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Restoring Functional Mobility For A Patient Following A Comminuted Patella Fracture Status Post Open Reduction Internal Fixation: A Case Report

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1 **Restoring Functional Mobility for a Patient Following a Comminuted Patella**
2 **Fracture Status Post Open Reduction Internal Fixation: A Case Report**

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13
14 The patient signed an informed consent form allowing the use of all medical information and
15 photographs for this case report. She received information on the university's policies regarding
16 the Health Insurance Portability and Accountability Act.

17
18 Key Words: patellar fracture, open reduction internal fixation, functional mobility

24 **Abstract**

25 Background and Purpose: The patella serves an important role in the protection and
26 biomechanics of the knee joint. A fracture of the patella typically requires surgery and
27 immobilization, which can have detrimental impacts on functional mobility. The purpose of this
28 case study was to document a rehabilitation program following a comminuted patella fracture
29 status post open reduction internal fixation (ORIF).

30 Case Description: The patient was a 62-year-old female who sustained a comminuted patella
31 fracture following a traumatic fall down the stairs, and underwent ORIF to her right patella. She
32 was prescribed a straight knee immobilizer for eight weeks leaving her unable to take daily
33 walks, play with her grandchildren, and drive. Physical therapy (PT) interventions, which began
34 four weeks post-operatively, were chosen based on deficits in range of motion (ROM) and
35 strength, quadriceps atrophy, knee extensor lag, and an antalgic gait pattern. The interventions
36 included a lower extremity (LE) strengthening program, ROM, manual therapy, and gait training.

37 Outcomes: The patient demonstrated gains in right knee flexion active ROM (48° to 120°) and
38 passive ROM (46° to 125°). Strength gains were demonstrated through manual muscle testing of
39 knee flexion (4-/5; *full ROM against gravity, mild resistance*) and knee extension (4/5; *moderate*
40 *resistance*). Treatment continued beyond the time of publication, but progress notes suggested
41 improvements in strength and ROM, despite persistent functional deficits.

42 Discussion: The outcomes suggested a holistic LE strengthening program appeared to be
43 successful in decreasing knee extensor lag, preparing the limb for ambulation without the
44 immobilizer, and increasing functional mobility. Consistent with the literature, this patient had
45 persistent functional deficits. Future research should focus on earlier PT intervention and
46 effective approaches for increasing quadriceps muscle activity.

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48 **INTRODUCTION/BACKGROUND and PURPOSE**

49 The kneecap, or patella, is a small triangular bone within the quadriceps femoris tendon
50 serving an important role in the biomechanics of the knee.¹ The patella functions to protect the
51 knee joint from direct trauma, serves as the insertion of the patellar tendon, and improves knee
52 extension mechanics by increasing the moment arm of the quadriceps femoris.^{1,2} Patella fractures
53 are rare and account for approximately 1% of all fractures, most commonly occurring between
54 the ages of 20 and 50 years old, and in males twice as often as females.^{3,4} The two most common
55 mechanisms of injury (MOI) resulting in a patella fracture include direct trauma or an avulsion
56 mechanism resulting in fracture. Direct trauma is typically from a high impact motor vehicle
57 accident, or from a fall directly onto a flexed knee. Both are typically associated with a
58 *comminuted fracture* (see Appendix 1) where the bone is broken into greater than two pieces. An
59 *avulsion fracture* (see Appendix 2), where a tendon or muscle pulls away a piece of bone,
60 commonly occurs from a sudden forceful contraction of the quadriceps and is frequently
61 associated with a transverse fracture of the patella.²

62 A patella fracture is diagnosed through physical examination, patient presentation, MOI,
63 and imaging. Radiographs, or X-rays, are needed for definitive diagnosis. Based on the diagnosis
64 and type of fracture, a conservative or surgical approach is taken. Conservative methods
65 including immobilization, activity modification, and physical therapy (PT) for restoring
66 functional mobility, are the treatment of choice for uncomplicated, minimally displaced
67 fractures.² Conversely, a surgical approach of open reduction internal fixation (ORIF) is typically
68 indicated for comminuted fractures, largely displaced fractures, or those with a loss of extensor
69 mechanism function.² The standard of care for ORIF is a technique using tension band wire
70 fixation, as shown in Appendix 3. Following ORIF, patients are prescribed a straight knee
71 immobilizer for a minimum of six weeks.^{2,3,4} Prolonged immobilization can lead to undesirable

72 consequences including decreased knee range of motion (ROM) and weakness of the
73 immobilized muscles.⁵ These impairments lead to difficulties in activities of daily living (ADLs),
74 limitations in activity, and a decreased quality of life. Physical therapy has an important role in
75 addressing these impairments and improving functional capacity.

