstrated a higher level of gait dysfunction than patients that underwent an accelerated weight-bearing program.[39] The results of these studies suggest that early progressive weight-bearing is not deleterious to graft healing or patient-reported outcome measures. However, limitations exist when interpreting the results of these studies. The effect of accelerated weight-bearing in each of these studies was evaluated following matrix-induced autologous chondrocyte implantation (MACI). MACI is a newer technique that uses a 3-dimensional scaffold for securing the chondrocytes to the defect.[58] As a result of improved methods for securing chondrocytes within the defect, it is possible that accelerated weight-bearing may occur safely following MACI. It is unknown if similar results would be observed following first or second generations of ACI. Future studies are warranted to assess the effect of a more accelerated weight-bearing program following different generations of ACI.

The benefits of early weight-bearing include increased patient satisfaction as a result of earlier return to normal activities. Although excluded from this review, Allen et al. conducted a case report using an accelerated weight-bearing protocol following ACI.[59] The patient, a 40 year old female, presented with an osteochondral lesion on the medial

femoral condyle. Her accelerated weight-bearing protocol included one week of WBAT for four weeks with two crutches, progressing to one crutch at five weeks postoperatively. At six weeks postoperatively, the patient resumed FWB activities. Over the course of 17 weeks, the patient met all functional goals of her program and reported 100% knee function at 30 months postoperatively. More importantly, the accelerated weight-bearing program enabled this patient to return to work at an earlier time period. Although a case report, this study demonstrates that accelerated weight-bearing following ACI can result in an earlier return to function and improved patient satisfaction.

An important consideration following ACI is patient compliance to weight-bearing restrictions. Patient education on the importance of these weight-bearing restrictions, along with adequate training in PWB is critical for a successful outcome. In a study by Ebert et al., 48 patients who had undergone ACI for a femoral condyle were trained in PWB using bathroom scales to determine percentage of weight-bearing. Patients were assessed immediately after instruction as well as seven days after training. Immediately following instruction and practice, patients were unable to replicate weight-bearing guidelines, exerting a greater percentage of body weight (15.8%) than expected during walking tasks.[60] The results of this study indicate the importance of patient education and practice in order to optimize healing following ACI.

The use of postoperative bracing following ACI is largely based on empirical evidence and biomechanics of the knee joint. The use of postoperative braces following knee injury are meant to prevent excessive compressive forces over the repair site as well as limit ranges of movement that might otherwise be deleterious to the repair.[3] Postoperative braces are typically recommended for 6 weeks following patellofemoral

repairs. Following ACI for patellofemoral lesions, use of a postoperative brace locked in extension provides protection to the healing graft. In full extension, the patella does not engage with the trochlea, allowing for weight-bearing without additional compressive stresses across the repair site. Postoperative braces for patellofemoral repairs are typically recommended for six weeks, at which time ROM is no longer restricted. However, it is important that patients have full quadriceps function before discontinuing the use of any postoperative brace. Functional unloader braces are commonly prescribed following ACI for femoral condyle lesions. An unloader brace is thought to prevent increased compressive forces across the repair site while still allowing for gradual increases in ROM and weight-bearing. Depending on the size and location of the defect, the unloader brace can be gradually opened to allow greater ranges of flexion. The maximum length of time recommended for unloader braces is eight weeks;[3] however, patients that have not demonstrated adequate quadriceps control should remain in the brace for protection. Studies evaluating the effects of postoperative bracing on gait and overall function are needed to validate clinical use.

Gradual progressions in both passive and active movements following ACI are necessary for enhancing the flow of synovial fluid throughout the joint. ROM is also indicated for decreasing pain, improving circulation, and preventing tissue adhesions following surgery.[3] Current evidence for ROM progressions following ACI is based almost entirely on the biomechanics literature. An understanding of the biomechanics of the knee joint as well as lesion size and location is important when prescribing ROM exercises following ACI. As a result, increases in knee flexion ROM are more judicious following ACI for patellofemoral lesions, as increasing knee flexion ROM increases the

contact pressure between the patella and trochlea. Furthermore, active ROM increases joint reaction forces and contact area; therefore, active ROM exercises are increased at a slower rate than passive ROM.[3,61] There is little clinical evidence for specific parameters on progression of ROM following ACI. The studies included in this review provide guidelines based on a thorough understanding of the biomechanics of the knee joint. Additional research is necessary for developing and implementing ROM progression guidelines following ACI for patellofemoral lesions and femoral condyle lesions in order to maximize patient outcomes.

This systematic review did not identify any level I evidence evaluating the efficacy of strength training prescription following ACI. Restoration of strength and neuromuscular control is an important rehabilitation goal as decreased strength has been shown to be associated with decreased function as well as an increased likelihood of the progression of osteoarthritis.[28,62,63] Several studies have documented strength deficits in patients following ACI. Howard et al. demonstrated significant decreases in isometric knee extension peak force at 6 and 12 months postoperatively in a group of 48 patients. In addition to these strength deficits, patients also demonstrated decreases in function at 6 and 12 months post-ACI.[28] Furthermore, Ebert et al. evaluated isokinetic strength in 60 patients at five years following MACI. There were no significant differences in peak knee flexor torque at five years between the operated and non-operated legs. Peak knee extension torque was less in the operated leg at all angular velocities, even though these differences were not significant.[27] This indicates that patients demonstrate deficits in knee extension strength as late as five years following ACI.

In a recent study by Della Villa et al., 11 athletes who had undergone ACI for lesions of the femoral condyle or trochlea were evaluated at 1-, 2-, and 5- year follow-ups. In addition to a 4-phase intensive rehabilitation protocol, this cohort of athletes was also treated with an isokinetic exercise program and on-field training. The isokinetic training consisted of pyramidal strengthening sessions starting with a high number of repetitions at high speed and ending with fewer repetitions at low speeds. All athletes underwent at least 10 isokinetic training sessions. Results demonstrated that athletes undergoing isokinetic training had a faster recovery and an earlier return to sport.[33] Although isokinetic training was shown to decrease recovery time, the external validity of these findings is limited.

It has been shown that preoperative quadriceps strength is a major predictor for postoperative joint function following anterior cruciate ligament (ACL) reconstruction.[64] Given this information, a period of strength training prior to implantation is necessary for optimizing clinical results following surgery. Furthermore, delaying implantation until adequate lower extremity strength and neuromuscular control is achieved is likely to lead to greater improvements in function and pain postoperatively. Strength training progressions following ACI must be prescribed based on an understanding of lesion size and location. Therefore, it is recommended that strengthening exercises be individually tailored.[3,32,44] The progression of open and closed kinetic chain exercises must be based on an understanding of joint biomechanics. Recently, closed-kinetic chain (CKC) have been advocated over the use of open-kinetic chain (OKC) exercises since CKC exercises are more functional and involve multiple joints, increasing muscular co-contraction and joint proprioception.[3] In contrast, OKC exercises produce higher patellofemoral

compressive forces than CKC exercises.[61] Following ACI for patellofemoral lesions, biomechanics of the knee joint suggest that OKC exercises are safest between 25°-90° of knee flexion as there are minimal joint reaction forces in this range. Exercises performed in CKC, however, are safest in the range of 0°-45° following repair of patellofemoral lesions since joint reaction forces increase as knee flexion nears 90°. [3,61] Exercise prescription following ACI should include a combination of CKC and OKC with consideration of defect size and location in order to optimize clinical outcome. Future studies are needed to assess muscle strength and activation following the use of various OKC and CKC chain exercises.

The role of therapeutic modalities, including cryotherapy, hydrotherapy, therapeutic ultrasound, and electrotherapeutic agents following ACI is controversial. The benefits of these modalities include pain reduction, improvements in ROM, increases in voluntary muscle recruitment, and decreased swelling. To date, no clinical studies have been publishing evaluating the role of therapeutic modalities in postoperative ACI rehabilitation. Research is currently limited to basic science studies with conflicting results on the effects of low-intensity pulsed ultrasound[65,66] and electrotherapy on chondrocyte healing. Neuromuscular electrical stimulation (NMES) is often recommended for patients with arthrogenic muscle inhibition (AMI).[63,67] Neuromuscular electrical stimulation has been shown to be effective in strengthening the quadriceps following ACL reconstruction.[67] In a review of physical modalities and articular cartilage repair, the author (Marks) provides a historical perspective on the use of physical modalities following articular cartilage repair. He concluded that specific modalities, such as electrotherapeutic agents and laser beam therapy have the potential to

promote cartilage healing.[68] However, his review is based solely on animal studies. Further studies are needed assessing the use of therapeutic modalities following ACI.

Return to sport, as evidenced by the results of this review, demonstrate significant variability in recommendations for return to low-impact activities but also return to competitive sport. It is generally recommended that running be restricted for 6 months following ACI, but can be delayed up to 9 months depending on the size and location of the lesion. Regarding return to competitive activity, some studies suggest a return as early as 12 months[40,43] while others recommend waiting a minimum of 16-18 months before returning to competitive activity.[44,46] In a recent systematic review, Mithoefer et al. investigated the efficacy of articular cartilage repair techniques to return athletes to competition. Overall, 73% of athletes were able to return to sport following articular cartilage repair, with an average return to sports participation of 67% in patients following ACI. The average time to return to sport following ACI was 18 months (range, 12-36 months), which seems to be consistent with current guidelines.[69] Bowen et al. provided a review of factors involved in determining when patients may return to full activity following meniscal or chondral injuries. The authors conclude that return to sport following ACI is longer as a result of the healing properties of articular cartilage compared to other tissues. In addition, they also propose that patient motivation is an important factor in the decision to return to sport and must be considered during the rehabilitation process.[70] In addition to patient motivation, it is generally advocated that certain objective criteria be met before returning to sport. These include: full, pain-free ROM, graft is able to withstand the demands of the sport (as measured through functional

testing), and return of muscular strength (>80% of uninvolved leg), endurance, and neuromuscular control specific to sport.

According to Hambly et al., the two primary goals for an ACI rehabilitation program are: "1) local adaptation and remodeling of the repair and 2) full return to function". [3] The general consensus is that achievement of these goals occurs through restrictions in weight-bearing and ROM along with improvement in muscle function and control. As demonstrated by this review, there is significant variability in the literature regarding the degree of these restrictions. A successful rehabilitation program is one that relies heavily on an understanding of clinical biomechanics and the healing response of articular cartilage in addition to patient characteristics such as age, body mass index (BMI), defect size, defect location, and presence of concomitant procedures when designing a rehabilitation protocol.

Canine studies have provided evidence for articular cartilage healing. Understanding this timeline of tissue maturation is essential for developing postoperative rehabilitation programs, in order that tissue development is promoted while preventing overload from occurring at the same time. The proliferation stage occurs immediately following surgery and lasts approximately 4-6 weeks. During this phase, the repair site is fluid-like. As a result, shear forces are deleterious at this stage. Mobilization and partial loading is critical to enhancing the nutrition of chondrocytes. Phase II, the transition stage, typically begins between weeks 4-6 and lasts through week 12. During the transition phase, the tissue is still in the process of "firming up" and is still vulnerable to shear stress. The goals during this phase include restoration of full ROM and gradual increases in weight-bearing. The third phase, remodeling, occurs between months 3-6 as

the tissue begins to integrate with the subchondral bone. The focus of the rehabilitation program during this phase shifts to muscle strengthening, endurance, neuromuscular training, and functional training. The final phase, maturation, lasts up to 2-3 years, with the goal being return to full function and sport.[13,14,19]

While the timelines provide guidance for progression of exercises following ACI, an optimal rehabilitation program should also be goal-oriented. Too often in rehabilitation, progression to the next phase is time-oriented, rather than based on pre-determined goals. Goal-setting in rehabilitation has been shown to increase adherence and patient satisfaction as well as contribute to a sense of control in managing injury.[71] Rehabilitation following ACI should always establish attainable goals in agreement with the patient. In a recent qualitative study by Heijne et al., the experiences of patients following ACL reconstruction were explored. The participants reported being frustrated that the progress during rehabilitation did not match their expectations.[72] Realistic patient expectations and patient-centered care are important components of any rehabilitation program. The rehabilitation protocol must be flexible enough to be adapted to individuals' needs and goals. According to Hirschmuller et al., the rehabilitation process following ACI is one of the most individualized processes in orthopaedics.[32] Cooperation between all members of the team is critical to overall patient success.

CONCLUSION

The results of this systematic review demonstrated that minimal clinical evidence exists for rehabilitation following ACI. Future research is needed to evaluate the efficacy of specific rehabilitation interventions following ACI. Until further evidence becomes available, rehabilitation following ACI will continue to be based on tissue healing

properties, clinical biomechanics, patient characteristics such as age, BMI, defect size/location, and patient expectations and goals. As a result of this review, a generic rehabilitation protocol has been developed, specific to defect location (Appendices A and B). These protocols are meant to serve as a guideline for rehabilitation clinicians. As is the case with all rehabilitation protocols, these protocols should be adapted based on individual patient characteristics.

Table 1.1 Search Strategy

Search Term	Cochrane Library	PubMed	EBSCO Host
Search knee joint	4114	56106	53151
Search chondral defect	26	337	257
Search condylar lesion	6	117	22
Search condyle lesion	21	497	155
Search trochlear lesion	4	127	24
Search patella lesion	24	310	63
Search knee lesion	303	2550	617
Search joint surface defect	81	589	39
Search articular cartilage	393	27546	28556
Search #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9	4429	78770	77167
Search articular cartilage repair	73	3491	1058
Search autologous chondrocyte implantation	48	669	684
Search autologous chondrocyte transplantation	56	1164	379
Search matrix-induced autologous chondrocyte implantation	12	0	48
Search #11 OR #12 OR #13 OR #14	124	4283	2013
Search physiotherapy	4490	124046	29627
Search rehabilitation	23283	320648	374788
Search physical therapy	20018	197335	99632
Search exercise therapy	19425	66445	32247
Search kinesiotherapy	257	90	183
Search instruction	6359	171662	56592
Search postoperative care	12761	104133	63971
Search intervention	91507	290934	373341
Search exercise movement techniques	615	4870	328
Search exercise	37871	242668	454005
Search #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25	148104	1150318	1276948
Search #10 AND #15 AND #26	69	416	209

Table 1.2 Levels of Evidence for Included Studies

Author	Year	Level-of-Evidence†
Bailey et al.[43]	2003	5
Ebert et al. [38]	2008	1b
Ebert et al. [39]	2010	1b
Ebert et al.[40]	2012	1b
Fazalare et al.[41]	2010	3a
Gillogly et al.[44]	2006	5
Hirschmuller et al.[32]	2011	5
Howard et al.[42]	2010	3a
Mithoefer et al.[45]	2012	5
Nho et al.[46]	2010	5
Wondrasch et al.[34]	2009	1b

†OCEBM Levels of Evidence Working Group. "The Oxford 2011 Levels of Evidence" Oxford Centre for Evidence-Based Medicine. http://www.cebm.net/index.aspx

Table 1.3 Rehabilitation Characteristics of Individual Studies

Author	Year	Study Design	Materials & Methods	Results	Method. Quality
				CONTINUOUS PASSIVE MOTION (CPM)	
Bailey et al.[43]	2003	Review	Review of basic science and clinical literature; development of a postoperative rehabilitation protocol for patients undergoing ACI.	PF Lesions: CPM 0°-30° for 4-12 h/day TF Lesions: CPM 0°-40° for 4-12 h/day; progress ROM in CPM beginning week 2 as symptoms allow.	n/a
Fazalare et al.[41]	2010	Systematic Review	Systematic review of 4 level III clinical studies evaluating the evidence for using CPM postoperatively after treating articular cartilage injuries of the knee.	There is a lack of clinical evidence to support the use of CPM following cartilage surgery.	12/20‡
Gillogly et al.[44]	2006	Review	Review of ACI surgical technique, treatment of concomitant pathology, and rehabilitation. Development of a protocol following ACI.	Begin CPM use on day 1 for 8-12 h/day (0°-60°; if patellofemoral lesions >6cm^2, 0°-40°). Progress CPM ROM as tolerated 5°-10° per day. Continue CPM use for 6-8 h/day for up to 6 weeks.	n/a

Table 1.3 (continued)

Hirschmuller et al.[32]	2011	Review	A review of evidence for rehabilitation following ACI and development of a rehabilitation protocol following articular cartilage repair.	PF Lesions: CPM for 6-8 h/day starting from 0°-40° on day 1 and extended to 60° in week 3 and 90° in week 5. TF Lesions: CPM for 6-8 h/day starting from 0°-40° on day 1 and progressing to 60° as tolerated over the following days; CPM is increased to 90° in week 5. Discharge use of CPM following 6 weeks.	n/a
Howard et al.[42]	2010	Systematic Review	Systematic review of mostly level III studies investigating the use of CPM in basic science and clinical studies.	There is evidence in the basic science literature to support the use of CPM following articular cartilage repair surgery; however, there is a lack of clinical evidence demonstrating the evidence behind CPM use following articular cartilage injury.	17/20‡
Nho et al.[46]	2010	Review	Review of the biology of cartilage healing and develop defect specific rehabilitation protocols for use in the athletic population.	PF Lesions: CPM use for 6-8 h/day in 2 hour increments at 1 cycle/min; begin 0°-30° and increase flexion by 5°-10° daily after week 3. TF Lesions: CPM use for 6-8 h/day in 2 hour increments at 1 cycle/min; begin 0°-30°, increasing 5°-10° daily as tolerated.	n/a
				WEIGHT-BEARING	
Bailey et al.[43]	2003	Review	Review of basic science and clinical literature; development of a postoperative rehabilitation protocol for patients undergoing ACI.	PF Lesions: Begin WBAT immediately TF Lesions: TTWB with progression to 1/4 body weight by week 6; progression to 1/2 body weight at week 6 with a gradually progression to FWB at week 8	n/a

Table 1.3 (continued)

Ebert et al.[38]	2008	RCT	Accelerated versus traditional load bearing approaches to rehabilitation following MACI. Follow-up of 3 months. (n=62)	Traditional group: TTWB for 5 weeks followed by a progressive increase to full WB by 11 weeks. Accelerated group: progressively increased WB immediately with full WB achieved at 8 weeks. The accelerated group reported less knee pain, improved function, and no complications at 3 months.	5/10†
Ebert et al.[39]	2010	RCT	Evaluation of knee biomechanics between patients who underwent an accelerated versus traditional weight bearing program following MACI. All patients compared to matched controls as well. Follow-up of 3, 6, and 12 months postoperatively. (n=61)	Traditional group: patients reached FWB at 11 weeks. Accelerated group: reached FWB at 8 weeks postoperatively. A higher level of gait dysfunction was observed in patients who followed the delayed WB rehabilitation program, with significantly reduced knee extension moments and knee adduction moments.	7/10†
Ebert et al.[40]	2012	RCT	Evaluation of patient-reported outcome measures and MRI outcomes in patients undergoing accelerated versus traditional load bearing approaches to rehabilitation following MACI. Follow-up of 3, 6, 12, 24 months and 5 years postoperatively. (n=70)	Traditional group: patients reached FWB at 11 weeks. Accelerated group: reached FWB at 8 weeks postoperatively. There were no significant differences in MRI-based outcomes or patient-reported outcomes at 5 years between groups. Accelerated WB is a safe regimen for patients undergoing MACI.	7/10†

Table 1.3 (continued)

Gillogly et al.[44]	2006	Review	Review of ACI surgical technique, treatment of concomitant pathology, and rehabilitation. Development of a protocol following ACI.	PF Lesions: Immediate TTWB of 25% body weight with brace locked in extension. Progress to 50% WB at week 2 and 75% WB at weeks 3-4. Progress to FWB at weeks 6-8. TF Lesions: NWB for 1-2 weeks, may begin TTWB immediately if lesion <2.0 cm^2; Begin TTWB at weeks 2-3 weeks with a progression to PWB (25% BW) at weeks 4-5. 50% BW at week 6 with progression to FWB at week 8-9.	n/a
Hirschmuller et al.[32]	2011	Review	A review of evidence for rehabilitation following ACI and development of a rehabilitation protocol following articular cartilage repair.	PF Lesions: FWB as tolerated in full extension of the knee TF Lesions: PWB (20-25% BW) allowed immediately for 6 weeks; beginning at week 7, a step-wise increase to FWB by week 8.	n/a
Nho et al.[46]	2010	Review	Review of the biology of cartilage healing and develop defect specific rehabilitation protocols for use in the athletic population.	PF Lesions: NWB for 2-4 weeks, PWB (30-40 lbs), continue with PWB, progressing to one crutch between 4-8 weeks with a progression to FWB between 8-12 weeks. TF Lesions: NWB for 2- weeks, PWB (30-40 lbs) during weeks 2-4, progression to use of one crutch from 4-6 weeks, and progression to FWB from 6-12 weeks.	n/a
Wondrasch et al.[34]	2009	RCT	Accelerated versus delayed weight bearing approaches to rehabilitation following MACI. Follow-up at 4, 12, 24, 52, and 104 weeks postoperatively. (n=31)	There were no differences in radiological or clinical outcome between groups, suggesting that a rehabilitation program that utilizes accelerated load bearing leads to good clinical outcomes without harming the graft following MACI.	6/10†

Table 1.3 (continued)

				BRACING	
Ebert et al.[40]	2012	RCT	Evaluation of patient-reported outcome measures and MRI outcomes in patients undergoing accelerated versus traditional load bearing approaches to rehabilitation following MACI. Follow-up of 3, 6, 12, 24 months and 5 years postoperatively. (n=70)	0°-30° for the first 2 weeks, with an increase to 45° at week 3. Gradual increase in knee flexion in brace with a goal of full knee flexion by week 6. Continue with knee brace in full flexion until 12 weeks. Authors do not specify brace use based on defect location.	7/10†
Gillogly et al.[44]	2006	Review	Review of ACI surgical technique, treatment of concomitant pathology, and rehabilitation. Development of a protocol following ACI.	Locked at 0° during WB activities; sleep in locked brace for 2-4 weeks. Discontinue brace at week 6 with consideration of unloading brace for femoral lesions	n/a
Mithoefer et al. [45]	2012	Review	A review of evidence for rehabilitation in athletes following ACI. Authors developed and implemented a criteria-based rehabilitation protocol specific to athletic populations.	PF Lesions: a brace locked in extension for 4-6 weeks is encouraged.	n/a

Table 1.3 (continued)

Nho et al.[46]	2010	Review	Review of the biology of cartilage healing and develop defect specific rehabilitation protocols for use in the athletic population.	PF Lesions: brace locked in extension for 4 weeks; open brace 20°-30° with ambulation starting at week 4 with a goal of discontinuing use of brace at week 6. TF Lesions: Locked in full extension for 2 weeks; gradual opening of the brace 20° at a time after 2 weeks until appropriate quadriceps control is achieved. Discontinue use of brace when no extensor lag with SLR.	n/a
				ROM PROGRESSION	
Baily et al.[43]	2003	Review	Review of basic science and clinical literature; development of a postoperative rehabilitation protocol for patients undergoing ACI.	PF Lesions: Limit active and passive ROM 0°-30° until week 6; beginning week 6, no limit to passive ROM, caution with active ROM 50°-30° TF Lesions: progress ROM as tolerated	n/a
Ebert et al.[40]	2012	RCT	Evaluation of patient-reported outcome measures and MRI outcomes in patients undergoing accelerated versus traditional load bearing approaches to rehabilitation following MACI. Follow-up of 3, 6, 12, 24 months and 5 years postoperatively. (n=70)	Passive and active ROM from 0°-30° for two weeks with an increase in active knee ROM to 90° by week 3 and 125° by week 6. Authors do not specify ROM limitations based on defect location.	n/a
Gillogly et al.[44]	2006	Review	Review of ACI surgical technique, treatment of concomitant pathology, and rehabilitation. Development of a protocol following ACI.	PF Lesions: knee flexion ROM goal is 90° by weeks 2-3, 105° by weeks 3-4, and 120° by week 6. TF Lesions: knee flexion ROM goal is 90° by weeks 1-2, 105° by week 3, 115° by week 4, and 120°-125° by week 6.	n/a

Table 1.3 (continued)

Hirschmuller et al.[32]	2011	Review	A review of evidence for rehabilitation following ACI and development of a rehabilitation protocol following articular cartilage repair.	PF Lesions: restricted to 0°-30° for 6 weeks; gradual progression to full ROM after 6 weeks. TF Lesions: restricted to 0°-90° for 6 weeks with a gradual progression to full ROM after 6 weeks.	n/a
				STRENGTH PROGRESSION	
Bailey et al.[43]	2003	RCT	Review of basic science and clinical literature; development of a postoperative rehabilitation protocol for patients undergoing ACI.	PF Lesions: isometric exercises and OKC exercises 0°-30°, no resistance for 3 weeks. OKC between 0°-30° and 90°-50° along with progression of resistance at week 6. TF Lesions: isometric exercises and OKC exercises 60°-75°; no resistance for 3 weeks. CKC and dynamic strength training as WB allows.	n/a
Ebert et al.[40]	2012	RCT	Evaluation of patient-reported outcome measures and MRI outcomes in patients undergoing accelerated versus traditional load bearing approaches to rehabilitation following MACI. Follow-up of 3, 6, 12, 24 months and 5 years postoperatively. (n=70)	Isometric activities for 6 weeks. Resistance and CKC activities begin and progress between weeks 7-12. During months 3-6, authors recommend introduction of more demanding OKC and CKC activities. Authors do not report strength progressions relative to defect location.	7/10†

