The Role Of Rehabilitation Following Autologous Chondrocyte Implantation: A Retrospective Chart Review

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Abstract

Clinical outcomes following autologous chondrocyte implantation (ACI) are influenced by multiple factors, including patient demographics, lesion characteristics, quality of the surgical repair, and post-operative rehabilitation. However, it is currently unknown what specific characteristics of rehabilitation have the greatest influence on clinical outcomes following ACI. The purpose of this study was to conduct a retrospective chart review of patients undergoing ACI with the intent to describe this patient population's demographics, clinical outcomes, and rehabilitation practices. This study aimed 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. The medical records of patients treated for chondral defect(s) of the knee who subsequently underwent the ACI procedure were retrospectively reviewed. A systematic review of medical, surgical, and rehabilitation records was performed. In addition, patient-reported outcome measures (IKDC, WOMAC, Lysholm, SF-36) recorded pre-oper- atively, and 3, 6, and 12 months post-operatively were extracted from an existing database. 20 medical charts (35.9 ± 6.8 years; 9 male, 11 female) were systematically reviewed. The average IKDC, WOMAC, Lysholm, and SF-36 scores all improved from baseline to 3, 6 and 12 months post-operatively, with the great- est changes occurring at 6 and 12 months. There was inconsistent documentation relative to post-operative rehabilita- tion, including CPM use, weight-bearing progression, home-exercise compliance, and strength progressions. Due to variations in the documentation process, the authors 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.

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

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ABSTRACT

Purpose/Background: Clinical outcomes following autologous chondrocyte implantation (ACI) are influenced by multiple factors, including patient demographics, lesion characteristics, quality of the surgical repair, and post-operative rehabilitation. However, it is currently unknown what specific characteristics of rehabilitation have the greatest influence on clinical outcomes following ACI. The purpose of this study was to conduct a retrospective chart review of patients undergoing ACI with the intent to describe this patient population's demographics, clinical outcomes, and rehabilitation practices. This study aimed 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.

Methods: The medical records of patients treated for chondral defect(s) of the knee who subsequently underwent the ACI procedure were retrospectively reviewed. A systematic review of medical, surgical, and rehabilitation records was performed. In addition, patient-reported outcome measures (IKDC, WOMAC, Lysholm, SF-36) recorded pre-operatively, and 3, 6, and 12 months post-operatively were extracted from an existing database.

Results: 20 medical charts (35.9 $\pm$ 6.8 years; 9 male, 11 female) were systematically reviewed. The average IKDC, WOMAC, Lysholm, and SF-36 scores all improved from baseline to 3, 6 and 12 months post-operatively, with the greatest changes occurring at 6 and 12 months. There was inconsistent documentation relative to post-operative rehabilitation, including CPM use, weight-bearing progression, home-exercise compliance, and strength progressions.

Conclusions: Due to variations in the documentation process, the authors 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.

Level of Evidence: 2C

Keywords: autologous chondrocyte implantation, chart review, clinical outcome, rehabilitation

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INTRODUCTION

Articular cartilage lesions of the knee are common and have been suggested to increase the risk of osteoarthritis.[1-3] 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.[4] 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.[5] There are several variations of current ACI procedures, 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.[6-8] 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[9-11] and patients with more active lifestyles[12,13] 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.[9,14,15] Prognostic indicators are conflicting relative to defect location and patient age. Recently, some researchers have found inferior clinical results in patients with medial femoral condyle and patellar lesions when compared to patients with lesions of the trochlea and lateral femoral condyle[5,9,16,17] while other researchers have demonstrated superior clinical results in patients with patellar lesions.[18] Several authors have reported superior clinical results in patients less than 30 years of age,[6,10,12,19] while Krishnan et al reported superior clinical results in patients less than 41 years of age.[9] In contrast, Niemeyer et al did not find any clinical differences in outcomes of patients greater than 40 years of age when matched with a younger cohort.[20] 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.[16,21-23] However, current guidelines and evidence for ACI rehabilitation are unclear, and mostly based on a combination of expert opinion and the basic science literature.[24-26] 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 the authors' 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 preoperatively and post-operatively were eligible to participate in the study and were contacted for participation in the study. The Institutional Review Board at the University of Kentucky approved the study 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 was 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.[27-31] 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.[32]

STATISTICAL METHODS

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 predetermined variables were extracted for analysis. Patients had a mean age of 35.9 $\pm$ 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 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). 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 $\pm$ 13.6 visits (range, 5-51). On average, patients attended post-operative rehabilitation for 15.6 $\pm$ 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 examined by the authors can be found in Table 3.