76 Following a literature review, there appeared to be a lack of research related to PT
77 rehabilitation for comminuted patella fractures status post (s/p) ORIF. Most related literature was
78 outdated, or focused on post-surgical quadriceps tendon ruptures, which presents similarly to a
79 post-surgical comminuted patella fracture. In a case study on a rehabilitation program following
80 a post-surgical quadriceps tendon rupture, Vasiliadis et al⁶ described the importance of utilizing
81 both open kinetic chain (OKC) and closed kinetic chain (CKC) exercises in a full lower
82 extremity (LE) strengthening protocol, and the achievement of full knee ROM to return to
83 normal gait kinematics.

84 A knee extensor lag is a common impairment following a comminuted patella fracture s/p
85 ORIF, although the exact prevalence is not well documented in the literature. A knee extensor
86 lag occurs when the patient can achieve full knee extension ROM passively, but not actively.
87 This is often a result of significant quadriceps weakness following surgery or immobilization.⁷ A
88 knee extensor lag is also noted in those with knee osteoarthritis, and has been successfully
89 treated with quadriceps strengthening exercises.⁸

90 Due to the minimal research regarding rehabilitation related to patella fractures, this case
91 report will contribute to the literature needed on the topic. Therefore, the purpose of this case
92 study was to document the rehabilitation program leading to full, unrestricted return to work
93 following a comminuted patellar fracture s/p ORIF in a 62-year-old female.

94 **Patient History and Systems Review**

95 The patient provided written consent allowing the use of her medical records, images,

96 and participation in this case report. The patient was a 62-year-old Caucasian female referred to
97 PT following a traumatic fall down the stairs. She landed directly onto the anterior aspect of her
98 right knee and sustained a comminuted patella fracture. She immediately underwent surgery for
99 an ORIF to her right patella. Please refer to Appendix 4 for x-rays pre- and post-surgery, and
100 Appendix 5 for immediate presentation after surgery. She was placed in a straight knee
101 immobilizer for six to eight weeks (depending on LE strength) and was weight bearing as
102 tolerated while using a single point cane (SPC). Prior to her injury, she was a healthy, active
103 individual who enjoyed taking daily walks and running after her grandchildren. She was the
104 manager at a veterinary hospital and lived in a two-story home with her supportive husband.

105 The patient presented to PT four weeks post-surgery with minimal pain, significant right
106 quadriceps atrophy, markedly decreased ROM, reduced strength, increased inflammation and
107 edema surrounding the knee (see Appendix 6) and an antalgic gait pattern while using a SPC and
108 knee immobilizer. Prior to PT, she was assessed by her orthopedic surgeon and the presenting
109 impairments were consistent with the surgical procedure. Therefore, there were no potential
110 differential diagnoses at the time. Upon initial examination (IE), the patient's primary complaints
111 were difficulty performing ADLs, inability to access her second-floor bedroom, sit for longer
112 than 30 minutes without discomfort, and drive. Her primary goal for the first four weeks was to
113 gain enough strength to ambulate effectively without the knee immobilizer, which the surgeon
114 stated could be weaned off on the eighth week (post-surgery) following adequate strengthening.
115 Beyond this, the patient's goals were to address the chief complaints listed above. Her medical
116 history included treatment for breast cancer and high blood pressure. Unfortunately, neither the
117 treatment course for her history of breast cancer, nor her medications for high blood pressure,
118 were obtained from the patient.

119 A review of the patient's history and systems review revealed impairments in the

120 musculoskeletal and integumentary systems as detailed in Table 1. Tests and measures were
121 chosen based on her history and presentation, and included ROM, observation of the quadriceps
122 muscle contraction, joint mobility, gait analysis, girth measurements, pain assessment, and
123 functional outcome measures. Manual muscle testing (MMT) of the LE was not performed at the
124 IE to protect the post-operative incision. This patient presented as an excellent candidate for this
125 case report due to her type of fracture, high level of motivation, and ambition to return to
126 functional activity.