Table 1.3 (continued)

Gillogly et al.[44]	2006	Review	Review of ACI surgical technique, treatment of concomitant pathology, and rehabilitation. Development of a protocol following ACI.	PF Lesions: no active knee extension exercises for 6 weeks; progress WB exercises at 6 weeks (e.g. mini squats); NWB knee extension from 90°-40° at 3 months. TF Lesions: Active knee extension without resistance between 90°-40°; progress WB exercises at 6 weeks	n/a
Nho et al.[46]	2010	Review	Review of the biology of cartilage healing and develop defect specific rehabilitation protocols for use in the athletic population.	PF Lesions: isometric exercises for 4 weeks; begin and progress isometric CKC exercises between 4-10 weeks. Begin light open chain isometrics between 10-12 weeks. TF Lesions: isometric exercises for 2 weeks followed by progressive CKC from 2-6 weeks. Begin OKC exercises between 6-10 weeks.	n/a
				RETURN TO SPORT/ACTIVITY	
Bailey et al.[43]	2003	Review	Review of basic science and clinical literature; development of a postoperative rehabilitation protocol for patients undergoing ACI.	All lesions: Light jogging, swimming, and cycling at 6 months; Running may begin at 8 months; Sport-specific agility training at 9 months with earliest return to contact sport at 12 months.	n/a

Table 1.3 (continued)

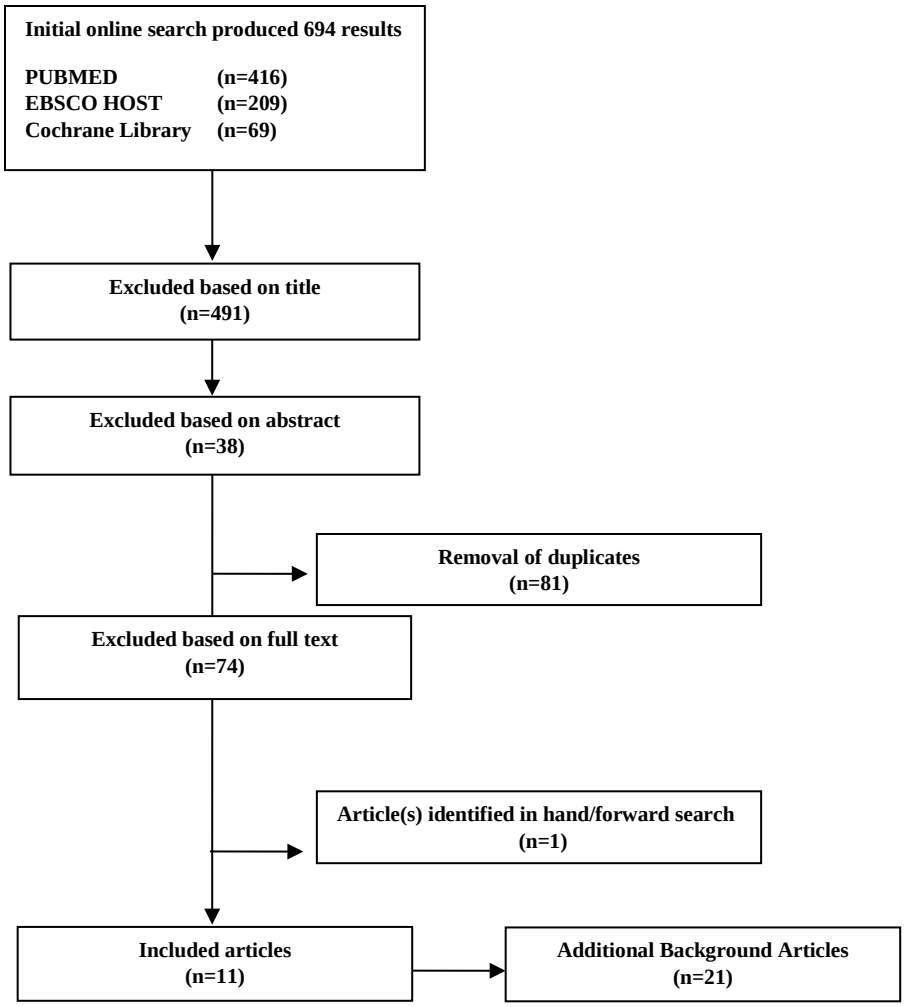
Ebert et al.[40]	2012	RCT	Evaluation of patient-reported outcome measures and MRI outcomes in patients undergoing accelerated versus traditional load bearing approaches to rehabilitation following MACI. Follow-up of 3, 6, 12, 24 months and 5 years postoperatively. (n=70)	Controlled trampoline jogging may begin between 6-9 months with introduction of agility drills between 9-12 months. Return to competitive activity after 12 months.	7/10†
Gillogly et al.[44]	2006	Review	Review of ACI surgical technique, treatment of concomitant pathology, and rehabilitation. Development of a protocol following ACI.	Low-impact activities (swimming, skating, cycling) are permitted around 6 months; higher-impact activities (running) permitted between 8-9 months for small lesions and 9-12 months for larger lesions; high-impact activities (basketball, tennis) permitted at 12-18 months	n/a
Nho et al.[46]	2010	Review	Review of the biology of cartilage healing and develop defect specific rehabilitation protocols for use in the athletic population.	May begin jogging program between 6-9 months; athletes may begin a progressive running and agility program between 9-18 months. High-impact activities (basketball, tennis) may begin at 16 months if pain-free.	n/a

Abbreviations: PF: patellofemoral; TF: tibiofemoral; ACI: autologous chondrocyte implantation; CPM: continuous passive motion; ROM: range of motion; WBAT: weight-bearing as tolerated; TTWB: toe-touch weight-bearing; MACI: matrix-induced autologous chondrocyte implantation; FWB: full weight bearing; PWB: partial weight bearing; NWB; non-weight bearing; OKC: open kinetic chain; CKC: closed kinetic chain

†PEDro Scale

‡PRISMA Checklist

Figure 1.1 Flow Chart



CHAPTER 2: THE ROLE OF REHABILITATION FOLLOWING AUTOLOGOUS CHONDROCYTE IMPLANTATION: A RETROSPECTIVE CHART REVIEW

INTRODUCTION

Articular cartilage lesions of the knee are common and have been suggested to increase the risk of osteoarthritis.[1,10,11] Chondral defects can result in significant pain, functional impairment, and a reduction in quality of life. Hyaline cartilage is avascular and has a limited potential to self-repair and regenerate when damaged.[2] Over the years, a variety of restorative and regenerative procedures have been developed to treat chondral lesions of the knee. Autologous chondrocyte implantation (ACI) is a regenerative technique that was first described in the literature by Brittberg et al. and is indicated to produce repair tissue similar in structure to hyaline cartilage through the use of harvested chondrocytes.[20] There are several variations of the current ACI procedure, including characterized chondrocyte implantation (CCI) and matrix-assisted chondrocyte implantation (MACI).

The short and mid-term clinical results of ACI have demonstrated high rates of patient satisfaction, improved function, and decreased pain.[73-75] Multiple factors have been suggested to contribute to the overall efficacy of the procedure. It has been suggested that patients presenting with clinical symptoms of less than two years[18,76,77] and patients with more active lifestyles[16,78] demonstrate greater clinical success following surgery. Furthermore, patients with single defects and those with less than three previous surgeries on the index knee have demonstrated superior clinical results.[76,79,80] Prognostic indicators are conflicting relative to defect location and patient age. Recent studies have

found inferior clinical results in patients with medial femoral condyle and patellar lesions compared to patients with lesions of the trochlea and lateral femoral condyle[20,22,23,76] while other studies have demonstrated superior clinical results for patients with patellar lesions.[81] Several studies have reported superior clinical results in patients less than 30 years of age[16,73,77,82] while Krishnan et al. reported superior clinical results in patients less than 41 years of age.[76] In contrast, Niemeyer et al. did not find any clinical differences in patients greater than 40 years of age when matched with a younger cohort.[83] As a result of these conflicting results, it is difficult for surgeons to predict clinical success of ACI based solely on patient demographics.

While patient demographics and clinical history have the ability to contribute positively or negatively to clinical outcome, these factors alone fail to identify other important considerations affecting patient success. Recent reviews have emphasized the importance of post-operative rehabilitation in achieving successful return to function following ACI.[6,22,30,31] However, current guidelines and evidence for ACI rehabilitation are unclear, and mostly based on a combination of expert opinion and the basic science literature.[4,33,34] Although post-operative rehabilitation plays a valuable role in patient success, it is currently unknown what specific characteristics of post-operative rehabilitation have the greatest influence on clinical improvement. Therefore, the purpose of this study was to assess the consistency of the documentation process relative to post-operative rehabilitation in order to provide information and guide initiatives for improving the quality of rehabilitation practices following ACI. To our knowledge, this is the first study to evaluate the documentation process relative to rehabilitation practices in an effort to further understand the role that rehabilitation plays following ACI.

METHODS

The medical records of 20 patients who were treated for chondral defect(s) of the knee and subsequently underwent the ACI procedure from 2008-2012 were retrospectively reviewed. Patients previously enrolled in an established Cartilage and Ligament Patient Registry that tracks patient-reported outcomes pre-operatively and post-operatively were eligible to participate in the study and were contacted for participation in the study. The study was approved by the Institutional Review Board at the University of Kentucky and informed consent was obtained prior to data collection. All patients were evaluated and treated by the same orthopedic surgeon. A systematic review of medical, surgical, and physical therapy records was performed. Since a standardized abstraction form is not available for this patient population, data were collected using an abstraction form that was created by the primary author (JLT) for the purpose of this study. This abstraction form was validated through the use of a pilot study prior to data collection in which two independent investigators reviewed the medical charts of three patients and levels of agreement were deemed excellent between reviewers (r=0.80).

In order to assess clinical improvement, scores from the following patient-reported outcome (PRO) instruments were extracted from patient records: Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the International Knee Documentation Committee Subjective Knee Form (IKDC), the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36), and the Lysholm Knee Scale. For the purposes of this study, the total WOMAC score was used. All PRO's used in the current study have been established in the literature as reliable and valid measures of patient reported knee symptoms, overall function, and health-related quality of life (HRQOL) in

articular cartilage patients.[84-88] PRO measures recorded pre-operatively, 3, 6, and 12 months postoperatively were extracted from individual charts.

The following demographic variables were extracted from patient medical records: age, gender, onset of symptoms, size, number, and location of the lesion, body mass index (BMI), smoking status, limb, duration of symptoms, concomitant procedures, number of previous surgeries, and level of activity prior to surgery. In addition, physical therapy notes were requested for all participants and the following physical therapy variables were extracted: number of treatment sessions, duration of post-operative rehabilitation, time to full weight-bearing (FWB), parameters of continuous passive motion (CPM) use, and compliance with home exercise programs. All patients undergoing ACI followed the same physician-prescribed rehabilitation protocol, which highlights restrictions in ROM, weight-bearing, and activities.[89]

Statistical Analysis

All data were entered into an electronic database (Microsoft Excel, Microsoft Corporation, Redmond, WA). Descriptive statistics were calculated for all variables, including means and standard deviations where appropriate. A paired-samples t-test was used to evaluate changes in PRO scores from baseline to 3, 6, and 12 months post-operatively.

RESULTS

A total of 20 medical charts were reviewed and pre-determined variables were extracted for analysis. Patients had a mean age of 35.9 ± 6.8 years at the time of surgical intervention (range, 20-45). Nine (45%) patients were male while 11 (55%) were female. A complete list of patient characteristics can be found in Table 2.1. The average

WOMAC, IKDC, Lysholm, SF-36 PCS, and SF-36 MCS scores all improved from baseline to each time-point post-operatively (Table 2.2). However, the greatest improvements in pain and function occurred at 6 and 12 months post-operatively. Patients were treated at eight different rehabilitation facilities throughout the Commonwealth of Kentucky and were treated, on average, for 22.9 ± 13.6 visits (range, 5-51). On average, patients attended post-operative rehabilitation for 15.6 ± 7.4 weeks following surgery (range, 4-28 weeks). Continuous passive motion (CPM) use was documented in 12 charts (60%); however, only 5 (41.7%) of the charts that documented CPM use documented the parameters of patient use (hours/day, range of motion). Weight-bearing (WB) progression was documented in 17 (85%) charts; however, only 8 (47.1%) of the charts that documented WB progression reported time to FWB. A complete list of rehabilitation characteristics can be found in Table 2.3.

DISCUSSION

It was the objective of this retrospective chart review to assess the consistency of the documentation process relative to post-operative rehabilitation in an effort to provide a complete picture of the recovery process following ACI. This study demonstrated that clinical measures for ROM and strength were most consistently documented within charts but weight-bearing status, parameters of CPM use and compliance with prescribed home exercise programs were rarely and inconsistently documented. Patient-reported outcome measures, surgical information, and patient demographics, however, were more consistently documented across all charts. This is likely a result of multiple parties responsible for capturing and recording this data. As part of a larger on-going study, PRO measures are currently being documented over time in this patient population,

providing explanation for the consistent documentation of these measures in this particular study.

Rehabilitation plays an important role in clinical improvements following ACI; however, the ability to document components within a rehabilitation program that contribute to these improvements is challenging. Hambly et al. has previously suggested that the three most important components of a rehabilitation program following ACI are 1) progressive weight-bearing, 2) restoration of range of motion (ROM), and 3) improvement of neuromuscular control and strength.[6] From our review, it is difficult to determine if variations in these components influence clinical outcome. Time to full-weight-bearing (FWB) was only documented in 47% of reviewed rehabilitation records. Furthermore, while ROM progressions were documented in 100% of records, the parameters of CPM use (ROM, frequency, duration) were only documented in 25% of records. Finally, strength measurement was documented in a majority of patient records (85%) but the methods/exercises utilized to achieve strength gains varied greatly between records.

A unique and challenging rehabilitation component following ACI is the requirement of delayed weight-bearing. This restriction in weight-bearing is dependent on the size and location of the lesion. The standard recommendation is that return to FWB is delayed in patients with femoral condyle lesions, while patients with patellar/trochlear lesions are encouraged to progressively increase weight-bearing as tolerated while braced in full extension.[4,6,43,46] Gradual progressions in weight-bearing and joint loading following articular cartilage repair must be implemented in order to

optimize the benefits of gradual loading without causing damage to the repair site by overloading the joint with compressive and shear forces.

Gradual progressions in active and passive movements following ACI are necessary for enhancing the flow of synovial fluid throughout the joint.[53] ROM is also indicated for decreasing pain, improving circulation, and preventing tissue adhesions following surgery.[6] Immediate restoration of knee extension is encouraged following surgery in order to prevent tissue adhesion and arthrofibrosis.[6] Increases in knee flexion ROM, however, are more conservative and are based on lesion size and location.[25,33,42] The use of CPM has been advocated for restoring passive knee flexion ROM following ACI. Additional benefits of CPM use include decreased pain and inflammation as well as enhanced metabolic activity of cartilage, necessary for regeneration.[6,42,90] Although there is limited clinical evidence for the use of CPM following articular cartilage repair, the basic science literature has demonstrated enhanced cartilage healing following use of CPM.[49-52] It is generally recommended that patients use a CPM immediately following surgery for 6-8 weeks for 4-12 hours/daily.[44,46] However, there was limited data from medical records to suggest that these guidelines were met.

Restoration of strength and neuromuscular control is an important rehabilitation goal as decreased strength has been shown to be associated with decreased function as well as an increased likelihood for the progression for osteoarthritis.[62,63,91] The majority (85%) of reviewed records in this study documented strength measurements, most often in the form of manual muscle testing. Manual muscle testing is commonly used clinically to assess strength gains; however, the subjective nature of manual muscle testing may not accurately reflect improvements in muscle strength. There are different

methods of manual muscle testing which may be limited by the healing constraints of the surgery. As such, it may be necessary to vary the methods utilized for evaluating strength throughout the rehabilitation process. For example, muscle activation is typically assessed using a straight-leg raise test in the early phases following surgery. In later stages of the rehabilitation process, other objective assessment tools, such as manual muscle testing, hand-held dynamometers or leg press are used to objectively assess strength.

It has previously been established that greater compliance with rehabilitation leads to improved patient outcomes following injury.[92,93] This study evaluated the prescription and compliance of home exercises as well as the number of missed/canceled sessions documented. While a majority (87%) of reviewed records documented prescription of a home exercise program, only two charts documented patient compliance with at-home exercises. Postoperative treatment commonly involves both clinic and home-based exercises. Due to insurance restrictions, the clinic-based component of rehabilitation typically involves 2-3 visits per week. In order to optimize outcomes, at-home rehabilitation is essential for improving strength, ROM, and function. It has been suggested that compliance with home exercise programs may improve rehabilitation outcomes[94] Patient compliance is difficult to assess, given its subjective nature. However, Likert scales have previously been utilized to assess compliance with rehabilitation programs and we recommend inclusion of these scales in reporting as a means of tracking patient compliance.[94] Attendance has frequently been used as a measure of adherence in rehabilitation research.[95,96] In the current study, five charts reported missed and/or canceled therapy sessions (range, 0-12). However, given the lack

of documentation relative to rehabilitation attendance and compliance with rehabilitation, we were unable to examine the influence of these factors on post-operative outcome.

Limitations

There are several limitations with this study. First, a small sample of charts (n=20) were reviewed for data. This limits the ability to establish relationships between specific demographic information, rehabilitation parameters and clinical outcome. Furthermore, as is the case with all retrospective chart reviews, the data presented are limited by inadequate documentation and therefore may not provide an optimal source of information to determine factors that influence clinical improvements following ACI. Inadequate reporting may be a misrepresentation of the rehabilitation process. Despite the limitation of retrospective study designs, our study provides some valuable information. It has led us to create a more specific rehabilitation protocol as well as a data collection sheet to verify that typical missing data is being documented to ensure consistent outcomes.

Clinical Implications and Future Research

The factors that have been suggested to be most important from a rehabilitation perspective include "progressive weight-bearing, restoration of ROM, and improvement of muscular control and strength".[6] In addition to capturing PRO's, it is likely that surgeons may want the capability of collecting and tracking these rehabilitation factors. Based on our knowledge, clinical experience, and results of this chart review, the following components should be documented: CPM use (including parameters of use) and compliance, WB progression (including time to FWB and compliance with WB restrictions), and neuromuscular activation and strengthening progressions. Furthermore,

consistent documentation of patient compliance with rehabilitation will provide valuable information on the role of compliance on patient recovery. Appendix C provides a list of outcomes that, when collected consistently, will provide valuable information regarding patient progress.

As expected, variability in documentation procedures exists between facilities and clinicians. As a result of this variability in patient reporting, future research is needed to establish the direct influence of rehabilitation on clinical outcome following ACI. This is only possible by the consistent and systematic collection of rehabilitation data. While this may occur initially on the small scale among discrete medical facilities or researchers, the collection of similar rehabilitation outcomes among multiple clinicians must occur to allow for comparisons to be made in the future.

CONCLUSION

Rehabilitation plays a valuable role in patient success following articular cartilage repair. This study aimed to assess the consistency of the documentation process relative to post-operative rehabilitation following ACI; however, due to variance in this documentation process, we were unable to determine what specific components of rehabilitation influence the recovery process. In order to further understand how rehabilitation practices influence outcomes following ACI, specific components of the rehabilitation process must be consistently and systematically documented over time. We have provided recommendations for researchers and clinicians for providing this information in a systematic way.

Table 2.1 Patient Characteristics

Characteristic	
Age at Time of Surgery, years (Mean, St. Dev)	35.9 (6.8)
Gender (No. and %)	
Male	9 (45%)
Female	11 (55%)
BMI (Mean, St. Dev)	28.9 (5.8)
Smoking Status (No. and %)*	
Non-Smoker	14 (73.6%)
Past Smoker	1 (5.3%)
Smoker	4 (21.1%)
Onset of Symptoms (No. and %)†	
Sudden	7 (35%)
Gradual	12 (60%)
Duration of Symptoms (No. and %)	
<6 months	2 (10%)
6-12 months	2 (10%)
12-24 months	3 (15%)
>24 months	12 (60%)
Concomitant Procedure (No. and %)	
No	10 (50%)
Yes	10 (50%)
Single or Multiple Defects (No. and %)	
Single	9 (45%)
Multiple	11 (55%)
Defect Location (No. and %)	
Medial Femoral Condyle	7 (21.2%)
Lateral Femoral Condyle	6 (18.2%)
Trochlea	11 (33.3%)
Patella	9 (27.3%)
Number of Defect(s) (Mean, St. Dev)	1.7 (0.7)
Defect Size (cm^2)(Mean, St. Dev) ‡	4.8 (2.6)
Number of Previous Surgeries (Mean, St. Dev)	1.2 (1.3)
Level of Activity Prior to Surgery (No. and %)	
Competitive	1 (5%)
Recreational	8 (40%)
No Sport	6 (30%)
Unknown	5 (25%)

Abbreviation: BMI: body mass index; *one chart did not report status; †one chart did not report onset; ‡one chart did not report defect size

Table 2.2 Clinical Outcome Measures over Time

Outcome Measure	Baseline	3 Months	6 Months	12 Months
WOMAC Total	29.2 ± 10.3 (n=20)	23.33 ± 14.5 (n=18)	19.1 ± 12.7* (n=19)	8.9 ± 8.4***** (n=15)
IKDC	40.5 ± 10.1 (n=20)	44.4 ± 17.8 (n=19)	52.9 ± 15.9***** (n=19)	64.1 ± 13.0***** (n=15)
SF-36 Physical Function Score	39.4 ± 9.2 (n=20)	37.9 ± 11.0 (n=19)	44.7 ± 8.9 (n=19)	49.4 ± 5.2***** (n=14)
SF-36 Mental Function Score	54.7 ± 12.4 (n=20)	56.5 ± 11.4 (n=20)	56.6 ± 7.3 (n=19)	57.6 ± 5.0 (n=14)
Lysholm	49.0 ±13.3 (n=20)	60.2 ± 16.9 (n=19)	66.4 ± 19.7***** (n=19)	76.7 ± 10.0***** (n=15)

*indicates significant improvement from baseline ($p<0.05$)

Abbreviations: WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; IKDC: International Knee Documentation Committee; SF-36: Short-Form 36

Table 2.3 Rehabilitation Characteristics

Characteristic	
Number of treatment sessions (Mean, St.Dev.)	22.9 (13.6)
Length of time in rehabilitation, weeks (Mean, St.Dev.)	15.6 (7.4)
CPM use documented (No. and %)	
Yes	12 (75%)
No	4 (25%)
Weight-bearing progression documented (No. and %)	
Yes	13 (81.2%)
No	3 (18.8%)
Strength assessment documented (No. and %)	
Yes	14 (86.5%)
No	2 (12.5%)
ROM measurements documented (No. and %)	
Yes	16 (100%)
No	0 (0%)
HEP prescribed and documented (No. and %)	
Yes	14 (86.5%)
No	2 (12.5%)

Abbreviations: CPM: continuous passive motion; ROM: Range of Motion; HEP: Home Exercise Program

CHAPTER 3: PATIENT'S EXPERIENCES OF RECOVERY FOLLOWING AUTOLOGOUS CHONDROCYTE IMPLANTATION: A QUALITATIVE STUDY

INTRODUCTION

Articular cartilage injuries of the knee are common and, when left untreated, may progress to significant deteriorations in function and quality of life as well as the potential for the development and progression of osteoarthritis. Due to its avascular nature, injuries to articular cartilage have a limited potential for healing[2] and surgical intervention is often recommended. The type of surgical technique is dependent on a variety of factors, including patient age, lesion depth, concomitant pathology, and patient goals and expectations.[2] Autologous chondrocyte implantation (ACI) was introduced in the early 1980's by Brittberg and has been recognized as a viable treatment option for full-thickness chondral injuries.[97] The short-term clinical results of ACI are reported to be good or excellent in 71% to 90% of cases[98,99] and rates of patient satisfaction with improved function and pain levels range from 72% to 100%.[24,25] The long-term durability of ACI was demonstrated by Peterson et al, who reported good or excellent results in 84% of patients with an average follow-up of 11 years.[99] However, despite improvements in self-reported symptoms, patients undergoing ACI continue to demonstrate functional deficits and weakness in the affected limb post-operatively.[27,100,101] These findings suggest the importance of post-operative rehabilitation following ACI.