DISCUSSION

The objective of this retrospective chart review was 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. 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 an explanation for the consistent documentation of the measures examined 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

Table 1. *Patient Characteristics.*

Characteristic	
Age at Time of Surgery, years (Mean, SD)	35.9 (6.8)
Gender (Count and %)	
Male	9 (45%)
Female	11 (55%)
BMI (Mean, SD)	28.9 (5.8)
Smoking Status (Count and %)*	
Non-Smoker	14 (73.6%)
Past Smoker	1 (5.3%)
Smoker	4 (21.1%)
Limb (No. and %)	
Right	8 (40%)
Left	12 (60%)
Onset of Symptoms (Count and %)†	
Sudden	7 (35%)
Gradual	12 (60%)
Cause of Injury (Count and %)	
No known injury	6 (30%)
Sports	7 (35%)
Work-related injury	2 (10%)
Other	5 (25%)
Duration of Symptoms (Count and %)	
<6 months	2 (10%)
6-12 months	2 (10%)
12-24 months	3 (15%)
>24 months	12 (60%)
Concomitant Injury (Count and %)	
No	17 (85%)
Yes	3 (15%)
Concomitant Procedure (Count and %)	
No	10 (50%)
Yes	10 (50%)
Single or Multiple Defects (Count and %)	
Single	9 (45%)
Multiple	11 (55%)
Defect Location (Count 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, SD)	1.7 (0.7)
Defect Size (cm^2) (Mean, D)‡	4.8 (2.6)
Number of Previous Surgeries (Mean, D)	1.2 (1.3)
Level of Activity Prior to Surgery (Count and %)	
Competitive	1 (5%)
Recreational	8 (40%)
No Sport	6 (30%)
Unknown	5 (25%)

BMI=body mass index; SD=standard deviation
***one chart did not report status**
†one chart did not report onset
‡one chart did not report defect size

Table 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 3. *Rehabilitation Characteristics for Documentation.*

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

SD= standard deviation; CPM= continuous passive motion; ROM= Range of Motion; HEP= Home Exercise Program

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.[22] From the results of this 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.[22,24,33,34] Gradual progressions in weight-bearing and joint loading following articular cartilage repair must be implemented in order to provide gradual articular loading, without causing damage to the repair site by compressive and shear forces that are too great.

Gradual progressions in active and passive movements following ACI are necessary for enhancing the flow of synovial fluid throughout the joint.[35] ROM is also indicated for decreasing pain, improving circulation, and preventing tissue adhesions following surgery.[22] Immediate restoration of knee extension is encouraged following surgery in order to prevent tissue adhesion and the development of arthrofibrosis.[22] Increases in knee flexion ROM, however, are approached conservatively 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.[22,36,37] 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.[38-41] It is generally recommended that patients use a CPM immediately following surgery for 6-8 weeks for 4-12 hours/daily.[34,42] 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.[43-45] 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 dynamometry, or the 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.[46,47] 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 the prescription of a home exercise program, only two charts documented patient compliance with at-home exercises. Post-operative 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. Brewer et al suggested that compliance with home exercise programs may improve rehabilitation outcomes.[48] Patient compliance is difficult to assess, given its subjective nature. However, Likert scales have been previously utilized to assess compliance with rehabilitation programs and the authors of this study recommend inclusion of these scales in reporting as a means of tracking patient compliance.[48] Attendance has frequently been used as a measure of adherence in rehabilitation research.[49,50] 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, the authors 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 outcomes. 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, the current study provides some valuable information. It has led to the creation of a more specific rehabilitation protocol as well as a standard data collection sheet that is used to verify that some of the data found to be missing in the current study is being documented. Both of these improvements attempt to ensure consistent outcomes.

Clinical Implications and Future Research

The rehabilitation factors suggested to be most important after ACI include "progressive weight-bearing, restoration of ROM, and improvement of muscular control and strength".[22] In addition to utilizing PRO's, it is likely that surgeons may want the capability to collect and track these rehabilitation factors. Based on the authors' knowledge, clinical experience, and results of this retrospective 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 the specifics of 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 A provides a list of outcomes that, when collected consistently, will provide valuable information regarding patient progress.

As was expected, variability in documentation procedures existed 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 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 in order 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, the authors 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. The authors have provided recommendations for researchers and clinicians to provide this information in a systematic way.

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Appendix A. *Suggested Parameters for Rehabilitation Documentation after Autologous Chondrocyte Implantation*

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:					