127 **Examination – Tests and Measures**

128 Tests and measures were chosen to capture the patient’s function including: ROM
129 assessment; observation of the quadriceps muscle contraction; joint mobility assessment;
130 anthropometric measurements; gait analysis; pain assessment via the Numeric Pain Rating Scale
131 (NPRS); and the Lower Extremity Functional Scale (LEFS). Please refer to Table 2 for the
132 results of the tests and measures.

133 The patient presented with severely limited right knee flexion ROM. Bilateral active and
134 passive ROM of the knee were assessed using a Baseline® Evaluation Instruments (Fabrication
135 Enterprises Inc, White Plains, NY) universal goniometer through methods described by Norkin
136 and White.⁹ Goniometric values were compared to the normative values reported by the
137 American Medical Association¹⁰ and were found to be reliable and valid in measuring LE
138 ROM.¹¹

139 The relative strength of the patient’s quadriceps muscles was assessed in the long sitting
140 position with the knees in full extension. The patient performed an isometric contraction of the
141 quadriceps on both legs. In comparison to the left side, the right quadriceps were noticeably
142 atrophied, and demonstrated less than one fourth of the visible force of the left side contraction.

143 Joint mobility was assessed through passively mobilizing the patella with the knee in

144 slight flexion as described by Dutton.¹ All motions were hypomobile in the right knee. The
145 psychometric properties of patellar joint mobility were not found in the literature; however,
146 restoration of joint mobility may contribute to regaining full ROM and decreasing pain.

147 Circumferential knee measurements using a tape measure were used to assess swelling
148 and muscle atrophy, which can lead to impairments in ROM, strength and functional activity.
149 Measurements were taken in centimeters at the superior and inferior pole of the patella with the
150 patient in supine and the knees fully extended. Circumferential measurements were a valid and
151 reliable tool following reconstructive surgery of the anterior cruciate ligament.¹² Despite the
152 differing surgical case types, this was appropriate given the acute nature and location of injury in
153 this patient.

154 The patient completed the LEFS, a patient-reported outcome measure assessing the
155 impact of their injury on functional ADLs (see Appendix 7).¹³ Each item is scored on a 0-4 scale
156 (0: *unable to perform* the activity; 4: *no difficulty*). A lower score indicates a higher level of
157 disability or a larger negative impact on function. This test was sensitive to change, valid, and
158 reliable.¹³ Based on the patient's presentation and difficulty with ADLs, it was an appropriate
159 tool to measure functional change over time.

160 The NPRS by McCafferey et al¹⁴ was used to assess her level of pain at IE as well as at
161 its best and worst. The NPRS is an 11-point numeric scale where zero represents *no pain* and 10
162 represents *the worst pain imaginable*. It is reported to have a moderate to high test-retest
163 reliability.¹⁵

164 **Clinical Impression: Evaluation, Diagnosis, Prognosis**

165 Based on the IE, patient presentation, and tests and measures, the initial impression of a
166 right comminuted patella fracture s/p ORIF was confirmed, with no further diagnoses identified.

167 The patient continued to be appropriate for this case report due to her functional deficits

168 that prevented her from returning to her prior level of function (PLF) and unrestricted work.
169 During the third week of PT, the patient presented with a regression in ROM, pain, and inability
170 to perform many exercises following a family emergency that required her to kneel to resuscitate
171 a family member several days prior. This increase in symptoms, and slight set-back in progress,
172 further made the patient appropriate for this case report.

173 Upon IE, a decision to proceed with PT services was made without further referral or
174 consultation. Interventions addressed her limitations with goals to improve LE strength, ROM
175 and gait pattern, decrease pain and swelling, and improve functional status. Consultation with the
176 surgeon occurred following the regression on week three to ensure no harm was done to the
177 surgical site. Ongoing consultation with the patient and surgeon occurred throughout the episode
178 of care regarding the plan of care (POC) and discharge planning.