Rehabilitation plays an important role in clinical improvements following ACI and is necessary for ensuring protection of the repair and returning patients to full function. It has been suggested that the three most important components of a

rehabilitation program following ACI are progressive weight-bearing, restoration of range of motion (ROM), and improvement of neuromuscular control and strength.[6] Rehabilitation can be significantly more challenging following ACI due to the extended period of weight-bearing restrictions and the lengthy recovery process. This lengthy recovery process is due in part to graft remodeling and maturation, a process that can take upwards of three years.[102] A recent study investigated patients' expectations and knowledge regarding ACI.[103] Patients were asked to provide the relative importance of different factors on clinical outcome. Factors included defect characteristics, personal risk factors, the quality of the surgery, previous surgeries and treatment, and post-operative rehabilitation. Only 7.6% of patients considered post-operative rehabilitation an important factor for influencing clinical outcome. This demonstrates that patients underestimate the importance of rehabilitation.[103] At the current time, the evidence base for ACI rehabilitation is lacking.[4,33,34] In particular, the perspective of the patient relative to factors that contribute to successful outcomes following ACI has not been established. Therefore, it is necessary to identify factors during the rehabilitation process from the patient's perspective that may influence outcome and quality-of-life.

Although patient-reported outcomes provide clinicians valuable information relative to the efficacy of the technique, the patients' experiences, expectations, and attitudes provide a deeper understanding of factors that may contribute to successful rehabilitation following ACI. The use of qualitative methods for investigating patients' experiences in post-operative rehabilitation can benefit both patients and clinicians alike by providing a more meaningful understanding of rehabilitation practices and their influence on patient success. Furthermore, understanding patients' experiences may lead

to more effective care and improved outcomes. To date, we are not aware of any publications that address patients' knowledge and experiences of the rehabilitation process following ACI. Therefore, the aim of the present study was to explore and describe patients' experiences during the recovery process following ACI.

RESEARCH METHODS

The qualitative methodology, phenomenology, was used because it offers an approach by which to identify a phenomenon (ACI recovery) and how it is perceived by participants. This type of methodology allows for gathering of 'rich' information through inductive, qualitative methods such as interviews and participant observation. Phenomenology is concerned with the perspective of the individual experiencing the phenomena of interest and provides insight into participant's motivations and actions.[104]

Participants

The study was approved by the University of Kentucky Institutional Review Board. Participants were strategically chosen from an existing database of patients who had previously undergone ACI performed by the same surgeon. Purposeful sampling was done to ensure that participants represented both sexes, patients of varying ages, and patients from both urban and rural residences. To meet eligibility criteria for the study, participants had to have undergone the ACI procedure within the previous 12 months in order to minimize recall bias, be between the ages of 16-65, and be fluent in the English language in order to participate in the interview process. Information was provided both verbally and written, and participation was voluntary. Informed consent was obtained prior to the initial interview. Patients were assured of confidentiality and pseudonyms were used to protect anonymity.

A total of seven patients agreed to participate in the study. The participants included two males and five females having undergone the ACI procedure who been involved in post-operative rehabilitation within the previous 12 months. Their age range was 25-46, with a mean age of 40.7 years. The mean time from surgery to the interview session was 8.7 months. For more detailed information, refer to Table 3.1.

Data Collection and Analysis

Data collection was performed through semi-structured interviews conducted by the primary author (JLT). The interviewer was a certified athletic trainer (ATC) with 13 years of clinical experience with rehabilitation following knee surgery and was not involved in the participants' rehabilitation. Each interview lasted between 25-50 minutes and took place in a quiet location chosen by the participant. Participants were asked to describe their experiences in rehabilitation following ACI. An interview guide was developed for use during the interviews. This open-ended interview guide was used to maintain consistency during the interview process among all participants. Interviews were conducted until data saturation was reached. Data saturation occurs at the point in which no new information is being heard during the interview process.[105] All interviews were recorded and transcribed verbatim.

To understand the experiences of patients recovering from ACI, a data analysis approach was used that encouraged reflection and interpretation. This analysis is a 6-step methodological approach based on work by Colaizzi.[106] Following transcription of the data, the transcripts were read several times in order to get an overall sense of the participants' perspective. Next, significant statements that were related to the phenomenon of interest were extracted from the transcripts. Once significant statements

were extracted, duplicate statements were removed from the analysis. The process of horizontalization was used to help with the organization of the remaining significant statements. Horizontalization is a process whereby all statements are treated as having equal value or significance.[106] Formulated meanings were then developed from the remaining significant statements. These formulated meanings were organized into clusters of themes, which were used to provide a full description of the participants' experiences. Finally, these themes were distributed to all participants (member-checks) for their feedback as a means of validating these findings.

Rigor

Several methods were used to establish scientific rigor. First, member-checks were used during data analysis to ensure that we were providing an accurate description of the participants' experience. Secondly, all interviews were transcribed verbatim and direct quotes from participants were used to enhance credibility of the study.[107] In addition, a researcher experienced in qualitative research reviewed the interview protocol and was available to review and challenge the emerging interpretations of data. This expert checking further acted to minimize bias in the interpretation of the results. Finally, epoche, or 'phenomenological bracketing', was used to validate findings. In epoche, the interviewer must put aside his or her own experience of the phenomenon in order to focus on the views or experience of the interviewee.

FINDINGS

A total of 150 significant statements were identified from seven transcribed interviews. Seven duplicate statements were removed from the analysis and a total of 18 formulated meanings developed through the process of horizontalization. Table 3.2

provides specific examples of significant statements and their corresponding formulated meanings. Four major themes and six sub-themes emerged from patients' experiences in rehabilitation following ACI. Table 3.3 presents the themes and sub-themes. Each theme is described below, using verbatim quotations from participants for support.

Theme 1: Recovery is an ongoing, emotional process

Many participants described the process from the initial injury to undergoing ACI as an ongoing process, marred by frustration and set-backs. Although recovery is often considered as a process that occurs following surgery, for many participants, recovery encompassed the long process from injury to surgery and the rehabilitation period following surgery. For some participants, this process occurred over several years. Participants expressed initial feelings of frustration and hopelessness, but these emotions transitioned to feelings of optimism for their future.

Feelings of hopelessness that nothing will fix the pain

This sub-theme described participants' emotional experiences from their initial injury to surgery. For many participants, previous surgeries had been unsuccessful in reducing their symptoms and allowing them to return to work, sports or daily activities. Participants' described feelings of hopelessness that they would be forced to live with pain and functional limitations. Betty described her experience of injuring her knee on the job, undergoing an unsuccessful surgery and months of rehabilitation:

> "*At one point in time, I didn't think anybody was going to be able to help me at all. Now I'm 38 and I'm just frustrated that I can barely move around and I can't do the stuff I enjoy like camping and hiking and it's not going to get better. Ever. So I was very upset and very frustrated. All of it has hugely affected my life. I've gained a lot of weight cause I'm not doing the things I used to do, like my job, which was my passion for me. Like a lot of people hate their jobs but my job was awesome. So I don't have that anymore. And that was very hard. I mean, I still have issues.*"

Therapy provides optimism for the future

Participants' emotional states changed throughout the recovery process. In contrast to feelings of frustration and hopelessness, many participants described a transition to feelings of optimism when they began therapy. Katie describes the feelings of optimism that came from attending therapy:

> *"I was just tired and sore and I guess I was also kind of glum because it seemed like recovery was never going to happen at that point. But once I got to therapy, I was fine. I got over it. Like I've always wanted to go to therapy. I think there's only been two days when I didn't care to go. I get excited to go to therapy because I know that I'm gonna make progress."*

Betty describes her transition from feelings of hopelessness to feelings of optimism:

> "*You know, the overall process of getting there was a nightmare but now I'm finally getting there. I'm pretty happy. I feel like if it keeps getting better from here, wow, you know. It's awesome. I'm just now feeling like I'm coming out of that. And starting to feel better about the possibility of having a regular life."*

Although recovery following chondral injury can be a lengthy and frustrating process, undergoing surgery and participating in rehabilitation can help participants feel optimistic about the possibility of being able to return to normal, everyday activities.

Theme 2: Therapy is an investment

For many participants, undergoing this surgical procedure was their last hope before the possibility of undergoing a total knee replacement. Due to their age, many participants wanted to delay or avoid this possibility. However, the recovery process following ACI is long and participants' recognized that they would need extensive rehabilitation for 6-12 months in order to have the greatest likelihood for successful outcomes. By committing to the recovery process, participants' were investing in themselves and their futures. Terry realized that the importance of this commitment:

> *"I just think there's a lot of prep work up front. Hey, you can be successful it's just like anything else in life, you know, through discipline you're going to have success. You're investing in yourself. And you only get, you know one pair of legs. You gotta commit to it and be able to have that."*

Therapy provides accountability

Participants described the importance of attending therapy regularly and being committed to the process, and therapy provided the accountability participants needed to stay focused on the goal of continued progress. However, several of the participants acknowledged that once they were discharged from therapy, they had a difficult time finding the time to maintain and improve on the progress they made during therapy. Amy recognized this importance:

> *"Physical therapy was good because it made you do it. I mean, you were going in two or three times a week. So, you were pretty much doing it."*

Terry also acknowledged the accountability that comes with therapy:

> *"Maybe you didn't need to go in because I could've been doing rehab at home that day. But I get that accountability. You have to have accountability. I think accountability is really important. If you can't do it yourself, you need to have that ability to go in and do it."*

Because the recovery process following ACI is a lengthy process, participants recognized that they needed to be committed to the entire process if they wanted to have the best possible outcomes. Therapy provided the accountability to remain committed to recovery; however, once formalized therapy ended, participants' struggled to find the motivation to continue with the recovery process on their own.

Theme 3: Recovery is a team-effort

This theme described the importance that participants' placed on having a support system while going through the recovery process, whether that support system came from friends

and family or from the therapists themselves. Katie described the importance of her parents support in helping her with therapy:

> *"I've actually been staying with my parents and they have been very supportive since surgery. They both brought me to therapy. They were very supportive, they helped me do my home therapy I couldn't do on my own."*

Participants were also comforted in the initial phases of therapy by having support from their therapist, particularly during times when they were fearful of injuring their knee. Linda describes her first experience with removing her brace and walking without crutches:

> *"You never have to do anything alone. Which is very comforting, so that I guess in my mind once they took me off of my crutches and out of my brace I was worried that what if I fall and I can't get up? And I didn't have to worry about that because they were there with me."*

Everyone involved in the recovery process must be on the same page

While participants viewed recovery as a team-effort, they also emphasized the importance of being on the same page with the surgeon as well as with their therapist. Participants' acknowledged the significance of their therapist communicating with and understanding the expectations of the surgeon. Betty describes a negative experience with a previous surgeon in which she and her surgeon were not on the same page:

> *"And I kept telling the doctor I was having these problems and I had gone to a lot of physical therapy. And he kept saying welcome to my world. Which was very frustrating for me because his world and my world were worlds apart."*

After undergoing ACI, Betty recalls a time when she was progressing at a rate that was faster than she expected, based on what she had been told by the surgeon. She admits that since the progress she was making in therapy didn't match the expectations she had been given, she had concerns that she wasn't doing what she should be doing:

> *"I mean my physical therapy went really, I was expecting it to be horrible. And it really wasn't. And my biggest thing was between what I though he [surgeon] said would be the steps or how quickly you can do things and how quickly I was doing them in physical therapy didn't seem to mesh with me. And I was like very concerned at first that we weren't doing what we were supposed to be doing. It didn't make me doubt my therapist. It made me wonder if she knew what everyone else was saying. So like I'd ask her questions, and luckily she was like not one of those people that gets angry when you ask them questions. She didn't do that. I mean a couple of times, she was like I swear I know what I'm doing."*

Participants do not go through recovery alone and acknowledge that having adequate support throughout the recovery process is essential to having a positive experience. It is essential that all members of the recovery team are on the same page so that expectations can be managed and support provided.

Theme 4: Expectations for recovery may not match reality

Participants spoke at length about their expectations for recovery. For many participants, the recovery process was much longer and more difficult than they had anticipated. Even after being discharged from therapy, recovery from ACI continues for months and even years. Participants acknowledged that most of their expectations regarding the recovery process came after talking with the surgeon. They recognized that the recovery process would be long, especially in the initial six to eight weeks following surgery when their weight-bearing was restricted. Jim describes how his expectations for this initial recovery period did not coincide with the reality:

> "*I think I was told I was gonna be laid up some. But I didn't know it was going to be to that extent."*

Terry was prepared for a lengthy recovery; however, he acknowledged that he didn't fully appreciate the amount of time it would take to be able to return to certain activities.

And although his expectations for recovery at 12 months did not match the reality of his situation, he acknowledged that more time was necessary for full recovery:

> "*Even though I was prepared for longer, I don't know if I fully understood that. I have to remind myself every once in a while, hey, we're only so many months out. But I don't know yet cause I'm still, you know, I was thinking I'd be further than I am now. But I guess realistically I'm looking at 18 months to 20 months to say all right this is 95% where it's going to be*".

Dependence on others is a source of frustration

When considering expectations for recovery, many participants described their lack of independence during the initial recovery period as unexpected. Jim describes his frustration with being laid up:

> "*I mean, actually you're like an infant. I mean I couldn't do anything and me I'm the type of person where I need to get up and go but to just be like that there. I mean to be beat up, can't move. It's just I hate being lame. I hate being where I can't do nothing for myself. I can't get up and go. And I was wanting to rush it.*"

Sara described pushing herself in therapy early-on so she was able to be independent again:

> *"My main thing was motion and strength so I could get up and walk and be able to not be completely dependent on people."*

There are other priorities in life besides recovery

This second sub-theme emerged as participants described the recovery process, which at times, became secondary to other priorities in life, such as family and work. As a result of the lengthy recovery process, participants acknowledged that over time, they were unable to make recovery a priority in their life. Terry describes the impact that his recovery had on his children:

> *"When I've had to say, no Daddy can't do that or I didn't carry my girls around for 12 weeks, which they were used to for the 6 weeks before. That was more the tough part, not for me but for the kids."*

As time passed, participants stated that they found less time to commit to their recovery because they needed to devote more time to work and family. Linda, a schoolteacher, admits that she returned to work too soon following surgery and found it difficult to commit to therapy once returning to work:

> *"I went back to school way too early. I mean, because the start of the school year, you don't want to miss so that was barely three weeks post-op. I should have stayed home at least three or four more weeks. But sometimes you do what you have to do. It's difficult making the time to do it [therapy]. When your life is crazy. Working all day. And then going to therapy and then getting home after 6."*

Participants expressed frustration that their expectations for recovery did not match the reality of the situation. Recovery was longer and more challenging than anticipated, and over time, participants were not able to prioritize their recovery because of other commitments in their life.

DISCUSSION

This study has shown that recovery following ACI is a lengthy process, a process that many participants were unprepared for. Throughout this lengthy recovery process many participants described a feeling of hopelessness prior to surgery; however, these feelings were replaced by optimism for the future throughout the process of rehabilitation. Overall, participants were committed to the recovery process, understanding that rehabilitation was an investment in their future. Having an appropriate support system in place provided participants reassurance that they didn't have to go through recovery alone. Finally, participant's expressed concern that their expectations for recovery did not match the reality of the recovery process. The length of

the recovery process coupled with the lack of independence during the early phases of recovery was described as a surprise and a frustration by many of the participants.

A surprising finding in this study was the feelings of hopelessness that many participants described leading up to surgery. All but one participant reported that they had originally seen a different surgeon for evaluation but had unsuccessful results and were forced to seek another opinion. For several participants, a previous failed cartilage procedure contributed to this feeling of hopelessness. Autologous chondrocyte implantation is often indicated as a secondary treatment option in patients who have failed one or more articular cartilage procedures previously.[6] Patients with an articular cartilage lesion commonly report symptoms such as pain, swelling, giving way/locking, and a subsequent decrease in function. Given the chronicity of the injury, combined with previously failed treatments, it is not surprising that many participants expressed a feeling of hopelessness and a decrease in their overall quality-of-life. One participant in this study described the negative affect her injury had on her life. She was forced into early retirement as a police officer, a job which she enjoyed. In addition to being unable to work, she also describes her disappointment with not being able to continue doing activities that she had previously enjoyed, such as camping, hiking, and biking. This feeling of hopelessness was echoed by several of the other participants, wondering if "normal" would once again be possible. This finding may have significant implications on an individual's quality-of-life and needs to be addressed before and during the recovery process as they may impact recovery and subsequent outcomes. Evaluating these emotional responses with the use of patient-reported outcome measures can provide clinicians valuable information regarding an individual's mental state. The Short-Form

36 (SF-36) is a global measure of health-related quality-of-life that can evaluate the effect of injury on an individual's mental health.[108] By using outcome measures such as the SF-36 to assess and track an individual's emotional response to their injury, surgeons and rehabilitation providers' can individualize their plan of care to address and manage these concerns.

Previous studies have demonstrated similar ranges of emotions in patients scheduled to undergo knee surgery. In a study evaluating the recovery process following total knee arthroplasty (TKA), participants describe a sense of "enduring", which describes their experiences living with osteoarthritis and their emotional struggles as they tried to live a normal life while waiting for surgery.[109] The findings of this study demonstrate that despite participants' feelings of hopelessness, rehabilitation contributed to feelings of optimism about the future. During ACI rehabilitation, it is common for patients to see noticeable improvements in pain and function as early as three months. For patients that have been struggling with pain and a decreased quality of life for several years or longer, it is not surprising that this progression leads to feelings of optimism. Optimism has been associated with positive outcomes in patients recovering from coronary artery bypass surgery[110] and those with increased adherence to exercise programs[111]. Furthermore, it has been demonstrated that patients who are optimistic about their recovery during rehabilitation are less likely to experience feelings of hopelessness and depression which can be detrimental to the recovery process.[112] For patients with chronic disabilities, optimism may help patients persist and adhere in rehabilitation, which is crucial following ACI, especially given the lengthy recovery process. The results of this study demonstrate that participants experience a range of

emotions during the recovery process following ACI and this knowledge may help surgeons and therapists provide support for patients during the recovery process through realistic goal-setting and the management of patient expectations.

A fundamental finding of this study was the inconsistency between what participants expected regarding the length of the recovery process and what actually occurred. To date, there is only one study that has investigated patients' expectations and knowledge regarding ACI.[103] According to Niemeyer, patients undergoing ACI estimated the time from implantation of chondrocytes to full maturation of the repair tissue to be 13.3 months.[103] It has previously been established that full maturation of the repair tissue following ACI takes up to 24 months.[6,113] These findings suggest that patients undergoing ACI may be unprepared for the lengthy recovery process. Previous qualitative studies have also demonstrated an incongruence between patient expectations and reality. In a study describing the experiences of patients and their spouses recovering from total joint arthroplasty, participants describe their frustration that they did not know what to expect following surgery and that their expectations were not consistent with the reality of their recovery.[114] This finding has also been confirmed in a recent study of patients recovering from anterior cruciate ligament (ACL) reconstruction. Participants recovering from ACL reconstruction acknowledged that they had unrealistic expectations regarding the content of their rehabilitation and expressed frustration that the rehabilitation period lasted longer than they expected.[72]

Given these findings and the findings from the present study, it is important that clinicians understand and manage expectations in patients undergoing ACI. Autologous chondrocyte implantation is a unique procedure given the extended period of immobility

that occurs following surgery. Depending on the location of the lesion, most patients undergoing ACI have significant restrictions in weight-bearing for 6-8 weeks.[4,115] This lengthy period of immobility as well as the overall recovery time may have been expressed to the participant prior to surgery; however, the participants in this study still reported an incongruence between their expectations for recovery and reality. Therefore, it is critical that patient expectations are managed throughout the recovery process, including prior to surgery and consistently throughout therapy. Managing and eliciting patient expectations is especially critical as pre-operative expectations have been shown to be positively correlated with postoperative outcome as measured by health-related quality-of-life (HRQoL) questionnaires in patients undergoing total joint arthroplasty.[116,117] In addition, patient expectations have been positively associated with adherence behavior, including exercise, following cardiac transplantation.[118] Both the surgeon and the rehabilitation provider play a critical role in managing patient expectations. Education regarding the procedure and the rehabilitation process, therefore, is a critical component that should be included during the patient's pre-operative visit.

Pre-operative education is common practice in many orthopaedic surgical procedures, including total joint arthroplasty. The goal of pre-operative patient education is to prepare the patient and their caregiver(s) for surgery, to make them aware of what to expect during rehabilitation, and discuss expectations relative to surgery and the recovery process. These education programs are often multidisciplinary and involve surgeons, physical and occupational therapists, nurses, and care coordinators. Evaluation of pre-operative education programs has demonstrated that patients who are more educated regarding the recovery process are more satisfied with their treatment and are more likely

to actively participate in their care.[119] A meta-analysis evaluating the effect of pre-operative instruction on post-operative outcomes concluded that pre-operative education has a positive effect on post-operative outcome in patients undergoing a variety of surgical procedures. Furthermore, the author found that 67% of patients receiving pre-operative education have more favorable outcomes and that their outcomes were 20% better than patients not receiving any pre-operative education.[120]

Formalized patient education, in the form of classes or videos, is not the current standard of care for patients undergoing ACI and it is the authors' recommendation that formalized pre-operative education, including preoperative rehabilitation be considered for all patients and their families considering ACI. Preoperative education for patients undergoing ACI should include the following: information on the surgical procedure itself, importance of weight-bearing restrictions and the subsequent impact of those restrictions on the ability to drive, a description of which exercises are common during rehabilitation to improve strength and mobility, expectations for pain, functional limitations, and improvements during the various phases of recovery, importance of adherence with postoperative guidelines, and an estimated time to return to high-level functional activity. In addition, providing patients the opportunity to talk with individuals that have previously undergone ACI may help to alleviate fear and anxiety. Finally, preoperative rehabilitation is recommended for patients undergoing ACI. The purpose of preoperative rehabilitation is to introduce the patient to their therapist, establish realistic goals for recovery, provide additional education regarding expectations for recovery, and prepare the patient for surgery both physically and mentally.

Although participants in the present study were hopeful that the surgical procedure would alleviate their symptoms, they also recognized that therapy was an important part of the recovery process. While the recovery process is long and challenging, participants acknowledged that by adhering to their rehabilitation program, they were investing in themselves. Postoperative rehabilitation has been emphasized as a contributing factor in patients achieving positive outcomes following ACI.[6,30,97] Adherence to therapy provides several advantages for the patient. These include accountability, improved optimism and the ability to see functional improvement. This is particularly important to reiterate six weeks following surgery when weight-bearing restrictions are removed but the patient still has significant activity limitations. It is easy for patient's to become discouraged during this time as they want to increase their activity but are unable to do so based on the healing constraints of the tissue.

Patient adherence with rehabilitation after ACI can be difficult, especially considering the lengthy recovery process. Full maturation of the repair tissue can take up to two years; however, formalized rehabilitation does not often extend past three months. Therefore, it is often the responsibility of the patient to continue the recovery process on their own. Previous studies have demonstrated that self-motivation,[121-123] the importance or value of rehabilitation to the patient,[124] and perceived social support during rehabilitation[95,122,123] have the ability to positively influence adherence to rehabilitation. Therefore, participants who view their commitment to recovery as an investment in themselves and had adequate social support during recovery are more likely to be compliant with their postoperative recommendations. Rehabilitation providers may need to provide additional attention to patients that do not have an

adequate support system as this may interfere with their ability to adhere to therapy in the long-term. Establishing realistic short-term goals, follow-up communication after discharge, and an individualized exercise plan can improve motivation and adherence with home exercise programs.

Participants also described the importance of a collaborative environment when it came to their treatment. They expressed the importance of their therapist and their surgeon being "on the same page". Although most of their experiences were positive, several of the participants described an experience in which their therapist was unfamiliar with the procedure and subsequent rehabilitation and was therefore overcautious in their therapeutic approach. Furthermore, participants described the desire to progress faster than the surgeon or therapist's recommendations. Given the fact that ACI is a relatively new and unknown procedure and rehabilitation must be highly individualized, a collaborative environment between the patient, surgeon, and therapist is fundamental to the recovery process.[6,115] Patient education regarding the recovery process, including avoidance of activities that may be harmful for the repair tissue, and the importance of adherence with the rehabilitation program are essential during the early phases of rehabilitation. Furthermore, communication between the therapist and surgeon is necessary for appropriate progression based on lesion size, location, and any other concomitant pathology.[115]

LIMITATIONS

While this study contributes to the understanding of the recovery process following ACI, it is difficult to generalize the findings and experiences of these participants to others who have gone through the recovery process. We purposefully

selected both male and female patients of varying ages, residing in both rural and urban settings in order to represent the heterogeneous make-up of patients from one specific orthopedic practice. Although the findings may not be generalizable to patients in all settings, this study does provide information on factors that are important to consider during the recovery process following ACI.

CONCLUSIONS

In conclusion, this study aimed to describe and explore the recovery of patients undergoing ACI. We identified four major themes that occurred during the recovery process, emphasizing the lengthy and ongoing recovery process, the commitment to therapy as an investment in the future, the role of the team during recovery, and the inconsistencies between patient expectations for recovery and the reality of the process. Based on these findings, it is necessary that patient expectations are managed throughout the recovery process. Pre-operative education is one way in which patient expectations can be assessed and managed, as a way of better informing and ensuring realistic expectations for patients undergoing ACI. Educating patients and managing unrealistic expectations can help to alleviate feelings of hopeless and frustration that are likely to occur during the lengthy recovery process.