179 The patient's ICD-10 medical/PT diagnoses were S82.001S for unspecified fracture of
180 the right patella, sequela and Z47.89 for encounter for other orthopedic aftercare. Despite a
181 paucity of evidence surrounding functional outcomes related to this case at the time of her care,
182 several studies have demonstrated relatively poor long-term outcomes including continued
183 functional deficits and symptomatic complaints effecting quality of life six to eight years
184 following patella fracture.^{16,17} Despite this evidence, the patient had a fair prognosis due to her
185 high PLF, enthusiastic attitude, and relatively limited pain. Furthermore, one of her primary
186 goals was to return to walking and running after her grandchildren. One study found no
187 statistically significant difference in either gait speed or cadence at eight and a half years post-
188 surgery.¹⁷

189 Planned interventions to address functional limitations included: LE strengthening;
190 passive and active ROM; joint and soft tissue mobilization techniques; gait and stair training;
191 neuromuscular re-education; modalities as indicated for decreased swelling; and a home exercise

192 program (HEP). Re-evaluations, including all previously listed tests and measures, were
193 completed every six weeks to monitor progress. The plan for additional testing included MMT of
194 the LE and observation of stair negotiation, which were not assessed on IE due to protection of
195 the surgical site.

196 Please refer to Table 3 for PT short- and long-term goals.

197 **Intervention and Plan of Care**

198 Coordination, Communication, and Documentation

199 Following the IE, the patient was educated on the findings, proposed POC, and the
200 importance of a HEP for optimal outcomes. Communication was consistent between all members
201 involved in the patient's care including the patient, PT, student physical therapist (SPT), physical
202 therapy assistant (PTA), and surgeon. The SPT communicated with the supervising PT on all
203 aspects of the POC, and delegated to the PTA regarding patient treatment. Communication with
204 the surgeon was established for post-surgical restrictions and patient progression. All treatment
205 sessions were documented via electronic medical records and included a subjective review of the
206 patient's symptoms and a list of all interventions performed. Re-evaluations were performed and
207 documented every six weeks.

208 Patient/Client Related Instruction

209 Patient education and instruction was a pivotal aspect of patient care. The patient was
210 provided with a HEP, which was reviewed and updated periodically based on patient
211 progression. She was instructed on proper form, intensity, and time for her exercises. The patient
212 reported compliance with her daily HEP, but missed several appointments secondary to family
213 matters.

214 Procedural Interventions

215 The patient received PT two times a week for 45-60-minute sessions along with a HEP.
216 All interventions including duration and frequency are listed in Tables 4 and 5 and Appendix 8.
217 The patient's POC was divided into two functional phases for ease of documentation. Phase One
218 ranged from the IE through the fourth week (visit 8) when the patient wore the knee immobilizer.
219 The goals during this phase were to strengthen and prepare the right LE for independent
220 ambulation after prolonged immobilization. Interventions included stretching, therapeutic
221 exercises for strengthening the R LE, ROM, manual therapy techniques, and modalities for
222 edema control (Table 4). Phase Two began after the knee immobilizer was discontinued in week
223 five and focused on normalizing gait mechanics and functional activities to return the patient to
224 pain free, unrestricted ADLs. Interventions included continued stretching and ROM, OKC and
225 CKC exercises, balance training, manual therapy, and gait and stair training (Table 5).

226 *Stretching*

227 During Phase One, active stretching of the hamstrings and gastrocnemius was utilized to
228 maintain tissue length. The hamstrings were stretched in the seated position with the knee
229 immobilizer on to protect the surgical site. Stretching was continued throughout Phase Two
230 based on patient presentation, report of symptoms, and clinical expertise.

231 *Therapeutic Exercise*

232 LE strengthening in Phase One included OKC exercises, which are effective in isolating
233 individual muscles and muscle groups, to address the functional deficits of prolonged
234 immobilization and the residual knee extensor lag.¹⁸ Isotonic OKC ankle exercises using a
235 resistance band (TheraBand, Akron, OH) and isotonic exercises at the hip were used to isolate
236 the muscles surrounding their respective joints. Initially, isometric quadriceps sets were utilized
237 to increase strength and decrease the knee extensor lag as recommended by Thakur et al.⁸ This
238 was progressed to a straight leg raise and short arc quad. In Phase Two, strengthening exercises

239 transitioned towards CKC functional exercises including step-ups, squats, terminal knee
240 extension, heel raises, and leg press. Vasiliadis et al⁶ described the importance of incorporating
241 both OKC and CKC exercises in a full LE strengthening protocol to increase strength, achieve
242 full knee ROM, and return to normal gait kinematics. The OKC exercises were added into the
243 patient's HEP, however, some needed to be reintegrated into the POC on the ninth week when
244 the patient demonstrated difficulty activating her quadriceps in CKC exercises. Bilateral and
245 unilateral balance exercises were also integrated into the patient's POC.

246 *Range of Motion and Manual Therapy*

247 ROM exercises were used to address mobility deficits due to prolonged immobilization in
248 knee extension and tightness of the surgical incision preventing full right knee flexion ROM. In
249 Phase One, ROM was addressed through active heel slides and further progressed to short sit
250 with overpressure applied by the opposite leg. To further increase ROM, transverse friction
251 massage was performed to separate adhesions and improve blood flow, followed by PROM.¹⁹
252 Due to patient apprehension and muscle guarding, PROM was often supplemented by STM to
253 the quadriceps to relax the patient and her muscles. These ROM exercises were progressed in
254 Phase 2 to the patient in prone performing active knee flexion with overpressure from the PT.
255 Joint mobilizations of the patella, as described by Dutton¹ were introduced in Phase Two to
256 increase patella mobility.

257 *Gait Training and Stair Training*

258 Gait training was initiated following removal of the knee immobilizer as the patient
259 demonstrated apprehension in bending her knee in the swing phase of gait. The patient
260 compensated for the lack of knee flexion through hip circumduction and a hip-hike in her right
261 pelvis. Gait training initially focused on normalizing gait in a straight plane and progressed to
262 stepping over 6-inch hurdles. The patient progressed to stair training when she was able to

263 simultaneously flex the hip and knee to perform the movement. For further details, please see

264 Tables 4 and 5.

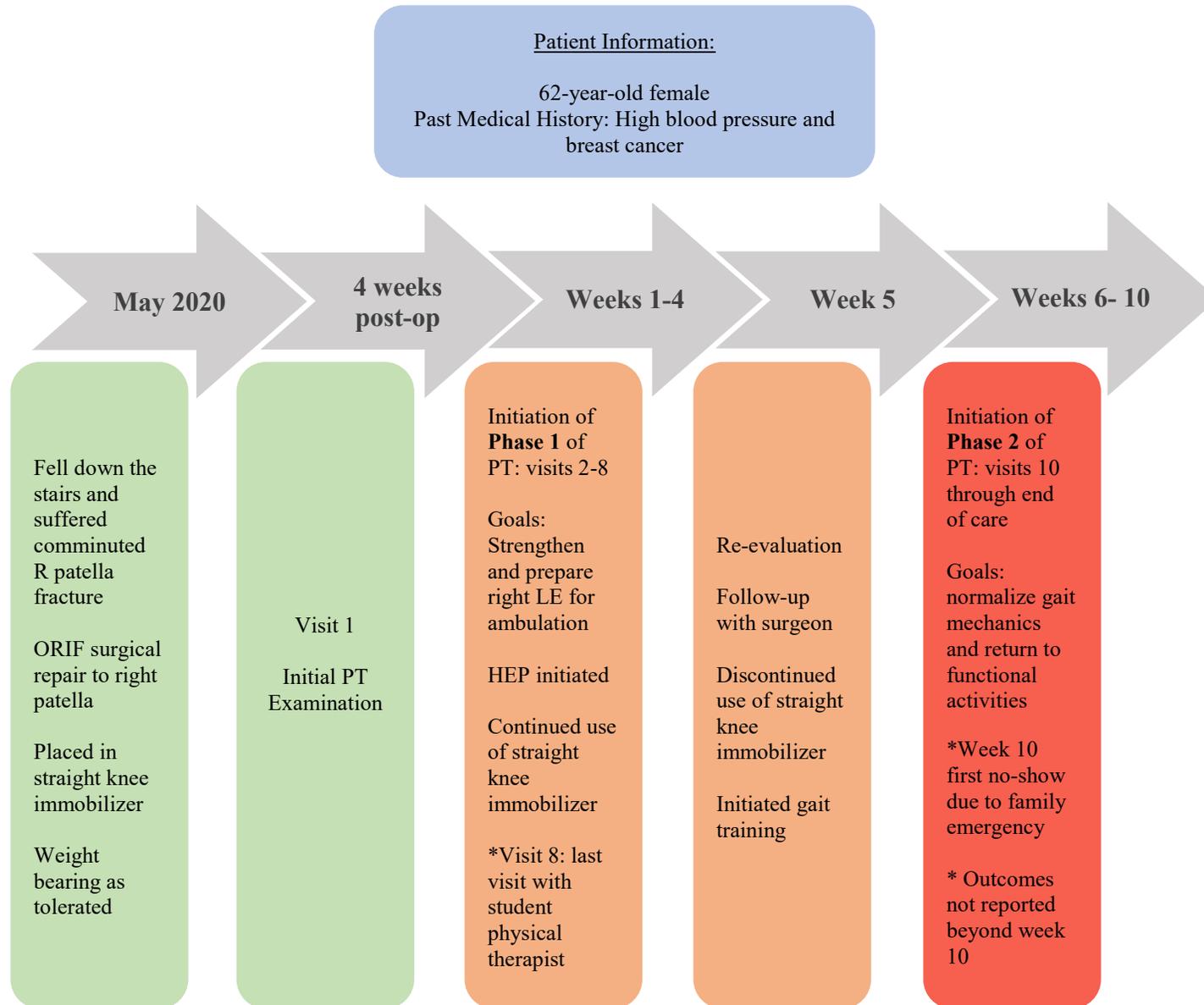
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Figure 1: Episode of Care Timeline