Table 3.1 Participant Characteristics

Subject	Age	Occupation	Time from Surgery to Interview	Number of Previous Surgeries
"Jim"	46	Staff Sergeant, US Army	12 months	1
"Amy"	46	Human Resources Director	12 months	0
"Linda"	42	Teacher	12 months	1
"Sara"	44	X-Ray Technician	6 months	0
"Terry"	44	Financial Advisor	12 months	2
"Katie"	25	Aquatics Instructor	3 months	0
"Betty"	38	Police Officer, Retired	4 months	0

Table 3.2 Selected Examples of Significant Statements of Patients' Rehabilitation Experiences and Corresponding Formulated Meanings

Significant Statement	Formulated Meaning
Getting back to having a life. I don't know if that is a part of rehabilitation. Yeah, that's been my biggest goal is getting back to normal.	Rehabilitation assists patients in achieving goals that allow them to return to normal daily activities.
I mean, actually you're like an infant. I mean I couldn't do anything and me I'm the type of person where I need to get up and go but to just be like that there, I mean to be beat up, can't move.	Reliance on others and the inability to be independent during the recovery process is discouraging for patients undergoing cartilage repair.
I've always wanted to go to therapy. I think there's only been like two days when I didn't care to go. I get excited to go to therapy because I know that I'm gonna make progress.	Rehabilitation following ACI offers patients hope that improvements will be made.
I go [to therapy] because I've gotta do it. I've gotta get better. So I have to push myself sometimes. I've gotta try to get back to work.	Therapy provides the motivation that patients need to improve and return to daily activity, including work.

Table 3.3 Themes and their Associated Sub-Themes

Theme	Sub-Theme
Recovery is an ongoing, emotional process	*Feelings of hopelessness that nothing will fix the pain*
	Therapy provides optimism for the future
Therapy is an investment	*Therapy provides accountability*
Recovery is a team-effort	*Everyone involved in the recovery process must be on the same page*
Expectations for recovery may not match reality	*Dependence on others is a source of frustration*
	There are other priorities besides recovery

CHAPTER 4: REHABILITATION PROVIDERS' PERSPECTIVE ON RECOVERY FOLLOWING AUTOLOGOUS CHONDROCYTE IMPLANTATION; A QUALITATIVE STUDY

INTRODUCTION

There are multiple factors that influence outcome following autologous chondrocyte implantation (ACI), including patient characteristics, defect characteristics, previous surgical history, patient expectations, and post-operative rehabilitation.[125-127] It has been emphasized that a lengthy rehabilitation period is necessary for successful return to function following ACI.[6,30,115,128] The development and progression of a rehabilitation program is a unique challenge for patients and therapists alike as these programs are often very time-consuming and must be highly individualized. At the current time, there is minimal evidence for the development and progression of rehabilitation following ACI. Guidance for the progression of rehabilitation is based almost entirely on expert opinion, basic science and the biomechanics literature.[6] This lack of evidence for optimal rehabilitation and a fear of graft failure may lead to an overcautious approach to ACI rehabilitation.[33]

Rehabilitation following ACI is meant to facilitate recovery and rehabilitation providers have a unique opportunity to positively influence outcome. Since the recovery process following ACI is a lengthy one, there is a high level of interaction that occurs between patient and therapist. The relationship between the patient and therapist has been studied extensively and is viewed as an important contributing factor to overall outcome. The term "alliance" refers to this relationship and describes the concept of collaboration, warmth and support that occurs between the patient and therapist.[129,130]

The therapists' behavior and communication skills can have a significant impact on this relationship by improving patient satisfaction, treatment compliance, and ultimately outcome.[131,132] In a recent systematic review, the therapist-patient relationship was found to have an effect on treatment outcome following rehabilitation in patients with a variety of medical conditions. Specifically, the therapist-patient alliance positively influenced rehabilitation adherence, patient satisfaction, and physical function.[129]

Autologous chondrocyte implantation is not a common procedure and thus may be unfamiliar for many rehabilitation providers, particularly therapists practicing in rural settings with limited access to the treating physician. Furthermore, therapists with less experience may not be able to draw from past clinical experiences or challenges if they have minimal experience treating this specific patient population. Therapist confidence for predicting patient outcomes is often-times related to knowledge that occurs over many years of experience.[133] A greater understanding of what makes therapy work from providers' that have experience treating patients following ACI may provide valuable information for therapists with limited knowledge and experience in this area.

To assist rehabilitation providers' in developing the tools necessary to effectively treat patients undergoing ACI, it is important to identify what strategies are used and how challenges are managed during the recovery process. To date, we are unaware of any studies that describe the experiences and perspectives of therapists' providing care to patients following cartilage repair of the knee. Therefore, the purpose of this qualitative study was to explore and describe the experiences of rehabilitation providers' experiences during the rehabilitation process following ACI and to determine what strategies they

employ to improve outcomes, encourage rehabilitation adherence, and establish positive therapist-patient relationships.

RESEARCH METHODS

The qualitative methodology, phenomenology, was used because it offers an approach by which to identify a phenomenon (ACI rehabilitation) and how it is perceived by participants (therapists). This type of methodology allows for gathering of 'rich' information through inductive, qualitative methods such as interviews and participant observation. Phenomenology is concerned with the perspective of the individual experiencing the phenomena of interest and provides insight into participant's motivations and actions.[104]

Participants

This study was approved by the University of Kentucky Institutional Review board. Participants were chosen through purposeful sampling in an effort to represent therapists working in both the urban and rural settings. A previous retrospective chart review identified rehabilitation providers providing services to patients that had undergone ACI from a single orthopaedic practice.[134] To meet eligibility criteria for the study, participants had to be licensed physical therapists in the State of Kentucky with prior experience treating patients that had undergone cartilage repair of the knee and be fluent in the English language. Information was provided both verbally and written, and participation was voluntary. Informed consent was obtained prior to the initial interview. Patients were assured of confidentiality and pseudonyms were used to protect anonymity.

A total of seven therapists agreed to participate in the study. Average number of years of clinical practice was 16 years, with a range of 6-30 years. Four of the

participants practiced in urban settings while the remaining three participants worked in a rural setting within the Commonwealth of Kentucky. For more detailed information on participants, refer to Table 4.1.

Data Collection and Analysis

Data collection was performed through semi-structured interviews conducted by the primary author (JLT). Each interview lasted between 30-60 minutes and took place in a quiet location chosen by each participant. Participants were asked to describe their experiences treating patients that had undergone ACI. All interviews were recorded and transcribed verbatim. An interview guide was developed for use during the interviews. This open-ended interview guide was used to maintain consistency during the interview process among all participants. Interviews were conducted until data saturation was reached. Data saturation occurs at the point in which no new information is being heard during the interview process.[105] All interviews were recorded and transcribed verbatim. As a researcher who is also experienced in orthopaedic rehabilitation, there were concerns relating to "insider bias".[135] Throughout the interview process, the researcher made every attempt not to influence the interviewees or make assumptions regarding the recovery process following ACI.

To understand the experiences and perspectives of therapists providing care to patients recovering from cartilage repair of the knee, a data analysis approach was used that encourages reflection and interpretation. This analysis is a 6-step methodological approach based on work by Colaizzi.[106] Following transcription of the data, the transcripts were read several times in order to get an overall sense of the participants' perspective. Next, significant statements that were related to the phenomenon of interest

were extracted from the transcripts. Once significant statements were extracted, duplicate statements were removed from the analysis. The process of horizontalization was used to help with the organization of the remaining significant statements. Horizontalization is a process whereby all statements are treated as having equal value or significance.[106] Formulated meanings were then developed from the remaining significant statements. These formulated meanings were organized into clusters of themes, which were used to provide a full description of the participants' experiences. Finally, these themes were distributed to all participants (member-checks) for their feedback as a means of validating these findings.

Rigor

Several methods were used to establish scientific rigor. First, member-checks were used during data analysis to ensure that we were providing an accurate description of the participants' experience. Following member-checks, participants stated that the themes were representative of their experiences and no changes were necessary. Secondly, all interviews were transcribed verbatim and direct quotes from participants were used to enhance credibility of the study.[107] In addition, a researcher experienced in qualitative research reviewed the interview protocol and was available to review and challenge the emerging interpretations of data. This expert checking further acted to minimize insider bias in the interpretation of the results. Finally, epoche, or 'phenomenological bracketing', was used to validate findings. In epoche, the interviewer must put aside his or her own experience of the phenomenon in order to focus on the views or experience of the interviewee.

FINDINGS

A total of 137 significant statements were identified from seven transcribed interviews and a total of 21 formulated meanings developed through the process of horizontalization. Table 4.2 provides specific examples of significant statements and their corresponding formulated meanings. Five themes emerged from therapists' experiences treating patients undergoing ACI, in no particular order: 1) *therapists believe their role is to facilitate recovery, 2) therapists believe that recovery is the patient's responsibility, 3) therapists believe that recovery must be collaborative, 4) therapists utilize patient education to maximize outcomes and manage expectations, and 5) therapists believe there are multiple factors that influence their decision-making.* Each theme is described below, using verbatim quotations from participants for support.

Theme 1: Therapists believe their role is to facilitate recovery

Participants recognized that their role during ACI rehabilitation was one of a facilitator, emphasizing that it was the patient who was ultimately responsible for their recovery. As a facilitator, participants discussed their role in motivating, encouraging and educating patients throughout the recovery process. Jeremy spoke about his role guiding and facilitating the recovery process:

> *"I say, who is going to get you better? And they usually point at me and I shake my head and say no. My job is to facilitate your recovery. If you need me, I'm there for you. My job is a facilitator. You are the one that is going to get your knee better. We'll help you and tell you what to do. If you need the push of the manual treatments, modalities, that's what we're here for. But ultimately you are the one that is responsible for your own recovery. It's your knee. My knee feels great. I don't have any problems with my knee."*

Participants acknowledged that it was a challenge as a facilitator to empower patients to be responsible for their recovery. One of the tools that participants found to be effective

was explaining the recovery process in terms that patients were able to understand. Kristen said,

> "*If you can explain why sometimes and you can put it in a context that makes sense for the patient; and you can relate to that patient specifically not just kind of a general relate to them. That seems to work better."*

Educating and relating to patients helps assure them that they are progressing as expected. According to Matthew, this was an important part of his role as a facilitator:

> *"Because it was a slower rehab with most of these people, I think our role is to assure them that they were doing the right thing and that they shouldn't be progressing any faster than they were. I think kind of letting them know that what they're doing is sufficient."*

By educating, motivating and encouraging patients, participants hoped to be able to provide patients with the tools for driving self-care and self-management and continue their recovery beyond formalized therapy.

Theme 2: Therapists believe that recovery is the patient's responsibility

While the therapist serves as the facilitator during rehabilitation, they acknowledged that recovery is ultimately the responsibility of the patient themselves. In order for the patient to be successful in rehabilitation, they must be compliant with their home exercise program, possess an understanding and knowledge of the healing process, and buy into the recovery process and their role in it. Kristen emphasized the patient's role in the recovery process:

> *"The patient's role is taking responsibility for their recovery process and understanding that in the long run it is their knee. And not my knee and not the surgeon's knee."*

Part of the patient's responsibility is being prepared for the recovery process. A part of this preparation is a knowledge of the process and how recovery will affect their lives. Matthew said:

> *"I think they bear the brunt of the responsibility. They have to be informed and understand what they are getting into. I think they need to know that the rehab is not a quick fix. I think they have to be prepared mentally and I think they have to be prepared socially and economically to have this type of surgery because a lot of people may not be able to afford the six, eight months off of work that it would take."*

Compliance with home exercises is an area that all therapists agreed was an important part of the recovery process and ultimately the responsibility of the patient. Although compliance was viewed as the patient's responsibility, participants acknowledged that their role as a facilitator was to help patients buy into the recovery process as this had the potential to influence their perseverance with home exercises in the long-term. Furthermore, when patients were compliant with their home exercises, they were able to meet short-term goals which improved their motivation and outlook. Jeremy talked about the importance of patient buy-in and his role in facilitating their cooperation and motivation with therapy:

> *"But buy-in more than anything is crucial because if they're actually doing things at home then they're going to make their strength gains and they're going to make their range of motion gains and everything else will fall into place. As far as patients I want is ones that are able to buy-in and understand that the home component is very important with this. And again, I try to empower them to do that."*

Several of the participants acknowledged that overall, patients were very committed to the recovery process, including compliance with their home program. However, participants also recognized that patients lose their motivation and compliance over time given the lengthy recovery process. Four of the participant's stated that patients become

frustrated around three months post-operatively because they tend to plateau with their functional gains. And this often affects their motivation and compliance with rehabilitation. Natalie recognized this plateau in several of her patients:

> *"I think in a lot of cases, it [plateau] coincides with the end of formalized therapy but even if they are still participating in therapy I think they're maybe not as compliant at home, maybe they're losing some of the enthusiasm and motivation. Especially when it's such a long process. If a patient has a strong sense that they are in control of their situation, I think they do better than somebody who perhaps feels like they don't have any control over their situation and then they've got this 12-month long rehab process that they're not in control of."*

Recovery following ACI is a lengthy process and patients generally participate in formalized therapy in the short-term. However, if patients are to have successful outcomes in the long-term, it is important for them to understand that they are ultimately responsible for their own recovery. An important component of this responsibility is compliance with home exercises once formalized therapy has ended. Therapists, as facilitators of recovery, must provide patients with the tools and knowledge to manage recovery on their own.

Theme 3: Therapists believe that recovery must be collaborative

While participants recognized their role in the recovery process, they acknowledged that recovery is a team effort and collaboration between themselves, the patient, and the surgeon is critical to a successful recovery. An important part of this collaboration is information sharing, which may help therapists to develop the most effective and individualized treatment plan. When information is missing, participants acknowledged that it was their responsibility to obtain this information. Luke said,

> *"Sometimes there is information that only the doctor knows that might be helpful. One thing we do, is we always request the operative report. And that way we're on the same page. We see where the issue is topographically. So that gives us a*

great deal of information."

The participants also acknowledged that collaboration during the recovery process helps with patient buy-in. Ashley spoke about the importance of this collaboration in developing a relationship with the patient:

> *"So we help to collaborate with the doctor and the team to make sure that what they want and what they want to see the patient do that that is being carried out. Because most of the time we do have a relationship with these patients and you know, so. I think that's helpful just to keep hearing it and hearing it."*

Successful communication between the surgeon and therapist may also improve the therapist's confidence level in progressing function and establishing appropriate goals for the patient. Since ACI is not a common procedure, therapists may not be familiar with the restrictions and treatment approach. Collaboration, therefore, is critical for progressing the patient safely and effectively.

Theme 4: Therapists utilize patient education to maximize outcomes and manage expectations

In addition to their role as facilitators of recovery, participants also emphasized the importance of patient and caregiver education during the recovery process. While patient education is an important component of any rehabilitation program, participants emphatically agreed that it is extremely critical following ACI given the time necessary for tissue healing. Educating both patients and their caregivers prepares patients for recovery and helps them to manage expectations on the front end. Natalie agreed that pre-operative education needed to be more of a focus in this patient population:

> *"I think they could take a page out of the total joint book. Because with total joints there is a lot more education on the front end both for patients and families. I don't think that family's expectations are where they need to be and I don't know what role that plays in the patient's motivation. But a lot of education up*

> *front. You know the joint, a lot of joint programs have them go to a class or school. I think that they should be required for a couple of pre-operative visits with the surgeon to discuss the procedure, to discuss the rehabilitation, maybe even have pre-op visits with the therapists so that we have the opportunity to reinforce what the physician has explained to them."*

An important component of patient education from the participants' perspective was to help alleviate the patient's fear of the unknown. All participants acknowledged that at some point during recovery, patients are either nervous or apprehensive about damaging their knee. Part of this fear is not fully understanding the healing process and the timeline. Jeremy talked about the anxiety that many of his patient's expressed:

> *"Patients are often a little bit nervous about the process because again it's a little different. You're taking cartilage and sending it where? And we're going to get it back and put it back into my knee and then it'll grow? So they're a little nervous about the process because it's a little different than some other knee scope."*

By educating patients on the procedure and the healing process, therapists are able to alleviate some of those concerns and instead focus on the recovery itself. Pre-operative patient and caregiver education, whether formal or informal and the addition of prehabilitation helps patients to make informed decisions regarding the timing of the procedure, alleviates any concerns regarding the procedure and the subsequent rehabilitation, and helps to manage their expectations. An understanding of the procedure and the recovery process can influence patients' motivation and cooperation with therapy, which may ultimately influence their outcome.

Theme 5: Therapists believe there are multiple factors that influence their decision-making

The final theme emerged as participants spoke about different factors that influenced their decision-making during the recovery process. Factors included

psychosocial influences, insurance restrictions, and their level of knowledge, experience and confidence treating patients recovering from ACI. All of the participants agreed that the patient's level of motivation, mentality regarding the recovery process, willingness and ability to adhere to treatment guidelines, and caregiver support influenced the recovery process. Depending on the patient's mentality towards the recovery process, the therapist might need to adjust and alter their treatment approach in an effort to provide assurance or instruction. Natalie described the difference in approaches taken based on the patient's mentality towards recovery:

> *"I think some patients really assume that patient mentality and they want their hand held and I think other patients are more independent and they just need an occasional pat on the back saying you're doing what you need to be doing, keep doing it. Sometimes I need to be right there with them hand holding and making sure they know that. This pain they are having, that is normal pain, and that is to be expected. And not to be afraid of that. That you're not doing damage. And then other patients, I almost have to pull the reigns in on them and say wait a minute you don't need to be doing that. You might be causing damage. I know you're doing well with your exercises but we need to slow it down a little bit."*

One of the challenges that many of the participants faced involved restrictions in insurance coverage. While recovery can take up to two years, many patients are only able to attend formalized therapy for a specified number of visits. This forces patients to spend the bulk of their recovery doing exercises on their own, without supervision and guidance from their therapist. Natalie spoke about the challenges of insurance restrictions coupled with poor compliance and how this impacted her decision-making:

> *"I think the main thing as far as the entire process goes is the compliance and the insurance. I find that these people are going to require some rehab pretty extensively throughout the course of several months and sometimes it might be on the part of the patient where they're just not being compliant with coming to therapy or doing the therapy at home. And if they're not compliant at home, I have to use more of their insurance visits to get them in the clinic to make sure that they don't get stuck or lose their motion or anything like that. We know up ,*

front that we are likely going to use their insurance visits up and I try to plan for that. I start upselling and talking about the wellness plan very early on so the patient doesn't feel like they are left hanging out to dry. That they know there are still options after insurance runs out."

Another factor that participants recognized influenced their decision-making was their overall experience, confidence, and knowledge in treating ACI patients. Several of the participants had treated a large number of ACI patients and were able to draw on these experiences to shape their decision-making. Other participants, however, had minimal experience treating ACI patients and this certainly factored into their confidence level as well as their ability to draw on past experiences when confronted with challenges and set-backs. Matthew, a physical therapist for six years, had only treated three ACI patients. He spoke about how this influenced his decision-making:

"My confidence level initially was low due to not having a background and actually having no reference point from classroom or any other internships. We actually contacted the surgeon right away and asked for some clarification on some of the protocols and tried to become a little bit familiar with what he was expecting out of these patients. One of our patients really wanted to think more and we were unable to give him much more information. Cause we just didn't know."

Participants recognized that recovery following ACI was not as easy as following an established protocol. Rather, their decision-making was influenced by the patient's level of motivation, insurance restrictions, and their own experiences, knowledge and confidence level.

DISCUSSION

This study sought to examine the perspectives of therapists providing rehabilitation services for patients undergoing ACI. Because of the extensive time that rehabilitation providers spend with patients post-operatively, they provide a unique

perspective on recovery process. The results of this study indicate that the role of the rehabilitation provider is to facilitate recovery through education, guidance, and managing the psychosocial needs of the patient. The patient, on the other hand, is ultimately responsible for their own recovery. This implies a knowledge of the recovery process, motivation, and the willingness to adhere to the post-operative guidelines, both in the short-term as well as in the long-term.

One of the biggest challenges of ACI rehabilitation is the length of the recovery process. It has been estimated that full maturation of the repair tissue takes two years.[6,113] However, as a result of insurance restrictions, patients are oftentimes only participating in formalized rehabilitation for several months following surgery. Therefore, the time spent in formalized therapy is critical for shaping patients attitudes and beliefs regarding their role in the recovery process and to provide patients with the tools to influence their health and behaviors. It has been suggested that the relationship between the therapist and patient has an important influence on outcome. The potential effects of this relationship occur through patient education, adherence to treatment, self-efficacy and the patient's perception of control.[136] The findings of this study demonstrate that rehabilitation providers consider each of these areas important for influencing outcome in patients recovering from ACI.

One of the fundamental findings from this study was the importance of patient education throughout the recovery process. During recovery, participants considered themselves facilitators of recovery. Patient education is one way in which participants are able to facilitate recovery. The aim of patient education is to influence patients' knowledge and health behavior so that they are able to assume an active role in the

management of their own recovery. [137] It has been demonstrated that patient education occurs in nearly all therapist-patient encounters. In a study of Dutch physiotherapists, 97% of treatment sessions included some form of patient education.[138] Patient education, regardless of the approach has the ability to positively influence adherence to treatment. While patient education following ACI is important for influencing behavior, increasing knowledge, and improving adherence, the timing of patient education is equally important. Pre-operative education is common practice in many orthopaedic surgical procedures, including total joint arthroplasty. However, formalized patient education is not the current standard of care for patients undergoing ACI.

The participants in this study all agreed that patient education was critical during the recovery process; however, they also believed that patients would benefit from more formalized pre-operative education. Evaluation of pre-operative education programs has demonstrated that patients who are more educated regarding the recovery process are more likely to actively participate in their care.[119] In addition, pre-operative education has been shown to have a positive effect on post-operative outcome. Specifically, 67% of patients receiving pre-operative education had more favorable outcomes and their outcomes were 20% better than patients not receiving any pre-operative education.[120] Given these findings and the recommendations expressed by all of the participants, pre-operative patient education should be developed, in the form of classes or videos, for patients (and caregivers) undergoing ACI. Pre-operative education should be modeled after total joint arthroplasty that allows clinicians to assess their knowledge and expectations, answer questions, and provide patients with information regarding the surgical procedure as well as an exercise booklet which includes precautions and

exercises to be performed post-operatively.[119] In addition, patients should undergo a period of pre-habilitation in an effort to prepare them both physically and mentally for surgery.

A common thread amongst all participants in this study was acknowledgement that recovery is ultimately the responsibility of the patient. While the participants recognized their role in facilitating recovery, providing guidance, and educating the patients, they all agreed that it was the patient's responsibility to manage their recovery. An important component of this role is compliance and adherence to their treatment program. Many of the participants noted that patients undergoing ACI are compliant with their treatment plan in the short-term, but that due to the lengthy recovery process, patients have a difficult time maintaining their adherence in the long-term. Patient compliance is important in physical therapy because treatment effects depend on it. However, research indicates that up to half of patients are noncompliant with exercise.[139,140] There are a multitude of factors that may be related to patient compliance. Previous research has demonstrated that patients with an external locus of control are less compliant than patients with an internal locus of control. In other words, patients who believe that recovery is not dependent on their own behavior or actions appear to be less compliant to treatment plans.[141] To date, only one study has investigated patients' expectations and knowledge regarding ACI. In this study, patients undergoing ACI were asked to provide the relative importance of different factors on clinical outcome. Factors included defect characteristics, personal risk factors (e.g. age), quality of the surgery, previous surgeries and treatment, and post-operative rehabilitation. Interestingly, only 7.6% of patients considered post-operative rehabilitation an important factor for

influencing clinical outcome. The majority of the patients believed that their outcome was determined by factors outside of their control.[103] This has significant implications for adherence, especially in the long-term.

Another factor that has been shown to influence compliance is feedback and supervision. Patients who are provided with positive feedback and whose compliance is being monitored are more likely to comply with instructions than patients who are unsupervised and do not receive consistent feedback.[142,143] Supervision in the long-term is difficult, given insurance restrictions and the length of the recovery process. However, several of the participants in this study offered patients an opportunity to participate in a "wellness program", in which patients pay a small monthly fee to use their facilities during established hours. The benefit of a wellness programs is that it provides accountability and offers patients' access to their rehabilitation provider should any questions or issues arise.

It is no surprise that recovery is influenced by psychosocial issues. Participants in this study identified motivation, degree of self-efficacy, and locus of control as potentially influential factors determining success following ACI. Self-efficacy, or the belief in one's ability to produce a desired action[144], has been associated with positive outcomes.[145,146] Even in patients with successful outcomes, however, lower levels of self-efficacy may exist. This may be due to patients attributing their success to factors outside of their control, such as the quality of the surgery. Furthermore, when patients feel helpless about trying to change their behavior or influence their health, motivation may decrease.[136] Therefore, it is important for rehabilitation professionals to recognize a

patient's effort as their own effort but also to encourage a sense of control over their problem.

Therapists' knowledge, experience, and confidence may influence clinical decision-making. The results of this study suggest that therapists with considerable clinical experience with ACI patients had greater confidence in their treatment approach whereas clinicians with minimal experience reported less confidence and knowledge with the recovery process. Previous studies have established that clinicians with limited experiential and conceptual knowledge experience a high degree of uncertainty and lack confidence when making clinical decisions.[133,147] A knowledge of the pathology combined with clinical experience may improve a clinician's understanding of how patients may respond and adapt to their disability. While clinical experience can only be improved with time and exposure, increasing a clinician's knowledge base through collaborative sharing of information and provision of detailed rehabilitation protocols can improve their confidence, regardless of clinical experience.