293 **OUTCOMES**

294 At IE, the patient presented with slight pain, right quadriceps atrophy, ROM deficits,
295 impaired strength, inflammation, and an antalgic gait pattern. During Phase One of rehabilitation,
296 the patient demonstrated improvements in LE strength and knee ROM and a decrease in pain,
297 inflammation, and knee extensor lag (see Table 2). The patient-stated goal of discontinuing the
298 straight knee immobilizer at the follow-up with the surgeon (on week 5) was met. At that time,
299 the patient also met the functional goal of driving 30 minutes to work. Regarding the other two
300 short term goals (see Table 3), she fully met her ROM goal through increasing right knee flexion
301 AROM from 48° to 120° and PROM from 46° to 125°. She partially met her strength goal of
302 demonstrating at least a score of 4/5 on right LE MMTs, with knee flexion strength at 4/5 and
303 knee extension at 4-/5. There was an increase in observed quadriceps muscle contraction force
304 from less than 25% to 50% of the force of the unaffected limb and a decrease in the
305 demonstrated knee extensor lag. Self-reported improvements included a decrease in pain on the
306 NPRS from 2/10 at worst, to 0/10 with slight tightness when standing up after sitting. She had a
307 2-point increase on her LEFS, indicating less overall dysfunction with ADLS, however this
308 change was not clinically significant.¹³ Finally, there was a decrease in size at the inferior pole
309 of the patella from 41cm to 38cm indicating decreased swelling surrounding the knee.

310 Phase Two of rehabilitation was not completed, nor were functional outcomes reported, at
311 the time of this publication. PT notes from the first five weeks of care during this phase showed
312 continued improvements in strength through increased tolerance to her exercises, improved
313 balance, and improved gait mechanics. She also reported increased confidence with negotiating
314 stairs and playing with her grandchildren.

315 On week three following the IE, the patient had an increase in symptoms due to the
316 unanticipated event of resuscitating a family member. This event further led the patient to miss

317 multiple sessions in Phase Two of care. She continued to report adherence to her HEP, although
318 her progression through the POC slowed.

319 **DISCUSSION**

320 This case report was intended to describe the PT management of a 62-year-old patient to
321 restore functional mobility following a comminuted patella fracture s/p ORIF. The patient's POC
322 and interventions were initially based around protecting the surgical site. Clinical experience and
323 research related to injuries with similar presentations were main contributors to the development
324 of the POC while maintaining a patient-centered approach. Although the outcomes of Phase Two
325 were not reported at the time of publication, the outcomes from Phase One suggest the LE
326 strengthening protocol and therapeutic exercises to decrease knee extensor lag appeared to be
327 successful in preparing the limb for independent ambulation following prolonged knee
328 immobilization. The purpose of this case report was met as demonstrated through increased knee
329 strength and ROM, improved gait mechanics, and return to functional activities.

330 After conducting a review of the literature, there appeared to be a paucity of evidence
331 related to rehabilitation following comminuted patella fractures s/p ORIF. Despite this,
332 utilization of research for therapeutic activities based on the patient's presentation appeared to
333 yield positive outcomes. Quadriceps strengthening, as previously described, appeared successful
334 in improving the knee extensor lag. Furthermore, taking a wholistic LE strengthening protocol
335 including both OKC and CKC exercises, as described by Vasiliadis et al,⁶ also appeared to yield
336 the desired outcomes of increasing functional mobility. This was evident by the patient regaining
337 the ability to drive, returning to her walking routine, playing with her grandchildren, and
338 negotiating stairs.