One of the final themes to emerge from this study is that participants viewed recovery from ACI as collaborative in nature. Recovery does not happen alone; rather, it requires a cooperative effort between surgeon, patient, therapist, and caregiver(s). An important aspect of effective collaboration, as acknowledged by many of the participants in this study is quality communication. There is evidence that effective communication between the surgeon and patient can positively influence outcome.[148] This interaction between physician and patient, however, is often brief. Rehabilitation providers spend significantly more time with patients and therefore have an advantage in establishing rapport and influencing the patient's behavior and attitudes. Participants in this study

also emphasized the importance of effective physician-therapist communication. This is particularly important for therapists practicing in rural settings with limited access to the treating physician and when therapists are unfamiliar with a procedure or rehabilitation protocol. Participants in this study that were unfamiliar with the protocol or the physician's expectations acknowledged that it was their responsibility to initiate communication with the physician to obtain additional information, such as the surgical report. Having the appropriate information available allows therapists to provide more individualized care.

Given the findings from this study and the available literature, there are several tools that rehabilitation providers can use to improve adherence, self-efficacy, and -motivation in patients undergoing cartilage repair of the knee. As mentioned previously, a formalized pre-operative education program in conjunction with pre-habilitation should be provided for patients undergoing ACI. In addition, therapists' should be given access to surgical reports that indicate the exact size and location of the lesion. This information, combined with a thorough knowledge of the patient's expectations, will allow therapists to tailor the rehabilitation program to an individual's situation. Assessing patient's self-efficacy and adherence to their rehabilitation program can be assessed through the use of validated instruments. For example, the Sport Injury Rehabilitation Adherence Scale (SIRAS) is a 3-item measure in which clinicians' rate patients' intensity of completion of rehabilitation exercises, the frequency with which they follow the clinician's instructions, and their receptivity to changes in the rehabilitation program.[149,150] Patient self-reports of adherence can be measured using a 10-point Likert scale, where 0=none and 10=exactly as prescribed. The Self-Efficacy for

Rehabilitation Outcome Scale (SER) is a 12-item measure designed to measure patients' beliefs about their abilities to perform activities in rehabilitation. By assessing adherence, therapists can adjust the feasibility of the exercises and adapt them as necessary. In patients with low levels of self-efficacy, therapists can establish realistic and attainable goals and provide feedback. Providing consistent feedback throughout the recovery process can also assist with improving adherence. Finally, there are several factors to consider for improving long-term compliance with exercise programs. Physical therapy clinics should consider offering a wellness program for patients that require extensive recovery time. When wellness programs are not an option, follow-up encouragement and input from the therapist may be beneficial.

LIMITATIONS

While this study contributes to the understanding of the recovery process following ACI from the perspective of the rehabilitation provider, it is difficult to generalize the findings and experiences of these participants to others who have provided care for patients with similar conditions. However, we selected participants with varying experiences with ACI patients as well as participants from both urban and rural settings in an effort to represent a more heterogeneous group of therapists. While these results may be limited to the views of the participants, results suggest that further exploration of pre-operative patient education programs and inclusion of outcome instruments for measuring adherence and self-efficacy is warranted.

CONCLUSIONS

This study aimed to describe rehabilitation providers' experiences during rehabilitation in patients recovering from ACI. We identified five themes that

emphasized the role of the therapist as a facilitator in the recovery process, the responsibility of the patient to comply with treatment and manage their own recovery, the importance of patient education, the collaborative nature of recovery, and the influence of psychosocial factors on recovery. The relationship between the therapist and patient can have an important influence on outcome. Adopting a patient-centered approach is best done by devoting time to patient education, managing expectations, encouraging compliance to treatment, assessing self-efficacy, providing feedback, and promoting a collaborative environment. Including these methods within a rehabilitation program will increase a patient's sense of control and enable them to take an active role in their own recovery.

Table 4.1 Participant Characteristics

Subject	Clinical Setting	Years of Clinical Practice
"Jeremy"	Urban	9 years
"Luke"	Rural	21 years
"Matthew"	Rural	6 years
"Anna"	Urban	12 years
"Natalie"	Urban	6 years
"Ashley"	Rural	30 years
"Kristen"	Urban	28 years

Table 4.2 Selected Examples of Significant Statements of Therapists' Experiences and Corresponding Formulated Meanings

Significant Statement	Formulated Meaning
I think what we try and instill in the patients is number one what we do here is important; what you do outside of here is probably more important as far as are you doing what we are asking for.	Rehabilitation is an important part of recovery following ACI, but the patient's compliance with the guidelines is more important.
But I think the biggest thing early-on with the process is it's got to be slow and there has to be good patient feedback.	Patient feedback regarding the recovery process is an important component of therapy following ACI.
So these patients seem to be very apprehensive about every little pain and everything. And letting them know that all those hurts don't necessarily equal harm.	Assuring patients that pain does not indicate harm helps to alleviate their apprehension about the recovery process.
It's just that this process is going to take a long time. It's going to take months and we're only half way through that. And you need to just kind of move forward as we progress you forward. And they hung in there. They all kind of hung in there.	Recovery following ACI is a long process and it can be difficult for patients to see the progression.

CHAPTER 5: THE RELATIONSHIP BETWEEN PATIENT EXPECTATIONS, FUNCTIONAL OUTCOME, SELF-EFFICACY, AND REHABILITATION ADHERENCE: A SEQUENTIAL EXPLANATORY ANALYSIS

INTRODUCTION

Cartilage injuries of the knee, when left untreated, can result in significant pain, functional impairments, decreased quality of life and an increased risk for the progression of osteoarthritis.[1,2] The aim of cartilage repair procedures is to restore full function and delay the progression of osteoarthritis. Over the years, a variety of surgical procedures have been developed to address cartilaginous defects in the knee, including meniscal transplant, osteochondral allograft, and autologous chondrocyte implantation (ACI). Regardless of the technique, the recovery period following cartilage repair is a lengthy one and often involves a period of restricted weight-bearing necessary for adequate tissue healing.[3,4] As a result, return to full function is often delayed 6-12 months, with return to unrestricted sport participation as late as 12-24 months.[5] In order to optimize the benefits of cartilage repair surgery, it is crucial that patients are well informed and educated regarding the recovery process and willing to adhere to a lengthy rehabilitation process.

Successful outcomes following cartilage repair of the knee are dependent on a multitude of factors, including patient history, lesion characteristics, quality of the repair, post-operative rehabilitation, and psychosocial factors. There is a growing body of literature in total joint arthroplasty that has investigated the role of patient expectations on clinical outcomes and patient satisfaction.[151-156] Independent of the surgical procedure, patient expectations for surgery and subsequent recovery are shaped by many

factors, including personal experience, media, information provided by their surgeon, or experiences from friends and relatives that have undergone similar procedures. [157,158] Since these expectations may be inaccurate or unrealistic, it is important that surgeons and clinicians manage patient expectations prior to undergoing surgery. Eliciting patient expectations is important for several reasons. First, involving patients in their care may increase adherence to post-operative recommendations.[155,159] In addition, it is important to understand which patients are at risk for poor outcomes following surgery, thereby emphasizing areas for patient education and selection.[159] Third, fulfilled expectations have been associated with increased patient satisfaction and clinical outcome following total joint arthroplasty.[155,160,161] Finally, measuring patient expectations helps clinicians provide more individualized medical care.

The literature suggests that expectations will result in patients experiencing better outcomes by improving their cooperation and motivation with therapy, yet this is not universally agreed upon.[162] In a recent study by Niemeyer et al., the expectations of patients undergoing ACI were investigated. Patients were asked to provide the relative importance of different factors on clinical outcome. Factors included defect characteristics, personal risk factors, the quality of the surgery, previous surgeries and treatment, and post-operative rehabilitation. Only 7.6% of patients considered post-operative rehabilitation an important factor for influencing clinical outcome. This demonstrates that patients underestimate the importance of rehabilitation.[163]

A preliminary qualitative study of patients undergoing ACI (unpublished) suggested that patients are not compliant with prescribed home exercise programs once being discharged from rehabilitation. Patients admit that while they understand the

importance of continuing exercises beyond formal therapy, they find it difficult to find the time to continue with these programs. Post-operative rehabilitation is critical for achieving a successful return to function following cartilage repair of the knee. Oftentimes, however, rehabilitation is directly influenced by both the motivation of the individual patient as well as the patient's compliance with rehabilitation. If a patient demonstrates low expectations for recovery following cartilage repair, this may adversely affect his/her adherence with a rehabilitation program.

Preliminary results from this same qualitative study also suggested that patients were unprepared for the lengthy recovery following cartilage repair. Patients expressed concerns that if they had known how "long and hard" the recovery process was going to be, they would have reconsidered undergoing surgery. Similar sentiments have been described in patients undergoing anterior cruciate ligament (ACL) reconstruction. In a study by Heijne, participants who had undergone ACL reconstruction reported being frustrated that the progress during rehabilitation did not match their expectations.[72] Therefore, eliciting and managing patient expectations for recovery following cartilage repair of the knee may be potentially useful for preparing patients for surgery and rehabilitation, thus improving patient satisfaction, adherence to post-operative recommendations, and treatment outcomes.

Past research has also demonstrated that patients' self-efficacy is an important factor in the rehabilitation process. Self-efficacy is an individual's belief about their ability to execute certain tasks that will lead to expected outcomes.[144] Within orthopaedics, the role of self-efficacy during rehabilitation has predominantly been studied in patients undergoing total joint arthroplasty (TJA). Results of these studies

suggest that self-efficacy was a significant predictor for rehabilitation outcome and post-operative behavior (e.g. ambulation distance, and frequency of exercise).[164,165] This suggests that patients' self-efficacy beliefs need to be considered when developing rehabilitation programs.

There are multiple factors that influence outcomes following cartilage repair surgery. However, to date, little is known about the expectations of patients undergoing cartilage repair surgery and whether these expectations influence post-operative outcome. Furthermore, the extent of patient participation in rehabilitation has not previously been measured. Therefore, it is unknown how patient expectations (whether realistic or unrealistic) influence adherence to post-operative rehabilitation recommendations. Furthermore, it is unknown how self-efficacy influences adherence in rehabilitation. Although patient expectations have been measured quantitatively, understanding the importance and values of those expectations for recovery using qualitative methods has not previously been conducted in this patient population.

THEORETICAL FRAMEWORK

The Social Cognitive Theory will be used as the theoretical framework that will guide this study. This study will assess the influence of patient expectations and self-efficacy on rehabilitation adherence and functional outcome. As such, the Social Cognitive Theory is an appropriate framework for studying how behavior influences outcome. According to Bandura, behavior is explained in terms of a dynamic model and reciprocal model in which behavior, personal factors, and environmental influences all interact. The Social Cognitive Theory identifies three key concepts, including incentives, outcome expectations, and self-efficacy expectations (Figure 5.1).[166] These elements

may be relevant to patients' expectations for recovery following surgery but also in their ability to persist in rehabilitation. Self-efficacy expectations, within the framework of this study, relate to one's own competence to perform a particular behavior necessary for influencing outcomes. Self-efficacy beliefs may arise from previous experience, observation, media, or from their own values and beliefs. Outcome expectations, on the other hand, occur when a person learns that certain outcomes occur in a given situation and expect them to occur when that situation presents itself again. Incentives are the values that patients assign to a particular outcome.[160,166,167]

Considering the Social Cognitive Theory within the context of this study, patients would ideally expect a level of post-operative improvements that are reasonable given their current functional level. These expectations then allow patients to establish incremental goals to achieve these expectations. As patients achieve these goals (based on their expectations), their confidence improves, enabling them to persist in rehabilitation and achieve greater functional results. Adherence in rehabilitation may therefore depend on the degree to which patients feel they are capable of performing and adhering with a rehabilitation program (*self-efficacy expectations*) as well as the degree to which patients anticipate positive outcomes following cartilage repair (*outcome expectations*).[168,169] This study sought to measure patient expectations and their relationship to patient satisfaction, functional outcome, self-efficacy, and rehabilitation through the use of quantitative methods; however, understanding patient's self-efficacy expectations and the values that they place on particular outcomes is better suited to qualitative research.

PURPOSES/AIMS/HYPOTHESES

The purpose of this sequential explanatory mixed methods study is to examine and explore the relationships between patient expectations, functional outcome, self-efficacy, and rehabilitation adherence in patients undergoing cartilage repair of the knee. We propose the following aims:

Aim 1: To examine the relationship between patient expectations and pre-operative functional status in patients undergoing cartilage repair of the knee. We hypothesize that there will be a positive association between patient expectations and baseline KOOS scores.

Aim 2: To examine the relationship between patient expectations and functional status 6 months following cartilage repair of the knee. We hypothesize that there will be a positive association between patient expectations and KOOS scores 6 months following cartilage repair of the knee.

Aim 3: To examine the relationship between patient expectations and rehabilitation adherence in patients undergoing cartilage repair of the knee. We hypothesize that there will be a positive association between patient expectations and rehabilitation adherence.

Aim 4: To examine the relationship between patient self-efficacy and rehabilitation adherence in patients undergoing cartilage repair of the knee. We hypothesize that there will be a positive association between patient self-efficacy and rehabilitation adherence.

Aim 5: To describe patients' expectations for recovery following cartilage repair of the knee and to provide insight into how these expectations shape recovery and adherence to postoperative recommendations.

CLINICAL IMPLICATIONS

The results of this study will provide insight into the broad range of expectations held by patients undergoing cartilage repair of the knee. It is currently unknown how patient's pre-operative expectations influence their outcomes and adherence with post-operative rehabilitation. Eliciting patient expectations pre-operatively will provide opportunities for patient education and counseling, assist surgeons in patient selection, and identify patients that might benefit from pre-surgical rehabilitation. Pre-surgical education and counseling too often focuses on details of the surgical procedure itself while information regarding the rehabilitation and recovery process is often neglected. If the proposed study demonstrates that patients exhibit unrealistic expectations for recovery, future research will aim to develop educational materials similar to protocols being utilized in total joint arthroplasty. These educational materials will better inform patients of the benefits and expectations for recovery following cartilage repair of the knee.

Although a variety of factors influence clinical outcome, unrealistic expectations for recovery may negatively influence clinical outcome and patient satisfaction. Certain factors, including patient age, previous history, and lesion size are not modifiable factors and may influence clinical outcome positively or negatively. Unrealistic expectations, however, are modifiable with appropriate education and counseling. Therefore, eliciting patient expectations pre-operatively will allow surgeons to consider patient expectations alongside patient demographics and lesion characteristics when determining which patients are likely to be successful following cartilage repair of the knee. Furthermore, discussing patient expectations may improve patient satisfaction, regardless of outcome.

We anticipate that patients with high, but realistic expectations for recovery following cartilage repair of the knee are more likely to adhere to post-operative rehabilitation programs. Ideally, patients would expect a level of post-operative functional gain that is reasonable given their pre-operative function and past history. These expectations then allow patients to establish appropriate and timely goals in order to achieve these expectations. As goals are achieved, confidence improves, enabling greater adherence in rehabilitation and ultimately greater improvements in function. Patients with low expectations for recovery, however, are unlikely to adhere to a rehabilitation program, especially in the long-term. Identifying these individuals allow surgeons to make recommendations for pre-operative rehabilitation before patients undergo cartilage repair.

This study is unique because we are using mixed methods to capture the trends and details of patient expectations and rehabilitation adherence thereby broadening the scope and depth of understanding patients' recovery process following cartilage repair of the knee. While the quantitative component of this study will capture patient's pre-operative expectations for outcomes, the qualitative component will allow us to further understand the values that patients assign to particular outcomes as well as the degree to which patients persevere in specific activities, such as those required for effective rehabilitation. Qualitative studies are rarely used to capture this information because of the time and expertise needed to capture this information. The qualitative component also has the advantage of tying the expectations of the patient more specifically to the outcome. Therefore, this study will provide valuable data that is often neglected in typical outcome studies.

METHODS

Study Design

This study employed a sequential explanatory mixed methods design (Figure 5.2). The overall purpose of this design is to use qualitative data to explain or build upon quantitative results.[170] In this study design, priority is given to the quantitative data. This study used a two-phased mixed methods model and began with the collection and analysis of quantitative data. After the collection and analysis of the quantitative data, the collection and analysis of qualitative data was undertaken. The quantitative and qualitative data were then synthesized and interpreted. For the quantitative component of the study, a prospective, longitudinal cohort study was employed. The qualitative methodology, phenomenology, was used because it offers an approach by which to identify a phenomenon (patient expectations for recovery following cartilage repair of the knee) and how it is perceived by participants. This type of methodology allows for gathering of 'rich' information through inductive, qualitative methods such as interviews. Phenomenology is concerned with the perspective of the individual experiencing the phenomenon of interest and provides insight into the participant's motivations and actions.[171]

Participants

For the quantitative component of the study, patients who were undergoing cartilage repair surgery of the knee were recruited. To be eligible for inclusion in the study, patients had to be 1) between the ages of 12-65, 2) currently enrolled in the Cartilage and Ligament Registry, and 3) undergoing surgery for repair of a cartilage injury of the knee. Cartilage repair procedures include meniscal transplant,

osteochondral allograft, or autologous chondrocyte implantation (ACI). Purposeful, criterion sampling methods was used to select participants for inclusion in the qualitative component of the study from the larger sample of patients in the quantitative study. This purposive sampling technique was employed to capture major variations by selecting patients with high expectations, moderate expectations, and low expectations for recovery following cartilage repair of the knee. Inclusion criteria for the qualitative study include 1) enrollment in the quantitative portion of the study, 2) ability to articulate information about their expectations for recovery and their rehabilitation experiences, and 3) the ability to speak and understand the English language in order to participate in the interview process.

Outcome Measures

For the quantitative portion of the study, outcome measures included the following: Knee Injury and Osteoarthritis Outcome Score (KOOS) (Appendix D), a modified version of the Hospital for Special Surgery (HSS) Knee Surgery Expectations Survey (Appendix E), the Self-Efficacy for Rehabilitation Outcome Scale (SER) (Appendix F), and measures of rehabilitation adherence.

<u>KOOS</u>

The KOOS is a site-specific outcome measure developed for the purpose of evaluating short and long-term function and symptoms in patients with a variety of knee injuries, cartilage damage, or different stages of OA. It is comprised of 42 items within five separately scored sub-domains, which include symptoms, pain, activities of daily living, sport and recreation function, and knee-related quality of life.[172] The KOOS produces separate scores for different health dimensions, with lower scores representing worse

function in each area.[173] Test-retest reliability, construct validity, and responsiveness have previously been established in patients with articular cartilage lesions.[174]

Expectations

Patient expectations were measured using a modified version of the HSS Knee Surgery Expectations Survey. The survey was developed from interviews with patients and validated by an expert panel of orthopaedic surgeons. It has demonstrated test-retest reliability in patients with a variety of knee disorders, excluding patients undergoing total knee arthroplasty (TKA).[159] This self-administered questionnaire is a 23-item survey addressing patient expectations regarding pain, physical activity, and psychological well-being following knee surgery.[159] Expectations are measured on a 5-point Likert scale, with 1=back to normal or complete improvement and 5=I do not have this expectation, or this does not apply to me. The expectations survey is scored by recording the responses in reverse order and then summed to generate a raw score from 0 to 92 and then transformed [= (raw score/92) x 100] to a score which ranges from 0 to 100.[159] Higher scores represent greater expectations for recovery.

Self-Efficacy

Self-efficacy for rehabilitation was measured using the Self-Efficacy for Rehabilitation Outcome Scale. The SER is a 12-item measure developed according to Bandura's guidelines for assessing participants' beliefs about their abilities to perform activities in rehabilitation.[8] The SER was developed in collaboration with psychologists, physical therapists, and occupational therapists. Reliability and construct validity of the SER has previously been established in patients undergoing total hip or knee arthroplasty.[144] Items within the SER increase in difficulty and address a person's belief in the ability to

perform activities in various rehabilitation settings, such as when experiencing pain or when feeling tired. Items are rated on an 11 point Likert Scale where 0=*"I cannot do"* and 10=*"Certain I can do"*. Efficacy scores were summed and divided by the total number of items to indicate the strength of perceived self-efficacy for rehabilitation.[8,175] For the purposes of this study, the mean self-efficacy score was used, where a higher score indicates greater levels of self-efficacy.

Adherence

Rehabilitation attendance and adherence to postoperative recommendations was measured using a therapy intake form that was developed by the principal author (JLT). Adherence to rehabilitation was measured in three ways. First, patient attendance at rehabilitation was monitored. For each participant, a ratio of sessions attended to sessions scheduled was calculated. Second, treating clinicians provided an average score (average for two weeks) using the Sport Injury Rehabilitation Adherence Scale (SIRAS). The SIRAS is a 3-item measure in which clinicians' rate patients' intensity of completion of rehabilitation exercises, the frequency with which they follow the clinician's instructions and their receptivity to changes in the rehabilitation program.[149] All three items are measured on a 5-point Likert Scale, and responses include *minimum effort/maximum effort, never/always, and unreceptive/very receptive*, respectively. Test-retest reliability (0.65) of the SIRAS has been previously established.[149] In addition, the SIRAS has been positively correlated with rehabilitation attendance, indicating criterion validity.[149] Finally, patient-self-reports of home exercise completion, weight-bearing restrictions, continuous passive motion (CPM) use, and bracing were measured bi-monthly using a 10-point Likert scale, where 0=none and 10=exactly as prescribed.[94]

Qualitative Questions

For the qualitative portion of the study, perspectives of patients on their pre-operative expectations for recovery and rehabilitation experiences were obtained through semi-structured one-on-one interviews. Interview guides with the following lead questions were used during interviews:

1. What were your expectations for surgery? What factor(s) influenced these expectations?

2. Have your expectations changed since surgery? If so, in what way(s)?

3. Since surgery, do you feel that your expectations for recovery have been met? Why or why not?

4. Do you feel as though your expectations were realistic? Why or why not?

5. Did your expectations for recovery influence your rehabilitation? If so, in what way(s)?

6. Are there any functional activities that you are not currently able to achieve? If so, which ones? Did you expect that you would be able to perform those activities by this time? How has the inability to perform these activities affected your daily life?

7. Describe your rehabilitation experience. What factor(s) influenced your ability to be compliant with rehabilitation guidelines and recommendations?

8. What did the physician tell you regarding what to expect following surgery? What about anything relative to rehabilitation?

Data Collection

Patients that met inclusion criteria for the quantitative study were approached during their pre-operative clinic visit. Informed consent was obtained from all participants prior to participation. Baseline demographic data including age, gender,

body mass index (BMI), and number of previous surgeries on the index knee were collected. Highest level of education was recorded as *less than high school, high school/GED, some college,* and *college degree or above.* Level of activity prior to injury was collected using the Tegner Activity Level Scale, where participants indicate the highest level of activity they participated in before their injury as well as the highest level of activity with which they are currently able to participate. Functional status and pain were assessed pre-operatively and at 6 months postoperatively with the KOOS. Patient expectations were assessed at the patient's pre-operative visit only using the HSS Knee Expectations Survey. Self-efficacy for rehabilitation was assessed during the patient's first post-operative visit to assess their confidence in performing a variety of rehabilitation exercises. Finally, patients were asked to provide the name and contact information for their treating therapist during their first post-operative visit. The treating therapist was then contacted and asked to provide measures of patient adherence to rehabilitation on a bi-monthly basis until discharge from rehabilitation.

Following data collection and analysis of quantitative data, a sub-group of participants was purposefully sampled based on results of the quantitative data. Participants that had completed their six-month follow-ups were eligible for participation and were contacted by telephone to determine their willingness to take part in the study and arrange a convenient interview time and location. Data collection was performed through semi-structured interviews conducted by the primary author (JLT). The interviewer was a certified athletic trainer (ATC) with 13 years of clinical experience and was not involved in the participants' rehabilitation. Each interview lasted approximately 30-60 minutes and took place in a quiet location chosen by the participant. All interviews

were recorded and transcribed verbatim. An interview guide was developed for use during the interview. Copies of the transcripts were sent to all participants to check the accuracy of the transcription, with an option to make changes or additions as necessary. All participant names were changed to pseudonyms to ensure confidentiality.

Statistical Analysis

Statistical analyses were performed using SPSS version 20.0 (Chicago, IL). Descriptive statistics (mean, standard deviation) were calculated for patient demographics. Univariate analyses (Pearson Correlation Coefficients (r), and independent t-tests as appropriate) were used to examine the relationships between patient expectations and functional outcome, patient satisfaction, rehabilitation adherence, and baseline demographic factors. An r value greater than 0.6 represents a strong correlation, $0.3 < r > 0.6$ represents a moderate correlation, $0.1 < r > 0.3$ represents a weak correlation, and any value less than 0.1 represents a negligible relationship.[176] A 0.10 2-sided Fisher's Z-test of the null hypothesis that the Pearson Correlation Coefficient p=0.000 will have 80% power to detect a p of 0.500 when the sample is 24.[177]

To understand the expectations of participants undergoing cartilage repair of the knee, a data analysis approach was used that encouraged reflection and interpretation. This analysis is a 6-step methodological approach based on work by Colaizzi.[106] Following transcription of the data, the transcripts were read several times in order to get an overall sense of the participants' perspective. Next, significant statements that were related to the phenomenon of interest were extracted from the transcripts. Once significant statements were extracted, duplicate statements were removed from the analysis. The process of horizontalization was used to help with the organization of the

remaining significant statements. Horizontalization is a process whereby all statements are treated as having equal value or significance.[106] Formulated meanings were then developed from the remaining significant statements. These formulated meanings were organized into clusters of themes, which were used to provide a full description of the participants' experiences. Finally, these themes were distributed to all participants (member-checks) for their feedback as a means of validating these findings.

Rigor

Several methods were used to establish scientific rigor. First, member-checks were used during data analysis to ensure that we were providing an accurate description of the participants' experience. Participants stated that the themes were representative of their experiences and no changes were necessary. Secondly, all interviews were transcribed verbatim and direct quotes from participants were used to enhance credibility of the study.[107] In addition, a researcher experienced in qualitative research reviewed the interview protocol and was available to review and challenge the emerging interpretations of data. This expert checking further acted to minimize insider bias in the interpretation of the results. Finally, epoche, or 'phenomenological bracketing', was used to validate findings. In epoche, the interviewer must put aside his or her own experience of the phenomenon in order to focus on the views or experience of the interviewee.

Synthesis of Qualitative and Quantitative Data

In the final step of the sequential explanatory mixed methods design, a connected mixed methods data analysis was employed. This type of analysis occurs when the analysis of the quantitative dataset is connected to the qualitative data set. Since the qualitative dataset was dependent on the results of the quantitative data, the qualitative

data was used to explain these results. Using the Social Cognitive Theory to guide the synthesis of the data, each qualitative theme was linked to specific results from the quantitative data through the use of direct quotes. This connection of quantitative and qualitative data was then used to draw conclusions, discuss findings, and offer clinical and theoretical implications.

RESULTS

Quantitative Results

A total of 21 subjects (9 male, 12 female) who fulfilled the inclusion criteria agreed to participate in the study and completed the baseline questionnaires prior to surgery. After surgery, SER scores were completed by 19 (90.5%) patients; 18 (85.7%) patients completed the follow-up KOOS at 3 months, and 10 (47.6%) patients completed the follow-up KOOS at 6 months. Measures of adherence were collected from rehabilitation providers on 14 (73.7%) patients. One patient was enrolled pre-operatively but is still awaiting insurance approval and has not undergone surgery at this time. In addition, one patient met all of the inclusion criteria prior to surgery but did not require a cartilage repair procedure at the time of surgery. Three patients have been classified as 'failures' during the study and required additional surgery. Also, one patient suffered an anterior cruciate ligament (ACL) during her recovery and required reconstruction. The average age of the patients was 30.8±10.7 and BMI was 29.5±5.6. Ten patients (47.6%) underwent ACI, 8 (38.1%) underwent osteochondral allograft, and 3 (14.3%) patients underwent a meniscal transplant. Prior to surgery, patients had undergone an average of 2.2±1.3 surgeries on their index knee. The mean expectation score was 67.8±16.1,

indicating moderate expectations for recovery. Baseline outcome measures are summarized in Table 5.1.

Patient Expectations and Demographics

There were no significant associations between patient expectations and patient demographics such as age, BMI, education level, number of previous surgeries, or workers compensation status. Tables 5.2 and 5.3 demonstrate the relationship between categorical variables and continuous variables, respectively.

Patient Expectations and Functional Outcome

A moderate positive correlation with expectations was seen for the pre-operative KOOS sub-domains of pain (r=0.39, p=0.08), ADL's (r=0.40, p=0.07), and QOL (r=0.42, p=0.06) (Table 5.3). This indicates that patients with greater scores on the KOOS sub-domains of pain, ADL's, and QOL had higher expectations for recovery. There were no significant correlations between patient expectations and KOOS scores at 3 or 6 months post-operatively.

Patient Expectations and Rehabilitation Adherence

There was a moderate positive correlation between patient expectations and attendance (r=0.45, p=0.10), indicating that patients with higher pre-operative expectations were less likely to cancel/no-show their physical therapy appointments. A strong negative correlation with patient expectations was seen with the frequency with which patient's follow clinician's instructions as measured by the SIRAS (r=-0.59, p=0.03), indicating that patients with higher expectations were less likely to follow clinician's instructions during rehabilitation (Table 5.3). There were no other significant correlations between patient expectations and the SIRAS. A moderate and strong

negative association with patient expectations was seen for patient-self reports of adherence with their HEP (r=-0.54, p=0.07) and adherence with weight-bearing restrictions (r=-0.63, p=0.04), respectively (Table 5.3). This indicates that patients with high expectations for recovery are less likely to adhere to their home exercise program or their weight-bearing restrictions. There were no significant correlations between patient expectations and self-reports of adherence with CPM or brace use.

Self-Efficacy and Rehabilitation Adherence

A moderate negative relationship with self-efficacy, as measured by the SER, was seen for patient-self reports of adherence with brace use (r=-0.58, p=0.08), indicating that patients with higher degrees of self-efficacy were less likely to comply with guidelines for the use of their brace (Table 5.4). There were no other significant correlations between the SER and rehabilitation adherence.

Qualitative Results

A total of six participants that were a minimum of six months post-surgery agreed to participate in semi-structured interviews. The average age of participants was 36 years and the mean expectation score was 71.0. For more detailed information on participants, refer to Table 5.5. A total of 104 significant statements were identified from six transcribed interviews and a total of 18 formulated meanings developed through the process of horizontalization. Four themes emerged related to patient's expectations for recovery following cartilage repair of the knee: *1) the expectation of returning to a normal life, 2) recovery is a journey, not a race, 3) past recovery experiences influence expectations, and 4) understanding expectations for recovery: the caregiver's role.* Each theme is described below, using verbatim quotations from participants for support.

Theme 1: The expectation of returning to a regular life

This theme captured patient's expectations for recovery following cartilage repair of the knee and describes their desire to return to a regular life. Even though several of the participants were very active prior to their knee injury, they all recognized that participating in high-level competitive athletics was not a realistic expectation. Rather, they all spoke about their desire to return to "normal" and to a "regular life" after recovery. For some individuals, "regular" entailed recreational sports, while for others "regular" indicated a return to daily activities that were not possible after the injury. Donna talked about her expectations for recovery, in the context of her "normal":

> *"I was hopeful that I would be able to get back to a functional level. And be able to do all of the things I did before all of the cartilage stuff happened. Going for walks, working in my hard, driving my riding lawn mower to mow my two acres. Playing outside with my daughter. Bending and kneeling to do gardening. Walking on the beach on vacation."*

In addition to the expectation that surgery would allow them to return to a regular life, participants also expected that surgery would provide a longer shelf-life for their knee. Most of the participants recognized that this surgery was likely their last option before undergoing a total knee replacement and they were hopeful that this would buy them time thus allowing them a return to "normal" in the meantime. Part of returning to a regular life and increasing the shelf-life of their knee was being selective on what activities they returned to following surgery. Carrie understood the importance of being selective with her activities:

> "*I gotta be more selective if I want this joint to last. I mean and I guess that was kind of the other thing knowing that this was the last ditch for this joint before a total knee. And they won't even look at me until I'm 20 years older. And you know I didn't want to limp this along so now I think OK, maybe jumping and parachuting isn't the thing I need to be doing on my joints. You know, maybe I can be happy with, you know, I can still repel. I can still rock climb. But you*

know some of these higher things I can't do. Physically I have no business doing them."

Participants recognized that returning to high level activity was not a realistic expectation of their surgery and that returning to a regular life was more important for the long-term health of their knee.

Theme 2: Recovery is a journey, not a race

The second theme that emerged describes participant's expectations that rehabilitation would progress faster than anticipated, the importance of motivation in their recovery, frustration with the slow-pace of improvement, and difficulty complying with exercises once formalized rehabilitation ended. Initially, many of the participants acknowledged that the recovery process was much slower than expected and progress did not happen as quickly as they expected. Ryan said,

"I actually expected therapy to move along a little faster than what it did. Than what the protocol said. As far as what I could and could not do. And really that's been the overall thing that I guess I thought the recovery time wasn't going to be as long as it's gonna be. You know, that was the misconception in my head."

Many of the participants spoke about their frustration with the time it took to return to certain functional activities. As time went on, even amidst their frustrations, participants began to realize that recovery would not happen overnight. Rather, it was a long and slow process and they were merely starting their journey. Donna spoke about the importance of motivation and optimism during the recovery process:

"They need to be motivated. They need to have a very positive outlook. Because there is a lot of time when you're down. And there's a lot of time when you're in pain. And it's very easy to slip into kind of a feel sorry for me mode. Or I can't do anything mode. And the part of it they need to understand is that it's a journey. And it's not a race. And you have to do lots of little steps to get to where you want to be. So I think if they understand that up front."

Participants also recognized that even though recovery was long, complying with the guidelines was necessary for achieving their goals. However, most of the participants found it difficult to comply with their exercises after being discharged from formal therapy. Ryan admitted that he was having a difficult time progressing at home:

> *"I mean I still do it but it's not as regimented as therapy was. I think my progress could be a little faster if I was in therapy. Only because I can do more there than what I can at home. They have more, better equipment. You know, all I have at home is an exercise bike and a band."*

While participants expected greater progress early on, they begin to realize that their recovery was a journey that would require patience, time, motivation, and commitment on their part if their expectations were to be reached.

Theme 3: Past recovery experiences influence expectations

This theme emerged as participants described the different factors that influenced their expectations for recovery. For many participants, previous surgeries and the knowledge that came from these experiences helped to shape their expectations. Two of the participants had previously undergone a cartilage repair surgery that had been unsuccessful and they were recovering from a second cartilage repair procedure. Carrie spoke at length about how her expectations and preparation changed from the first procedure to the most recent surgery:

> *"The first surgery, before, I thought this was the miracle cure. That I wouldn't have any problems. That it was going to be a fix-all. My expectations were probably through the roof. But I wasn't ready for it. I emotionally was not ready for it. My husband was not physically ready for it. The house was not ready for it. I didn't realize I was gonna be on crutches as long as I was. I don't know if I had an expectation [for the second surgery]. I don't know. But my family knew what to expect this time."*

Participants acknowledged that previous experiences shaped their expectations for recovery, but that their level of knowledge regarding the procedure and information provided from friends and family also helped shape their expectations. Lisa had previously undergone an anterior cruciate ligament (ACL) reconstruction and her expectation was that recovery following osteochondral allograft would be similar. However, her mother recognized the severity of her surgery:

> *"It [procedure] was new. I had never heard of it before. When he [surgeon] first told me I didn't really understand the significance of the surgery so it wasn't like major to me until I think I told my Mom and she was like that's really a serious surgery, you getting someone else's cartilage put inside of you. But it didn't dawn on me when he [surgeon] told me cause I actually thought it was like maybe another ACL surgery and I was like OK."*

Participants also discussed the importance of being educated about the recovery process. Several of the participants researched the surgical procedure and the rehabilitation process on their own, while others gained most of their knowledge through information that the surgeon provided during their pre-operative visit. Regardless of the source of their knowledge, all participants believed that the level of knowledge they had regarding the recovery process influenced their expectations. Donna spoke about the importance of educating herself:

> *"At the time of the visit, I didn't know anything. It was after the visit when I went home and he [surgeon] had given me the website and I went on that and did a lot of reading about the surgery and the rehab. And then I started researching it on the internet, looking at research studies and so I felt pretty confident because there was a high success rate with it. I think for me, being college educated and being a professor, I'm at a higher level of knowing where to look and how to interpret information. But I think a video would be great. I think a class would be a good idea. For people to really understand what to expect".*

Theme 4: Understanding expectations for recovery: the caregiver's role

The final theme emerged as participants described their experiences in recovery being dependent on others for support. All of the participants stated that recovery is not possible without assistance, especially in the short-term when they have significant limitations. Many of the participants, particularly the ones that had not previously undergone a cartilage repair procedure, spoke about the difficulty of needing to depend on others for their own recovery. Carrie said:

> *"You know that's a really long time when you're on crutches and you're non-weight-bearing and you're having to ask everybody and their brother to do things for you."*

Participants agreed that it was necessary for their primary caregiver(s) to understand the expectations for recovery as well and this happens best when the caregiver is present during the patient's pre-operative visit with the surgeon. Several of the participants felt that if their caregivers had had a better sense of what to expect regarding their recovery, it would have made the recovery process easier. Donna spoke about her Mother's role in her recovery process:

> *"Since my Mom was going to be the primary person that was going to help me, I think it would have been good for her to experience the same thing I was going to before the surgery happened. Because then she would better understand that this is why I can't do this. And if they understand what is going on with you, they are less likely to be resentful or to kind of feel like you're just laying around and they're having to do everything."*

Not only do patients need to be fully informed of what to expect following surgery, but the individuals providing care need to be informed of these expectations as well.

DISCUSSION

Using the Social Cognitive Theory as a framework, we examined the impact of patient expectations and self-efficacy on baseline function, rehabilitation adherence, and post-operative function. Several findings emerged from this mixed-methods study. Results demonstrated that while patient expectations do not appear to be related to pre-operative symptoms (e.g. swelling, stiffness, mobility) or higher level physical function (e.g. running, jumping), they do appear to be related to a patient's perceived level of pain with ADL's and overall knee-related QOL. Furthermore, patient expectations do not appear to be associated with outcomes in the short-term (3-6 months post-surgery). While unexpected, patient expectations and self-efficacy were not positively associated with adherence to post-operative guidelines as previously thought. The qualitative study offered insightful glimpses into patient's expectations for recovery and what influenced those expectations. It also helped to highlight the need for patient and caregiver education programs prior to surgery.

In an effort to better understand the quantitative results, the qualitative results will be discussed first and then linked to specific results from the quantitative aims. Four themes emerged from the qualitative data: *the expectations of returning to a regular life, recovery is a journey, not a race, past recovery experiences influence expectations, and understanding expectations for recovery: the caregiver's role*. The patients enrolled in this study had moderate expectations for recovery. Previous studies evaluating expectations in patients undergoing ACI and total joint arthroplasty have demonstrated high expectations for recovery.[103,157,178] Niemeyer et al, in their examination of patient expectations prior to undergoing ACI, found that greater than 70% of patients expected

pain-free sports participation.[103] The participants in this study expected to return to a regular life. For some, this was a return to recreational sports, but for others, returning to a regular life meant returning to normal, everyday activities that they had been unable to perform as a result of their injury. While several of the participants had previously participated in a high level physical activity prior to their injury (e.g. basketball, running, baseball), they recognized that although they desired to return to that level, it was not likely. Rather, their expectation was to return to a regular life that was free of symptoms. Several of these participants stated that the surgeon had recommended discontinuing high level athletics following surgery. This may have contributed to the notion that participants expected to return to a regular life. In a recent study evaluating expectations in 1,035 patients undergoing total hip arthroplasty (THA), patients were asked a single, open-ended question: "*What things do you think you might be able to do in a year's time, that you NEED to be able to do, but CANNOT do now, if the surgery is a total success*?" In addition to pain relief and managing ADL's, patients expected a return to a "normal life".[179] The similar finding in this study is not surprising given the symptomatic nature and chronicity of chondral lesions of the knee.

Participants recognized that recovery was a journey, not a race. For several of the participants, this lengthy recovery process was unanticipated. Even at six months post-surgery, many of the participants were still limited in their activities. This was a source of frustration for two of the participants who had hoped to return to running by this time but had not been cleared to begin a running program. Participants acknowledged that part of their journey of returning to full activity was continuing with their prescribed rehabilitation. All but one participant had been discharged from therapy and had been

prescribed a home exercise program. However, many of the participants admitted that they were having a difficult time adhering to this program, mostly due in part to a lack of motivation. This is not surprising given the literature on non-compliance which has demonstrated that 63% of patients do not adhere fully to their home exercise programs,[138] even though adherence to a prescribed rehabilitation program is oftentimes associated with successful outcomes.[150] Regardless of their expectations, participants' motivation began to decrease over time and their confidence in performing the exercises on their own became difficult. All participants noted that their initial confidence for success in rehabilitation was high but once they realized how much longer their recovery process would last, they became frustrated and lacked motivation to continue.

The third theme that emerged from the data was that patients' past recovery experiences shaped their expectations. Patient's expectations for recovery are shaped by many factors, including information from their physician, media, friends or relatives, and their own past experience(s). Two of the participants had previously undergone cartilage repair procedures and were able to use their experiences to prepare them for their second procedure. However, one of the participants had previously undergone an anterior cruciate ligament reconstruction (ACLR) and she expected that the recovery process following osteochondral allograft would be similar to her ACLR recovery. Past experiences, therefore, may lead to realistic or unrealistic expectations. Since expectations have the ability to influence outcome, it is necessary that these expectations are discussed with the patient and their caregiver so that patients have an accurate picture of the recovery process. Realistic expectations help patients develop manageable goals

and strategies to reach these goals. Furthermore, by achieving realistic goals, self-efficacy is enhanced, enabling patients to achieve even greater functional outcomes.[116]

In this study, participants that had previously undergone a failed cartilage repair procedure felt that they were more prepared for recovery the second time. They also felt that their caregivers were more prepared for their recovery. Participants that had not previously undergone cartilage repair were unprepared for recovery. Their caregivers were also unprepared for recovery. The primary caregiver plays a pivotal role in the patient's recovery and therefore must be encouraged to be present for pre-operative education along with the patient. Since formalized patient education is not currently the standard of care for patients or caregivers undergoing cartilage repair of the knee, it is the authors' recommendation that education programs be developed to address and manage expectations prior to surgery. Using the Social Cognitive Theory, good intentions (e.g. adherence) are more likely to be translated into action when patients develop success scenarios and preparatory strategies.[167] Preparatory strategies can only occur when patients and caregivers are fully informed of the recovery process. These preparatory strategies include pre-operative education for both the patient and the caregiver. Suggestions for specific education topics with the primary caregiver should include assistance with getting in and out of bed, showering and bathing, and driving to therapy. Pre-operative education will allow patients and their primary caregivers to establish realistic outcome expectations. Furthermore, by talking with individuals that have successful navigated recovery, efficacy expectations are likely to increase. The combination of high efficacy expectations coupled with realistic outcome expectations is more likely to lead to successful outcomes in the long-term.

The first aim of this study was to evaluate the relationship between patient expectations and pre-operative functional status. Our hypothesis that there would be a positive relationship between patient expectations and the KOOS was partially accepted as patient expectations were positively associated with pain, ADL's and QOL but not associated with symptoms and sport-and-recreation. This indicates that patients with less pain, higher functional ability with daily activities, and higher perceived QOL had greater expectations for recovery following cartilage repair of the knee. These results are in partial agreement with previous literature evaluating expectations in patients undergoing total knee arthroplasty (TKA). In these studies, patient expectations were positively associated with pre-operative KOOS QOL[178] scores as well as pre-operative WOMAC pain scores and SF-36 Mental Health Scores.[154] Given these findings and the findings from this study, it appears that patients do not alter their expectations based on the pre-operative status of their knee. In other words, patient's expectations are not tied to symptoms but rather to their overall function and life modifications. Of interesting note is the similarity between questions on the KOOS sub-domains of pain, sport-and-recreation, and symptoms with questions on the HSS Knee Surgery Expectations Survey. Given these similarities, one would expect that that patient expectations were most closely aligned with pain, sport activity, and symptoms; however, in this study, patient expectations were most closely aligned with ADL's and QOL. This suggests that there are other factors, including psychosocial factors, that influence patient expectations for recovery following cartilage repair of the knee that must be assessed independently from patient self-reports of pain and function.

The first theme, *expectations of returning to a regular life* best coincides with patient's expectations being positively associated with pre-operative pain, ADL's and QOL scores. The HSS Knee Surgery Expectations Survey asks patients to rate their expectations for pain relief, functional activity, and psychological well-being. Based on an item analysis from the expectations survey, patient's highest expectations were relief of pain, improve ability to perform daily activities, have confidence in the knee, improve ability to maintain general health, improve ability to interact with others, and improve psychological well-being. This not only explains the relationship between patient expectations and pre-operative pain, ADL's, and QOL, but also the participants' desire to return to a 'regular' life.

We hypothesized that there would be a positive association between patient expectations and functional outcome, as measured by the KOOS, six months post-operatively. However, results indicated that there was no significant associations between pre-operative patient expectations and functional outcome at six months. Although patients demonstrated significant improvements in both symptoms and ADL's from baseline to six months, this did not appear to correlate with their expectations for recovery at this time point. Previous studies that have evaluated the relationship between patient expectations and post-operative function have found that patients with greater expectations had greater improvements in pain relief and physical function, as measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Short-Form 36 (SF-36) in patients undergoing total joint arthroplasty.[154,158,179] However, these improvements in pain and function were noted 12 months post-surgery. To date, there is only one study in which patient expectations were predictive of better physical

function and pain as early as six months post-operatively in patients undergoing total joint arthroplasty.[117] Since improvements in function following cartilage repair procedures have been shown to continue as late as 12 and 24 months post-operatively, it is likely that improvements in this study were not great enough in the mid-term to demonstrate a relationship between patient expectations and outcome. The relationship between patient expectations and functional outcome in the long-term (12-24 months) needs to be established in this patient population. An interesting finding in this study was the negative association between patient expectations and adherence to home exercise programs and weight-bearing restrictions. It would be expected that patients with high expectations for recovery would be more compliant with post-operative recommendations during rehabilitation. This has previously been supported in a study assessing adherence following heart transplantation. In this study, authors found that higher pre-operative expectations predicted adherence to a medical treatment regimen three months following surgery.[118] While it is difficult to explain an inverse relationship between patient expectations and adherence, the Social Cognitive Theory may provide support for this finding. The Social Cognitive Theory suggests that individuals will change their behavior (adherence) if they believe that their behavior will change the outcome and if they believe they are capable of changing the behavior (self-efficacy).[169] Hence, even if patients have high expectations for recovery, this does not necessary imply that they will adhere to their rehabilitation program. There are other factors that influence their outcome, such as motivation and self-efficacy. Furthermore, pre-operative expectations may be clouded by a lack of knowledge and/or experience

regarding the recovery process and therefore may not be predictive of rehabilitation adherence.

Adherence has previously been associated with factors such as attribution of personally controllable factors[96] and the importance or value of rehabilitation to the patient.[124] Therefore, it is possible that patients may have attributed successful outcomes following cartilage repair to factors outside of their control, (e.g. quality of the repair, defect characteristics) rather than their own effort. To date, only one study has examined patient expectations and knowledge regarding ACI. In this study, the majority of patients (55%) considered defect characteristics the most important factor concerning clinical outcome following ACI compared to 7.6% of patients that considered post-operative rehabilitation an important factor.[103] This demonstrates that patients not only underestimate the value or importance of rehabilitation but also believe that achieving successful outcomes is outside of their control. Furthermore, an inverse relationship has previously been established between adherence and ego involvement in injured patients. In this study, injured patients being treated in a sports-medicine clinic were categorized as ego-involved and not ego-involved. Adherence was measured by the number of missed appointments as well as practitioner ratings of effort and progress. Results suggested that patients low in self-esteem and high in ego-involvement tended to miss the most treatment sessions.[180] Therefore, it is possible that participants in this study with high pre-operative expectations also exhibited higher egos such that they believed they were capable of walking without the brace or complying with their home exercise program. Further investigation into the causes of non-compliance is necessary in this patient population.

We hypothesized that there would be a positive association between self-efficacy and rehabilitation adherence. The results of this study demonstrated that there was actually an inverse relationship between self-efficacy and rehabilitation adherence, with a significant negative association between self-efficacy and self-reports of adherence with bracing. This is interesting given the paucity of literature demonstrating that self-efficacy is positively associated with post-operative recovery in patients with various types of surgical procedures.[181-183] Given that self-efficacy is considered contextual and situational-dependent as opposed to a global trait, it is possible that patients were confident about their ability to be successful in rehabilitation but once they started formal therapy, these efficacy expectations may have changed. Previous research investigating the temporal nature of self-efficacy has concluded that self-efficacy may change over the course of rehabilitation. In a study by Wesch et al, self-efficacy was evaluated every two weeks during an eight-week rehabilitation period. While task self-efficacy remained stable over the course of the eight week treatment program, coping self-efficacy declined, suggesting that a patient's competence to perform tasks under challenging conditions may decrease over time as patient's are unable to find the time to adhere to the treatment program.[184] Therefore, self-efficacy in patients undergoing cartilage repair of the knee should be assessed at multiple time points throughout the recovery process. Self-efficacy has also been shown to diminish in patients that are anxious or tense.[167] Furthermore, without verbal reinforcement, encouragement, and personal mastery of a skill, self-efficacy beliefs may change.[167] Therefore, it is important that rehabilitation providers not only assess self-efficacy during an intervention but also address low self-efficacy through verbal reinforcement and feedback, setting short-term goals, and attributing a patient's

progress to their own abilities and efforts. It is also important to note that self-efficacy regarding an individual's capabilities during supervised exercise may not generalize to unsupervised exercise at home. This has implications for patients relative to adherence in the long-term.