339 The positive factors that contributed to the patient's success include the patient-centered
340 approach, clinical expertise used, patient's PLF, and patient motivation for returning to work and

341 leisure activities. The potential negative factors included prolonged knee immobilization,
342 delayed PT until four weeks post-op, and the unexpected family emergency that ultimately led
343 this patient to regress and miss several appointments.

344 Based on the improvements the patient made, utilization of a holistic LE strengthening
345 protocol through incorporating both OKC and CKC exercises post-surgery may be beneficial,
346 although more research surrounding its utility is needed. Future research may be targeted at
347 earlier PT intervention after surgery to decrease the likelihood of prolonged knee
348 immobilization. Another avenue for future research could investigate the effects of different
349 therapeutic activities, such as neuromuscular electrical stimulation, on the quadriceps muscles to
350 increase their activity. In alignment with the expected outcomes from the review of literature,
351 this patient continued to demonstrate functional deficits, especially with activating her
352 quadriceps in functional activities, through Phase Two.^{16,17} Future research on increasing muscle
353 activity may be beneficial to future patients.

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435 **TABLES and FIGURES**

436 **Table 1: Systems Review: Initial Evaluation**

Cardiovascular/ Pulmonary	Not Impaired
Musculoskeletal	<p>Impaired</p> <ul style="list-style-type: none"> • Impaired gross ROM- reduced knee active and passive knee flexion ROM on right • Impaired strength: significantly reduced quadriceps muscle contraction strength on right side
Neuromuscular	<p>Impaired</p> <ul style="list-style-type: none"> • Gross lower extremity sensation intact bilaterally • Antalgic gait noted
Integumentary	<p>Impaired</p> <ul style="list-style-type: none"> • Healing surgical scar over right knee from ORIF surgery • Swelling and bruising surrounding incision and on medial aspect of right knee
Communication	Not Impaired
Affect, Cognition, Language, Learning Style	<p>Not Impaired</p> <ul style="list-style-type: none"> • Preferred Language: English • Learning Style: verbal and demonstration; written instructions for HEP

437 ROM= range of motion; ORIF= open reduction internal fixation; HEP= home exercise program

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446 **Table 2: Examination Results**
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Tests & Measures	Initial Evaluation Results		Re-evaluation Results (Week 5)	
	Left	Right	Left	Right
Knee ROM	Flexion AROM: 112° PROM: 125° Extension A/PROM: 0°	Flexion AROM: 48° PROM: 46° Extension A/PROM: 0°	Flexion AROM: 135° PROM: 140° Extension A/PROM: 0°	Flexion AROM: 120° PROM: 125° Extension A/PROM: 0°
Joint Mobility (patellar glides)	Superior: normal	hypomobile	Superior: normal	hypomobile
	Inferior: normal	hypomobile	Inferior: normal	hypomobile
	Medial: normal	hypomobile	Medial: normal	hypomobile
	Lateral: normal	hypomobile	Lateral: normal	hypomobile
Lower Extremity MMT	NT	NT	Flexion: 5/5 Extension: 5/5	Flexion: -4/5 Extension: 4/5
% Quadriceps Contraction	100%	<25%	100%	50%
Anthropometric Measures	Superior pole of patella: 42.5cm Inferior pole of patella: 38.6cm	Superior: 45cm Inferior: 41cm	Superior: 43cm Inferior: 39cm	Superior: 44cm Inferior: 38cm
LEFS	54/80; 32% dysfunction		56/80; 30% dysfunction	
NPRS	At time of eval: 0/10 At best: 0/10 At worst: 2/10		At time of eval: 0/10 At best: 0/10 At worst: 0/10	
Gait Observation	Antalgic gait with hip circumduction on right due to knee immobilizer. Use of single point cane in left hand. Shortened stance phase on right.		Mild limitation of push off on right with evidence of weakness on the right side	

448 ROM= range of motion; AROM= active range of motion; PROM= passive range of motion; NT= not tested; cm= centimeter; LEFS= Lower Extremity Functional
 449 Scale; NPRS= Numeric Pain Rating Scale Manual Muscle Testing Scoring: -4/5=full ROM against gravity, mild resistance; 4/5= full ROM against gravity,
 450 moderate resistance; 5/5=normal, maximal resistance