The second qualitative theme, *recovery is a journey, not a race*, most closely aligns with the results from Aims 2-4. We did not find a relationship between patient expectations and post-operative KOOS scores. This may be a function of the lengthy recovery process associated with chondral repair. Oftentimes patients are limited in the intensity of activity they can undertake up to 12 months post-surgery due to the lengthy time required for graft maturation. While many other surgical procedures of the knee often see a linear trend of recovery (ACL, meniscectomy, TKA), this is often not the case with patients undergoing cartilage repair. Patients may not see significant improvements in pain and function until as late as six months post-surgery. Recovery is not a race; rather, it is a lengthy process that requires motivation, commitment, and patience. Previous research has shown moderate to strong relationships between self-efficacy and adherence in the short-term[184]; however, self-efficacy about capabilities during supervised exercise may not always transfer to unsupervised exercise at home. The loss of motivation and inability to adhere fully to a home exercise program may explain the inverse relationships between patient expectations and adherence as well as the inverse relationship between self-efficacy and adherence. Considering the Social Cognitive Theory, outcome expectations may mediate patient's initial motivation with the recovery process while efficacy expectations influence maintenance of this recovery process.

Since recovery following cartilage repair of the knee is such a lengthy process, motivation and self-efficacy are critical for maintaining adherence in the long-term.

The last two qualitative themes, *past experiences influence expectations* and *the role of the caregiver in the recovery process* were not represented in the quantitative data but are important aspects identified in recovery by participants and have implications for clinical care. The close connection between patient expectations pre-operatively and outcomes after total joint arthroplasty[154,158,179] highlight how important it is that surgeons and other health care professionals talk to their patients and caregivers about what they can realistically expect from surgery. This information can help to shape patient expectations, which therefore may lead to fulfillment of expectations in the long-term. Burton et al observed that the majority of patients who reported not meeting their expectations after hip replacement felt that they had not been given sufficient information about the operation by their surgeon.[185] Realistic expectations help patients develop attainable aims about their recovery and the support strategies to achieve them. Also, achieving realistic goals can improve self-efficacy, enabling patients to achieve even greater functional outcomes.

LIMITATIONS

There are several limitations of this study. First, because this is a correlational study, it is difficult to establish cause and effect into what may influence a patient's pre-operative expectations. However, other factors such as the patient's previous experience, knowledge, and character traits captured qualitatively enabled us to broaden our understanding of patient expectations and factors that influence them. Furthermore, we did not attempt to standardize the methods of pre-operative patient education or

rehabilitation following surgery. While this limits our ability to determine what factors influence expectations, we believe it allowed us to present a more relevant picture of true clinical practice. At the time of data analysis, only 48% of patients enrolled have completed their six-month follow-ups so we are limited in the ability to accurately establish relationships with so few participants. Furthermore, functional improvements following cartilage repair continue 12 and 24 months post-operatively. Therefore, the relationship between patient expectations and functional outcome in the long-term must also be assessed. Capturing patient adherence requires collaboration on the part of the researcher and clinician(s). While the majority of therapist's completed bi-monthly adherence measures with their patients, five therapists did not report these values. It is unknown whether the results would have been different if data were available. Finally, it is difficult to generalize our qualitative findings and understand that the participants' views may not be representative of all patients that undergo cartilage repair of the knee. However, their perspective allowed us to provide a better explanation of the relationships or lack of relationships present in this study.

CONCLUSIONS

Our research highlights that no single approach or tool is available for assessing and managing patient expectations or improving self-efficacy and rehabilitation adherence following cartilage repair of the knee. It does, however, require a collaborative effort between physicians, researchers, patients, and rehabilitation providers. A patient's expectation and understanding of the recovery process is influenced by a variety of sources. The integration of information by patients via the variety of sources is translated into actions. This process is based on their individual

attitudes, beliefs and past experiences. Patient and caregiver education will improve patient understanding of the process and may lead to increased participation, enhanced self-efficacy, and empowerment necessary for the long journey of recovery following cartilage repair of the knee.

Table 5.1 Baseline Outcome Measure Scores

Outcome Measure	Mean±SD
KOOS	
Pain	56.2±21.5
Symptoms	48.4±14.8
ADL's	68.7±20.6
Sport-and-Recreation	26.9±29.3
Quality-of-Life	26.7±19.6
Expectations Score	67.8±16.1
Tegner Activity Scale	3.2±3.0
Average SER Outcome Score	7.3±1.6

Abbreviations: KOOS: Knee Injury and Osteoarthritis Outcome Score; ADL's: Activity Daily Living; SER: Self-Efficacy for Rehabilitation Outcome Scale

Table 5.2 Relationships between Categorical Variables and Patient

		Expectations Scores	
	N (%)	**Mean±SD**	**p-value**
Sex			0.97
Male	9 (42.9%)	68.7±18.8	
Female	12 (57.1%)	67.1±14.6	
Surgical Procedure			0.6
ACI	10 (47.6%)	67.8±13.5	
Osteochondral Allograft	7 (33.3%)	62.3±12.7	
Meniscal Transplant	3 (14.3%)	71.4±28.0	
Smoking Status			0.71
Non-Smoker	17 (81.0%)	68.1±15.3	
Current Smoker	3 (14.3%)	70.3±25.5	
Former Smoker	1 (4.8%)	55.4	
Workers' Compensation			0.17
No	17 (81.0%)	70.5±16.3	
Yes	4 (19.0%)	56.5±10.5	
Time Since Onset			0.33
<1 Month	0 (0%)		
1-3 Months	4 (19.0%)	78.8±12.0	
4-12 Months	6 (28.6%)	64.1±8.4	
>12 Months	11 (52.4%)	65.8±19.5	
Education			0.6
Less than High School	2 (9.5%)	70.7±4.6	
High School/GED	1 (4.8%)	45.7	
Some College	7 (33.3%)	72.4±17.7	
College Degree or Above	11 (52.4%)	66.1±16.2	

Abbreviations: ACI: Autologous Chondrocyte Implantation; GED: General Educational Development

Table 5.3 Pearson Correlation Coefficients for Patient Expectations (HSS)

		Pearson Correlation Coefficients	p-value
Age		-0.29	0.2
BMI		-0.12	0.6
Number of Previous Surgeries		-0.24	0.29
Tegner Activity Score		0.25	0.28
KOOS			
Pain		0.39	0.08*
Symptoms	Pre-Operative	0.1	0.97
ADL's	(n=21)	0.4	0.07*
Sport-and-Recreation		0.32	0.15
QOL		0.42	0.06*
KOOS			
Pain	3 Months	0.19	0.46
Symptoms	Post-	-0.32	0.19
ADL's	Operative	0.02	0.94
Sport-and-Recreation	(n=18)	0.12	0.65
QOL		-0.07	0.78
KOOS			
Pain	6 Months	-0.37	0.29
Symptoms	Post-	-0.004	0.99
ADL's	Operative	0.15	0.67
Sport-and-Recreation	(n=10)	0.09	0.81
QOL		-0.22	0.55
Average SER			
Outcome Score	(n=19)	0.05	0.84
Attendance Ratio	(n=13)	0.45	0.10*
SIRAS			
Intensity		-0.20	0.52
Frequency	(n=13)	-0.59	0.03*
Receptivity		-0.14	0.64
Adherence			
HEP		-0.54	0.07*
WB	(n=13)	-0.63	0.04*
CPM		0.13	0.71
Bracing		-0.49	0.15

*p≤0.10; Abbreviations: KOOS: Knee Injury and Osteoarthritis Outcome Score; ADL's: Activities of Daily Living; QOL: Quality-of-Life; SER: Self-Efficacy for Rehabilitation Outcome Score; SIRAS: Sport Injury Rehabilitation Adherence Scale; HEP: Home Exercise Program; WB: Weight-Bearing; CPM: Continuous Passive Motion

Table 5.4 Pearson Correlation Coefficients for SER Outcome Score with Rehabilitation Adherence (n=13)

	Pearson Correlation Coefficients	p-value
Attendance Ratio	-0.03	0.91
SIRAS		
Intensity	0.35	0.26
Frequency	-0.22	0.49
Receptivity	0.28	0.38
Adherence		
HEP	-0.14	0.64
WB	-0.36	0.25
CPM	-0.27	0.42
Bracing	-0.58	0.08*

***** $p \leq 0.10$; Abbreviations: SER: Self-Efficacy for Rehabilitation Outcome Score; SIRAS: Sport Injury Rehabilitation Adherence Scale; HEP: Home Exercise Program; WB: Weight-Bearing; CPM: Continuous Passive Motion

Table 5.5 Participant Characteristics

Subject	Age	Occupation	Number of Previous Surgeries	HSS Expectations Score	SER Score
"Carrie"	39	Planning	3	81.5	7.7
"Matthew"	45	Student	4	55.4	7.0
"Ryan"	34	Computer Programmer	1	76.1	8.8
"Lisa"	21	Women's Basketball Coach	2	68.5	8.7
"Keith"	26	Physical Therapy Student	2	76.1	6.7
"Donna"	51	Nursing Professor	2	68.5	9.1

Abbreviations: HSS (Hospital for Special Surgery); SER (Self-Efficacy for Rehabilitation Outcome Score)

Figure 5.1 Bandura's Social Cognitive Theory[167]

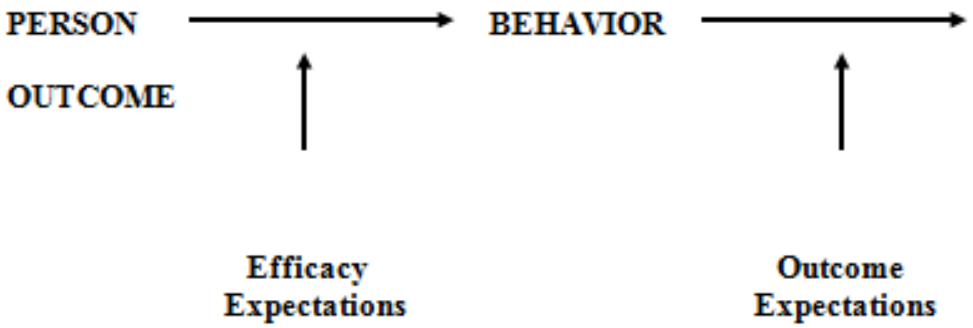


Figure 5.2 Sequential Explanatory Design

CHAPTER 6: SUMMARY

The primary purpose of this dissertation was to investigate current rehabilitation practices following cartilage repair of the knee in an attempt to better understand the role of rehabilitation and its impact on patient care and outcomes. The individual purposes of each chapter of this dissertation were 1) to systematically review the current evidence for rehabilitation interventions and progressions following ACI, 2) to assess the consistency of the documentation process relative to post-operative rehabilitation in order to provide information and guide initiatives for improving the quality of rehabilitation practices following ACI, 3) to explore and describe patients' experiences during the recovery process following ACI, 4) to explore and describe the experiences of rehabilitation providers' experiences during the rehabilitation process following ACI and to determine what strategies they employ to improve outcomes, encourage rehabilitation adherence, and establish positive therapist-patient relationships, and 5) to examine and explore the relationships between patient expectations, functional outcome, self-efficacy, and rehabilitation adherence in patients undergoing cartilage repair of the knee.

Synthesis and Application of Results

From these investigations, several observations and recommendations for clinical application can be made regarding rehabilitation following cartilage repair of the knee:

1. The evidence base for rehabilitation following cartilage repair of the knee is still lacking. Until further evidence becomes available, rehabilitation following cartilage repair of the knee will continue to be based on tissue healing properties, clinical biomechanics, patient characteristics, and patient expectations and goals. A more detailed rehabilitation protocol has been developed that is both goal-oriented and time dependent. Implementation of this rehabilitation protocol into clinical practice will serve as a guideline for clinicians in developing and implementing an individualized plan of care for patients recovering from cartilage repair (Appendices A and B).
2. While current practices are able to systematically document patient characteristics, defect characteristics, and patient-reported outcome measures, there is currently no system in place for the systematic documentation of rehabilitation practices. The most important components of a rehabilitation plan following cartilage repair include: restoration of ROM (including CPM use), improvement of neuromuscular control and strength, progressive weight-bearing, and rehabilitation adherence. Until we are able to consistently and systematically document these specific components of rehabilitation over time, we will not fully understand how rehabilitation practices influence outcomes following cartilage repair of the knee. As a result, a data collection form was developed that will allow rehabilitation providers' a means for capturing these outcomes in cartilage patients over time (Appendix C).

3. Patients and rehabilitation providers alike acknowledge that patients do not have realistic expectations for recovery following cartilage repair procedures. Patients are often unprepared for the significant restrictions in the short-term as well as the time it takes for full recovery. Patient expectations need to be assessed and managed appropriately, both pre-operatively and post-operatively. Formalized education, similar to total joint arthroplasty programs, will provide patients and their caregivers a better understanding of what to expect during the recovery process. Patient education, either in the form of on-site classes or through the use of DVD's, should highlight the surgical procedure, short-term expectations regarding weight-bearing and ROM restrictions, typical rehabilitation exercises, and a general time line for recovery based on tissue healing. In addition, speaking with patients that have successfully recovered from cartilage repair procedures may alleviate anxiety and fear on the part of the patient.
4. Cartilage repair procedures are not common and therapists practicing in rural settings with limited experience and access to the treating physician may require additional information and training regarding chondral lesions. This can occur in multiple ways: first, as stated previously, a more detailed rehabilitation protocol has been developed which includes the exact location and size of the lesion. This will allow clinicians to individualize their rehabilitation programs. These updated protocols are also goal-oriented which provide clinicians additional information on when it is appropriate to progress patients to the next phase. Second, continuing education workshops and/or conferences should be developed in which the physician and researchers share with clinicians the best available

evidence relative to patient outcomes and rehabilitation following cartilage repair of the knee.

5. Overall, patients are fairly compliant with rehabilitation in the short-term. However, adherence to home exercise programs in the long-term is difficult and may explain the strength and functional deficits that persist two years post-surgery. While not every clinic has the capability of offering wellness programs, patients should be encouraged by their physician and rehabilitation provider to take advantage of these wellness programs so that patients have accountability and access to the appropriate equipment to continue their recovery.
6. Clinicians should be provided with tools that both assess and enhance self-efficacy in patients recovering from cartilage repair procedures. The SER is a tool that evaluates self-efficacy relative to specific tasks in rehabilitation and can be used to assess changes in self-efficacy over time. There are a variety of techniques clinicians can use to enhance self-efficacy. These include: establishing short-term goals so patients are able to see progress and mastery of skills, providing consistent and positive feedback and by attributing progress to the patient's abilities and efforts.

Future Research

This dissertation reviewed current rehabilitation practices following cartilage repair of the knee and examined the role of rehabilitation from both a quantitative and qualitative perspective. Overall, patients undergoing cartilage repair procedures have moderate yet unrealistic expectations for recovery. These expectations may influence their motivation and ability to adhere to a treatment program. Future research should

continue to evaluate patient expectations relative to patient outcomes. However, it is necessary to evaluate patient expectations relative to long-term outcomes (e.g. 12-24 months) as there is evidence that improvements continue beyond six months. In addition, it is important to identify factors that may influence patient expectations, such as age, gender, activity level, previous surgical history, etc. as identifying these factors may assist with patient selection and education. Formalized patient education is not the current standard of care for patients undergoing cartilage repair and it is the authors' belief that patients will benefit from pre-operative education. Future studies should examine whether patients that participate in formal pre-operative patient education have higher satisfaction and rehabilitation adherence rates and demonstrate superior short- and long-term outcomes compared to patients that do not participate in pre-operative education.

In addition to developing and evaluating pre-operative education programs for patients undergoing cartilage repair procedures, it is necessary to identify which components of rehabilitation influence outcome. Future research should evaluate the impact of early weight-bearing, CPM use, and adherence (as measured by attendance, practitioner ratings of adherence, and self-reports of adherence) on short- and long-term outcomes. There is basic science literature to support CPM use for articular cartilage healing but there is minimal evidence to support the use of CPM in human subjects following cartilage repair and this is an avenue that should be explored. Also, international studies have investigated outcomes following accelerated weight-bearing in individuals undergoing matrix-induced autologous chondrocyte implantation (MACI); however, the effectiveness of accelerated weight-bearing has not been studied relative to

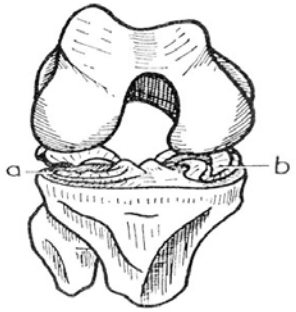
ACI or other cartilage repair procedures. Finally, the impact of recovery on patients in the long-term has not been evaluated from a qualitative perspective and would shed light not only on the durability of cartilage repair procedures but also on how patients' experiences and expectations changed over time.

Appendix A: Rehabilitation Protocol: Tibiofemoral Lesions

Defect Location:_____

Concomitant Procedure:_____

Defect Size:_____



Phase I: Proliferation

Goals

1. **Minimal or no effusion (grade 0 or 1+) by week 6**
2. **Minimal or absent pain (VAS less than 3/10) by week 6**
3. **Increase ROM**
   - Extension: achieve full passive extension by week 2
   - Flexion: see goals below in ROM progression
4. **Patient understanding and compliance with WB restrictions**
   - See below for WB progression goals
5. **Improve neuromuscular control**
   - 10 straight leg raises without evidence of extension lag by week 6

CPM Guidelines	ROM Progression	Weight-Bearing Progression	Brace	Strength Progression	Criteria for Progression
Begin CPM 0°-30° -6-8 hours/day at 1 cycle/min Increase 5°-10° daily as tolerated Discontinue CPM week 6	Restore full passive knee extension immediately Patellar mobilizations 4-6 times/daily Goals for knee flexion ROM: -90° by week 2 -105° by week 3 -115° by week 4 -120°-125° by week 6	Non-weight-bearing for 2 weeks -May begin toe-touch weight-bearing if lesion <2.0 cm^2 (per physician) Begin PWB (25% body weight) at weeks 2-4 Progress PWB (50% to 75% body weight) at weeks 4-8 Begin pool therapy (if facilities are available) at week 4: -Walking in chest-deep water: 25% body weight -Walking in waist-deep water: 50% body weight	Locked at 0° during all weight-bearing activities for 2 weeks -Remove for CPM use/exercises Gradually open brace 20° at a time as quad control is gained between 2-4 weeks Discontinue use of brace at 6 weeks if no evidence of extensor lag with SLR	Quadriceps sets/SLR (4 directions) for 1-2 weeks -SLR in brace if poor quadriceps control Active knee extension 90°-40° (no resistance) Begin progressive closed chain exercises at 2-6 weeks May begin stationary cycling (with minimal resistance) when ROM allows	Minimal pain and swelling Achievement of full passive knee extension Active, pain-free knee flexion of 90° Voluntary quadriceps contraction ****Earliest progression to Phase II: 4 weeks**

Phase II: Transition/Loading: no earlier than 4 weeks

Goals:

1. **Increase ROM**
   - Maintain full passive knee extension
   - Increase passive knee flexion to 135° by week 8
   - Increase active knee flexion >120° by week 12
2. **Increase strength of quadriceps, hamstring, and hip musculature**
   - Manual muscle testing: 3/5 by week 12
   - Hand-held dynamometer: 50% of uninvolved limb by week 12
3. **Full weight-bearing without use of assistive device by week 10**
   - **Equal stride length and stance time between limbs, no limp**
4. **Improve functional performance**
   - **Fifty feet timed walk**
   - **'Get up and Go' test**
   - **Stairs ascent**
   - **Stairs descent**

ROM Progression	Weight-Bearing Progression	Brace	Strength Progression	Criteria for Progression
Maintain full passive knee extension Continue with patellar mobilizations as needed Progress knee flexion to 125°-135° by week 8	Partial-weight-bearing (50%) at week 6 Progress to full-weight-bearing at weeks 8-9 Continue use of pool (if facilities available) for gait training	Discontinue use of brace at 6 weeks if no evidence of extensor lag with SLR -Option of unloader brace, per physician orders	Progress bilateral closed chain strengthening between 6-10 weeks if WB/equipment allow Mini-squats 0°-45° at week 8 Begin calf raises at week 8 Begin open kinetic chain (OKC) exercises without resistance at week 9 Progress to unilateral closed chain exercises and begin balance activities between 10-12 weeks Begin treadmill walking between weeks 10-12 as symptoms allow -Gradually increase intensity and duration ****Precautions: (consult physician for location of defect)** If defect on <u>anterior</u> aspect of femoral condyle: -May perform exercises in deeper ROM of flexion, but AVOID hyperextension If defect on <u>posterior</u> aspect of femoral condyle: -AVOID exercises in deep knee flexion ROM (>45°)	Active pain-free knee flexion >120° Full-weight-bearing without use of assistive devices and without evidence of gait dysfunction Minimal pain and effusion Full passive knee extension Voluntary quadriceps contraction ****Earliest progression to Phase III: 12 weeks**

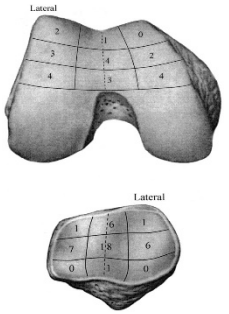
Phase III: Remodeling: no earlier than 12 weeks		
Goals: **1. Maintain full ROM equal to the uninvolved limb** **2. Increase strength of quadriceps, hamstring, and hip musculature** • Manual muscle testing: 4/5 by 6 months • Hand-held dynamometer testing: 70% of uninvolved side by six months **3. Improve functional performance?** • **Fifty feet timed walk** • **'Get up and Go' test** • **Stairs ascent** • **Stairs descent**		
Strength Progression	**Functional Progression**	**Criteria for Progression**
Progress bilateral and unilateral CKC exercises -Bilateral squats (0°-60°) Progress loading during balance exercises Leg press (0°-90°) Precautions: (consult physician for location of defect) If defect on anterior aspect of femoral condyle: -May perform exercises in deeper ROM of flexion, but AVOID hyperextension If defect on posterior aspect of femoral condyle: -AVOID exercises in deep knee flexion ROM (>45°)	As symptoms allow, increase walking (distance, incline, etc.)	Full pain-free ROM Strength within 85% of contralateral extremity (quadriceps, hamstrings, hip muscles) Balance and/or stability within 75% of contralateral extremity No pain or swelling after 30 minutes of impact activity ****Earliest progression to Phase IV: 6 months**

Phase IV: Maturation: no earlier than 6 months		
Goals: **1. Return to desired activity level**		
Strength Progression	**Functional Progression**	**Criteria for Return to Sports**
Continue maintenance program 2-4 times/week Advance strength training and progress as tolerated -Emphasize single leg loading as tolerated	Begin jogging program (earliest return to jogging program: 6 months) -Start with 2 min-walk/2 min jog -Progress time and intensity as symptoms allow Begin agility program around 9 months -Emphasis on sport-specific training Low-impact sports (swimming, cycling, skating) permitted around 6 months if goals are met Higher-impact sports (running, aerobics) permitted at 8-9 months for smaller lesions if goals are met; 9-12 months for larger lesions High-impact sports (basketball, tennis) permitted between 12-18 months if all goals are met	Clearance by physician Graft is able to withstand the specific demands of the activity, as evaluated through functional testing: -Hop tests -Isokinetic testing (≥90% of contralateral side) Full pain-free ROM Patient is motivated to return to sport

Autologous Chondrocyte Implantation (ACI) Rehabilitation Variations Based on Concomitant Surgical Procedures and Lesion Variation‡	
Concomitant Procedure	**Rehabilitation Variations**
Meniscal Allograft	Rehabilitation is altered to allow healing of meniscus allograft Weight-bearing similar to isolated femoral condyle lesion ROM progression is slightly slower No active knee flexion is allowed past 90° for the first 6-8 weeks Resisted hamstring exercises are avoided for the first 12 weeks
High Tibial Osteomy	Rehabilitation is altered to allow healing of the tibial osteotomy Weight-bearing is progressed similar to an isolated femoral condyle lesion, although may be delayed based on radiographic evidence of bone healing ROM progression is slightly accelerated to minimize loss of knee motion The use of heel wedges, orthotics, and/or unloading knee braces is recommended when weight-bearing is progressed
Anterior Cruciate Ligament Reconstruction	Dependent on graft selection (patellar tendon, hamstring, allograft) Weight-bearing similar to isolated femoral condyle lesion ROM progression is slightly accelerated to minimize arthrofibrosis, prevention is key
Distal Realignment	Rehabilitation is altered to minimize strain on tibial tubercle ROM is slower, from 0°-90° for up to the first 4 weeks Weight-bearing is similar to isolated trochlea lesion, with immediate partial weight-bearing in a knee brace locked in extension Active knee extension exercises are avoided for the first 6-8 weeks
Osteochondritis Dissecans	Rehabilitation is similar to isolated guidelines initially Return to functional and impact activities is slightly decelerated Weight-bearing may also be delayed up to 4 weeks in the presence of concomitant bone-grafting procedures
Large, deep, uncontained, and multiple lesions	Rehabilitation program is highly individualized and is decelerated due to more extensive lesions and more tenuous repair For femoral condyle lesions, weight-bearing progression is delayed for 2-4 weeks, with an initial period of non-weight-bearing for up to 2-4 weeks For trochlea lesions, ROM, and the initiation of active knee extension exercises are slightly decelerated, aggressive knee extension resisted exercises are avoided for up to 9-12 months

Combined femoral condyle and trochlea lesions	Rehabilitation is altered to address healing constraints of both lesion locations Weight-bearing progression followed the isolated femoral condyle lesion guidelines ROM and exercise progression follows the isolated trochlea lesion guidelines

Appendix B: Rehabilitation Protocol: Patellofemoral Lesions

Defect Location:_____ **Defect Size:**_____ **Concomitant Procedure:**_____	

Phase I: Proliferation

Goals:

6. **Minimal or no effusion (grade 0 or 1+) by week 6**
7. **Minimal or absent pain (VAS less than 3/10) by week 6**
8. **Increase ROM**
   - Extension: achieve full passive extension by week 2
   - Flexion: see goals below in ROM progression
9. **Patient understanding and compliance with WB restrictions**
   - See below for WB progression goals
10. **Improve neuromuscular control**
    - 10 straight leg raises without evidence of extension lag by week 6

CPM Guidelines	ROM Progression	Weight-Bearing Progression	Brace	Strength Progression	Criteria for Progression
Begin CPM 0°-30° for two weeks -6-8 hours/day at 1 cycle/min Starting week 3, increase knee flexion 5°-10° daily as tolerated Discontinue CPM week 6	Restore full passive knee extension immediately Patellar mobilizations 4-6 times/daily Limit active ROM 0°-30° for 6 weeks Goals for knee flexion PROM: -90° by week 2-3 -105° by week 3-4 -120° by week 6	Immediate toe-touch weight-bearing of 25% body weight with brace locked in extension Progress to 50% body weight partial-weight-bearing at week 2 with brace locked in full extension Progress to 75% body weight partial weight-bearing at weeks 3-4 with brace locked in full extension Begin pool therapy (if facilities are available) at week 4: -Walking in chest-deep water: 25% body weight -Walking in waist-deep water: 50% body weight	Locked in full extension during all weight-bearing activities for 2 weeks -Remove for CPM use/exercises Locked at 0° with weight-bearing at 2-4 weeks Begin to open 20°-30° with ambulation as tolerated at 4-6 weeks Discontinue use of brace at 6 weeks if no evidence of extensor lag with SLR	Quadriceps sets/SLR (4 directions) for 1-4 weeks -SLR in brace if poor quadriceps control Active knee extension 90°-40° (no resistance) May begin stationary cycling (with minimal resistance) when ROM allows Initiate weight-shifting exercises with knee in full extension at weeks 2-3 Begin closed chain exercises as WB and equipment allows	Minimal pain and swelling Achievement of full passive knee extension Active, pain-free knee flexion of 90° Voluntary quadriceps contraction ****Earliest progression to Phase II: 4 weeks**

Phase II: Transition/Loading: not before 4 weeks
Goals
5. Increase ROM • Maintain full passive knee extension • Increase passive knee flexion to 135° by week 8 • Increase active knee flexion >120° by week 12 **6. Increase strength of quadriceps, hamstring, and hip musculature** • Manual muscle testing: 3/5 by week 12 • Hand-held dynamometer: 50% of uninvolved limb by week 12 **7. Full weight-bearing without use of assistive device by week 10** • **Equal stride length and stance time between limbs, no limp** **8. Improve functional performance** • **Fifty feet timed walk** • **'Get up and Go' test** • **Stairs ascent** • **Stairs descent**

ROM Progression	Weight-Bearing Progression	Brace	Strength Progression	Criteria for Progression
Maintain full passive knee extension Continue with patellar mobilizations as needed Caution with 50°-30° active knee flexion ROM Progress knee flexion to 125°-135° by week 8	Progress to full-weight-bearing at weeks 6-8 Continue use of pool (if facilities available) for gait training	Discontinue use of brace at 6 weeks if no evidence of extensor lag with SLR	Progress WB exercises as tolerated Progress balance/proprioception exercises (increased loading) between 6-12 weeks Initiate calf raises at week 6 Mini-squats 0°-40° at week 8 Begin NWB knee extension without resistance in a ROM that does not engage defect Initiate front lunges, wall squats between weeks 8-10 -use caution in deep knee flexion Begin treadmill walking between weeks 10-12 as symptoms allow -Gradually increase intensity and duration	Active pain-free knee flexion >120° Full-weight-bearing without use of assistive devices and without evidence of gait dysfunction Minimal pain and effusion Full passive knee extension Voluntary quadriceps contraction ****Earliest progression to Phase III: 12 weeks**

Phase III: Remodeling: not before 12 weeks		
Goals: **4. Maintain full ROM equal to the uninvolved limb** **5. Increase strength of quadriceps, hamstring, and hip musculature** • Manual muscle testing: 4/5 by 6 months • Hand-held dynamometer testing: 70% of uninvolved side by six months **6. Improve functional performance?** • **Fifty feet timed walk** • **'Get up and Go' test** • **Stairs ascent** • **Stairs descent**		
Strength Progression	**Functional Progression**	**Criteria for Progression**
Continue to progress closed chain exercises Progress loading during balance exercises Unrestricted static cycling, stepping, rowing Progress NWB extension 90°-40° (or avoid angle where lesion engages)	As symptoms allow, increase walking (distance, speed, incline, etc.)	Full pain-free ROM Strength within 70% of contralateral extremity (quadriceps, hamstrings, hip muscles) Balance and/or stability within 75% of contralateral extremity No pain or swelling after 30 minutes of impact activity ****Earliest progression to Phase IV: 6 months**

Phase IV: Maturation: not before 6 months		
Goals: **1. Return to desired activity level**		
Strength Progression	**Functional Progression**	**Criteria for Return to Sports**
Continue maintenance program 2-4 times/week Advance strength training and progress as tolerated -Emphasize single leg loading as tolerated	Begin jogging program (earliest return to jogging program: 9 months) -Start with 2 min-walk/2 min jog -Progress time and intensity as symptoms allow Begin agility program between 9-12 months -Emphasis on sport-specific training Low-impact sports (swimming, cycling, skating) permitted around 6 months if goals are met Higher-impact sports (jogging, running, aerobics) permitted at 8-9 months for smaller lesions if goals are met; 9-12 months for larger lesions High-impact sports (basketball, tennis) permitted between 12-18 months if all goals are met	Clearance by physician Graft is able to withstand the specific demands of the activity, as evaluated through functional testing: -Hop tests -Isokinetic testing (≥90% of contralateral side) Full pain-free ROM Patient is motivated to return to sport

Autologous Chondrocyte Implantation (ACI) Rehabilitation Variations Based on Concomitant Surgical Procedures and Lesion Variation‡	
Concomitant Procedure	**Rehabilitation Variations**
Meniscal Allograft	Rehabilitation is altered to allow healing of meniscus allograft Weight-bearing similar to isolated femoral condyle lesion ROM progression is slightly slower No active knee flexion is allowed past 90° for the first 6-8 weeks Resisted hamstring exercises are avoided for the first 12 weeks
High Tibial Osteomy	Rehabilitation is altered to allow healing of the tibial osteotomy Weight-bearing is progressed similar to an isolated femoral condyle lesion, although may be delayed based on radiographic evidence of bone healing ROM progression is slightly accelerated to minimize loss of knee motion The use of heel wedges, orthotics, and/or unloading knee braces is recommended when weight-bearing is progressed
Anterior Cruciate Ligament Reconstruction	Dependent on graft selection (patellar tendon, hamstring, allograft) Weight-bearing similar to isolated femoral condyle lesion ROM progression is slightly accelerated to minimize arthrofibrosis, prevention is key
Distal Realignment	Rehabilitation is altered to minimize strain on tibial tubercle ROM is slower, from 0°-90° for up to the first 4 weeks Weight-bearing is similar to isolated trochlea lesion, with immediate partial weight-bearing in a knee brace locked in extension Active knee extension exercises are avoided for the first 6-8 weeks
Osteochondritis Dissecans	Rehabilitation is similar to isolated guidelines initially Return to functional and impact activities is slightly decelerated Weight-bearing may also be delayed up to 4 weeks in the presence of concomitant bone-grafting procedures
Large, deep, uncontained, and multiple lesions	Rehabilitation program is highly individualized and is decelerated due to more extensive lesions and more tenuous repair For femoral condyle lesions, weight-bearing progression is delayed for 2-4 weeks, with an initial period of non-weight-bearing for up to 2-4 weeks For trochlea lesions, ROM, and the initiation of active knee extension exercises are slightly decelerated, aggressive knee extension resisted exercises are avoided for up to 9-12 months

Combined femoral condyle and trochlea lesions	Rehabilitation is altered to address healing constraints of both lesion locations Weight-bearing progression followed the isolated femoral condyle lesion guidelines ROM and exercise progression follows the isolated trochlea lesion guidelines

Appendix C: Rehabilitation Data Collection Form

Patient Name_____	/ /	/ /	/ /	/ /	/ /
ATTENDANCE *(In the Past 2 weeks)*					
# of visits attended					
# of visits canceled/rescheduled/no-show					
WEIGHT-BEARING STATUS *(Check the status that applies)*					
Non-Weight-Bearing (NWB)					
Partial Weight-Bearing (PWB)					
• **Date initiated (if applicable)**					
• **% of body weight at last visit**					
• **Method of patient education for PWB (e.g. bathroom scale)**					
Full Weight-Bearing (FWB)					
• **Date initiated (if applicable)**					
CPM USE					
Average hours/day of use:					
Current ROM in CPM:					

Not applicable					
QUADRICEPS STRENGTH ASSESSMENT (*measured at last visit*)					
# of straight-leg raises without extensor lag					
Manual Muscle Testing (Involved/Uninvolved)					
Hand-Held Dynamometer (*if applicable*) (Involved/Uninvolved)					
RANGE OF MOTION (ROM) *(measured at last visit)*					
Flexion					
• **Involved knee:**					
• **Uninvolved knee:**					
Extension					
• **Involved knee:**					
• **Uninvolved knee:**					
REHABILITATION ADHERENCE: Clinician Perspective *(average over the past 2 weeks)*					
Intensity of completion of rehabilitation exercises					
Minimum Effort 1 2 3 4 5 Maximum Effort					
Frequency with which patient follows clinician's instructions and advice					
Never 1 2 3 4 5 Always					

Receptiveness to changes in therapy program					
Very Unreceptive 1 2 3 4 5 Very Receptive					
REHABILITATION ADHERENCE: Patient Self-Report ***Rating 0-10, where 0=none and 10=exactly as prescribed (average over the past 2 weeks)***					
Self-report of home-exercise program (HEP):					
Self-report of adherence with bracing:					
Self-report with WB restrictions:					
Self-report of adherence with CPM use:					

Appendix D: Knee Injury and Osteoarthritis Outcome Score (KOOS)

SOCRATES

ICRS

 # 17 KOOS KNEE SCORE

Patient Name_____

Patient ID _____ **Study ID** _____ **Date**_____ **Side** ☐Right ☐Left

Filled in by: ☐Operating Dr. ☐Other MD ☐Research Assistant ☐Questionnaire ☐Other

Reviewer Name: _____

INSTRUCTIONS: This survey asks for your view about your knee. This information will help us keep track of how you feel about your knee and how well you are able to do your usual activities. Answer every question by ticking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can.

Symptoms

These questions should be answered thinking of your knee symptoms during the **last week**.

S1. Do you have swelling in your knee?

☐Never ☐Rarely ☐Sometimes ☐Often ☐Always

S2. Do you feel grinding, hear clicking or any other type of noise when your knee moves?

☐Never ☐Rarely ☐Sometimes ☐Often ☐Always

S3. Does your knee catch or hang up when moving?

☐Never ☐Rarely ☐Sometimes ☐Often ☐Always

S4. Can you straighten your knee fully?

☐Never ☐Rarely ☐Sometimes ☐Often ☐Always

S5. Can you bend your knee fully?

☐Never ☐Rarely ☐Sometimes ☐Often ☐Always

Stiffness

The following questions concern the amount of joint stiffness you have experienced during the **last week** in your knee. Stiffness is a sensation of restriction or slowness in the ease with which you move your knee joint.

S6. How severe is your knee joint stiffness after first wakening in the morning?

☐None ☐Mild ☐Moderate ☐Severe ☐Extreme

S7. How severe is your knee stiffness after sitting, lying or resting later in the day?

☐None ☐Mild ☐Moderate ☐Severe ☐Extreme

Pain

P1. How often do you experience knee pain?

☐Never ☐Monthly ☐Weekly ☐Daily ☐Always

What amount of knee pain have you experienced the **last week** during the following activities?

P2. Twisting/pivoting on your knee

☐None ☐Mild ☐Moderate ☐Severe ☐Extreme

P3. Straightening knee fully

☐None ☐Mild ☐Moderate ☐Severe ☐Extreme

P4. Bending knee fully

☐None ☐Mild ☐Moderate ☐Severe ☐Extreme

Pain, continued

P5. Walking on flat surface				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
P6. Going up or down stairs				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
P7. At night while in bed				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
P8. Sitting or lying				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
P9. Standing upright				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme

Function, daily living

The following questions concern your physical function. By this we mean your ability to move around and to look after yourself. For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

A1. Descending stairs				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A2. Ascending stairs				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme

For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

A3. Rising from sitting				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A4. Standing				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A5. Bending to floor/pick up an object				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A6. Walking on flat surface				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A7. Getting in/out of car				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A8. Going shopping				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A9. Putting on socks/stockings				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A10. Rising from bed				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A11. Taking off socks/stockings				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A12. Lying in bed (turning over, maintaining knee position)				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A13. Getting in/out of bath				
☐None	☐Mild	☐Moderate	☐Severe	☐Extreme

For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

A14. Sitting	☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A15. Getting on/off toilet	☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A16. Heavy domestic duties (moving heavy boxes, scrubbing floors, etc)	☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
A17. Light domestic duties (cooking, dusting, etc)	☐None	☐Mild	☐Moderate	☐Severe	☐Extreme

Function, sports and recreational activities

The following questions concern your physical function when being active on a higher level. The questions should be answered thinking of what degree of difficulty you have experienced during the **last week** due to your knee.

SP1. Squatting	☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
SP2. Running	☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
SP3. Jumping	☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
SP4. Twisting/pivoting on your injured knee	☐None	☐Mild	☐Moderate	☐Severe	☐Extreme
SP5. Kneeling	☐None	☐Mild	☐Moderate	☐Severe	☐Extreme

Quality of Life

Q1. How often are you aware of your knee problem?	☐Never	☐Monthly	☐Weekly	☐Daily	☐Constantly
Q2. Have you modified your life style to avoid potentially damaging activities to your knee?	☐Not at all	☐Mildly	☐Moderately	☐Severely	☐Totally
Q3. How much are you troubled with lack of confidence in your knee?	☐Not at all	☐Mildly	☐Moderately	☐Severely	☐Extremely
Q4. In general, how much difficulty do you have with your knee?	☐None	☐Mild	☐Moderate	☐Severe	☐Extreme

Thank you very much for completing all the questions in this questionnaire.

Appendix E: Hospital for Special Surgery (HSS) Knee Surgery Expectations Survey

HOSPITAL FOR SPECIAL SURGERY
KNEE SURGERY EXPECTATIONS SURVEY

Please circle the number that best describes your response to each question.

How much relief or improvement do you expect in the following areas as a result of your knee surgery?

	Back to normal or complete improvement	Not back to normal, but… a lot of improvement	a moderate amount of improvement	a little improvement	I do not have this expectation, or this expectation does not apply to me
Relief of pain	1	2	3	4	5
Improve ability to walk * short distance (indoor, 1 block)	1	2	3	4	5
* medium distance (take a walk up to 1 mile)	1	2	3	4	5
* long distance (more than 1 mile)	1	2	3	4	5
Increase knee stability	1	2	3	4	5
Increase knee mobility	1	2	3	4	5
Improve ability to go up and down stairs	1	2	3	4	5
Improve ability to squat	1	2	3	4	5
Improve ability to kneel	1	2	3	4	5
Stop knee from catching or buckling	1	2	3	4	5
Stop knee from giving way when coming to a quick stop while running	1	2	3	4	5
Stop knee stiffness or swelling	1	2	3	4	5
Be employed for monetary reimbursement	1	2	3	4	5
Improve ability to run (for example across the street, to catch the bus)	1	2	3	4	5
Improve ability to perform daily activities (for example, daily routine, household chores)	1	2	3	4	5
Improve ability to exercise or participate in recreational sports	1	2	3	4	5
Improve ability to participate in professional sports	1	2	3	4	5
Have confidence in knee	1	2	3	4	5
Avoid future degeneration of knee	1	2	3	4	5
Improve ability to maintain general health	1	2	3	4	5
Improve ability to interact with others (for example, take care of someone, play with children)	1	2	3	4	5
Improve psychological well-being	1	2	3	4	5
For knee to be back to the way it was before this problem started	1	2	3	4	5

Appendix F: Self-Efficacy for Rehabilitation Outcome Scale (SER)

Self-Efficacy for Rehabilitation Outcome Scale (SER)

Patient ID: _____ Date: _____

Please circle the number on the scale at the level which corresponds to your confidence in performing the following activities in therapy. 0 = "*I cannot do*" and 10 = "*certain I can do.*"

During my rehabilitation, I believe I can do….

1. *Therapy that requires me to stretch my leg*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

2. *Therapy that requires me to lift my leg*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

3. *Therapy that requires me to bend my leg*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

4. *Therapy that requires me to stand*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

5. *Therapy that requires me to walk*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

6. *All of my therapy exercises during my rehabilitation*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

7. *My therapy every day that it is scheduled*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

8. *The exercises my therapists say I should do, even if I don't understand how it helps me*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

9. *My therapy no matter how I feel emotionally*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

10. *My therapy no matter how tired I may feel*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

11. *My therapy even though I may already have other complicating illnesses*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

12. *My therapy regardless of the amount of pain I am feeling*

I cannot do Certain I can do

0 1 2 3 4 5 6 7 8 9 10

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Vita

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I. General Information

Place of Birth Grand Rapids, Michigan

Certificate or Specialty Board Licensure
National Athletic Trainers' Association Board of Certification #040002048

II. Education:

2010-present The University of Kentucky, Lexington, KY
Candidate, Doctor of Philosophy, Rehabilitation Sciences
Anticipated graduation date: May 10, 2014
Dissertation: "The relationship between patient expectations, functional outcome, self-efficacy, and rehabilitation adherence following cartilage repair of the knee: A sequential explanatory analysis"

2003-2004 The Steadman Hawkins Clinic, Vail, CO
Athletic Training/Sports Medicine Fellowship

2001-2003 Western Michigan University, Kalamazoo, MI
Master of Arts in Physical Education-Athletic Training Emphasis
CAAHEP Post-Professional Graduate Program
Thesis: "Institutional barriers in obtaining CAAHEP accreditation: A comparison study

1995-1999 Calvin College, Grand Rapids, MI
Bachelor of Arts in Exercise Science-Athletic Training Emphasis
Minor: General Science

III. Professional Experience

2010-present Graduate Assistant,
Department of Rehabilitation Sciences
University of Kentucky, Lexington, KY

2011-2013 Teaching Assistant
University of Kentucky, Lexington, KY
Division of Athletic Training
AT740-Musculoskeletal Anatomical Dissection

2009 Adjunct Faculty
Grand Valley State University, Allendale, MI
Movement Science Department

	CAATE Accredited Undergraduate Athletic Training Program PED217- Modern Principles of Athletic Training
2006-2010	Head Athletic Trainer, Calvin College, Grand Rapids, MI
2006-2010	Adjunct Instructor Calvin College, Grand Rapids, MI HPERDS Department PE255- Basic Athletic Training
2004-2006	Assistant Athletic Trainer Colby-Sawyer College, New London, NH
2004-2006	Clinical Faculty Colby-Sawyer College, New London, NH Exercise and Sport Sciences Department CAAHEP Accredited Undergraduate Athletic Training Program ESS 105-Community First Aid and CPR ESS 231-Practicum I ESS 232-Practicum II ESS 316-Therapeutic Rehabilitation ESS 316L-Therapeutic Rehabilitation Lab ESS 431-Practicum V ESS 432-Practicum VI
2005	Medical Volunteer Boston Marathon, Boston, MA
2003-2004	Athletic Trainer/Physician Extender The Steadman-Hawkins Clinic, Vail, CO
2003	Instructor Vail Mountain School, Vail, CO
2003	Head Athletic Trainer Southwest Michigan Jaguars, Otsego, MI
2003	Head Athletic Trainer WMU Women's Ice Hockey, Kalamazoo, MI
2001-2003	Graduate Assistant Athletic Trainer WMU Sports Medicine Clinic, Kalamazoo, MI
2000-2001	Head Athletic Trainer Grand Rapids South Christian High School NovaCare Rehabilitation, Grand Rapids, MI

1999-2000	Head Athletic Trainer Grand Rapids Catholic Central High School Athletic Trainer, Rehabilitation Professionals, Grand Rapids, M

IV. Scholastic and Professional Honors

2013-2014	Recipient, University of Kentucky, College of Health Sciences Wright Scholarship
2013-2014	Recipient, University of Kentucky, College of Health Sciences Academic Enhancement Scholarship
2011-present	Member, Delta Epsilon Iota Academic Honor Society
2002	Recipient, Sears' Directors Postgraduate Scholarship
1998-1999	Outstanding Physical Education Major of the Year

V. Professional Publications and Presentations

a. Peer-Reviewed Publications

Toonstra JL, Mattacola CG. Test-retest reliability and validity of isometric knee flexion and extension measurement using three methods of assessing muscle strength. *Journal of Sport Rehabilitation.* 2012 Sep 4. PMID: 22951307.

Toonstra JL, Howard JS, Uhl TL, English RA, Mattacola CG. The role of rehabilitation following autologous chondrocyte implantation: A retrospective chart review. *International Journal of Sports Physical Therapy.* 2013; 8(5): 670-679.

b. Refereed Abstract Presentations

Toonstra JL, Miller MG, Ritenour DM & Schutten MC. Institutional barriers in obtaining CAAHEP accreditation: A comparison study. Free Communications, Thematic Posters: Athletic Training Education. NATA National Convention, St. Louis, MO. 2003.

c. Peer-Reviewed Abstracts

Padgett CA, Smith JS, Uhl TL, **Toonstra JL** & Butterfield TA. Strength and endurance in shoulder musculature is enhanced with 5 minute exercise programs. 9th Annual CCTS Spring Conference. Lexington, KY. 2014.

Iannicelli JP, Werner JL, Howard JS, Mattacola CG, Howell DM & **Toonstra JL**. To return or not return? A qualitative investigation of factors influencing return to sport following ACL reconstruction. 9th Annual CCTS Spring Conference. Lexington, KY. 2014.

Toonstra JL, Mattacola CG, Uhl TL & Howard JS. Factors that influence patient expectations for recovery following cartilage repair of the knee. *Journal of Athletic Training*. 2014.

Meade AR**,** Mattacola CG, **Toonstra JL**, & Howard JS. Feasibility of conducting a web-based survey of patient-reported outcomes and rehabilitation progress. *Journal of Athletic Training*. 2013; 48(3), S-251.

Toonstra JL, Mattacola CG, Lattermann C, & Howard JS. Rehabilitation attendance following knee surgery is not influenced by driving distance. *Medicine and Science in Sports and Exercise.* 2013; 5(5), S-296.

Toonstra JL, Mattacola CG & Lattermann C. Reliability and validity of isometric knee flexion and extension measurements using three methods of assessing muscle strength. Transactions of the 2012 Annual Meeting of the Orthopaedic Research Society, San Francisco, CA. Poster number 0854. 2012.

Toonstra JL, Miller MG, Ritenour DM, & Schutten MC. Institutional barriers in obtaining CAAHEP accreditation: A comparison study. *Journal of Athletic Training.* 2003; 38(2), S-30.

d. Presentations

Toonstra JL. "The relationship between patient expectations, functional outcome, and rehabilitation adherence following cartilage repair of the knee: A mixed methods study." Southeast Athletic Trainers' Association (SEATA) Annual Meeting. Atlanta, GA. 2014.

Howard JS & **Toonstra JL**. "Articular cartilage injuries: Treatment options and expectations for return to activity." National Athletic Trainers' Association Annual Meeting. Evidence-Based Forum. Las Vegas, NV. 2013.

Toonstra JL. "A look inside athletic training". University of Kentucky, College of Health Sciences. HSE 101: Survey of Health Professions. Lexington, KY. 2012.

Gruner M, Kornoelje E, O'Connor EA, & **Toonstra JL**. "Practical approaches to addressing the female athlete triad". Aquinas College. Grand Rapids, MI. 2010.

Toonstra JL. "When bad knees happen to good people". Allegro Coaching. Grand Rapids, MI. 2010.