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454 **Table 3: Short- and Long-Term Goals**

Time Frame	Goal
Short-Term Goals	
3 weeks	Patient will achieve at least 90° of right knee AROM & PROM, with no increase in pain to improve ambulation and participation in ADLs. (GOAL MET)
6 weeks	Patient will demonstrate at least a 4/5 on all LE MMTs to improve ambulation and participation in ADLs. (GOAL PARTIALLY MET) Patient will be able to tolerate up to 30 minutes of driving without increased pain once knee immobilizer is removed in order to independently drive herself to work. (GOAL MET)
Long Term Goals	
12 Weeks	Patient will negotiate one flight of stairs demonstrating a reciprocal gait pattern and use of one railing in order to access her second-floor bedroom. (NOT MET) Patient will be able to independently ambulate up to 2 miles without increase in symptoms to return to recreational activities. (NOT MET) Patient will achieve at least 115° of R knee AROM in order to achieve functional independence in daily activities. (GOAL MET)

455 AROM= active range of motion; PROM=passive range of motion; ADLs= Activities of daily living; LE= lower extremity; MMTs= manual muscle testing; R=Right

456 **Table 4: Rehabilitation Phase 1**

Intervention	Initial Eval	Week 1	Week 2	Week 3	Week 4
	Visit 1	Visits 2+3	Visits 4+5	Visits 6+7	Visit 8
Manual Therapy					
Passive ROM Knee flexion/extension	4 minutes: patient supine	7 minutes: patient supine 6 minutes: seated edge of table	6 minutes: supine and seated w/ legs off table	6 minutes: supine and seated w/ legs off table	7 minutes: seated w/ legs off table
Soft Tissue Mobilization		6 minutes: Retrograde w/ elevation	7 minutes: transverse friction to surgical scar	6 minutes: Retrograde for swelling 5 minutes: transverse friction	6 minutes: transverse friction
Manual Stretching					2 minutes; prone quad stretch
Stretching					
Hamstring Position: Seated at end of table with immobilizer		2x30 sec	2x30 sec	2x30sec	2x30sec
Gastroc Position: long sitting		2x30sec	2x30sec	2x30sec	2x30sec
OKC Strengthening					
Gluteal Sets Position: supine	1x10; 3 sec hold	2x10; 3 sec hold	2x10; 5 sec hold	2x10; 5 sec hold	2x10; 5 sec hold
Quad Sets Position: long sitting	1x10; 3 sec hold	2x10; 3 sec hold	2x10; 5 sec hold	2x10; 5 sec hold	2x10; 5 sec hold
4-Way Ankle Position: long sit with knee immobilizer		2x10 Resistance: Red TheraBand	2x10 Resistance: red TheraBand	2x10 Resistance: green TheraBand	

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Straight Leg Raise Position: supine Active quad set performed first		2x10 *not performed visit 2	2x10	1x10 (painful)	2x10
Short Arc Quad ½ foam roll under right knee			1x10	Pt in too much pain	2x10
Straight Leg Raise: Abduction and Adduction Position: side lying			2x10	2x10	2x10
Clam Shell Position: side lying					2x10
ROM					
Ankle Pumps Position: supine	1x10	1x10			
Heel Slides Position: supine; towel under foot	2x10	2x10	2x10	2x10	2x10
Active-Assisted Knee Flexion Position: Seated with legs off table; overpressure applied by opposite leg		4 minutes	3 minutes	3 minutes	3 minutes
Modalities					
E-Stim with ice and elevation Parameters: IFC; 80-100pps; continuous; (+) medial aspect of knee; (-) lateral aspect of knee	20 minutes	20 minutes	20 minutes	20 minutes	20 minutes

ROM=Range of motion; w/=with; sec=second; TheraBand (TheraBand, Akron, OH); E-stim= electrical stimulation; IFC= interferential current; pps=pulses per second

*Please see Appendix 9 for pictures of these exercises

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462 **Table 5: Rehabilitation Phase 2**

Intervention	Week 4 (continued)	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11
	Visit 9	Visit 10 (re-eval) +11	Visits 12+13	Visits 14+15	Visit 16+17	Visit 18	Visit 19+20	
Warm Up								
Bicycle Ergometer (SciFit)	5 minutes; ¾ cycles	8 minutes *able to do full revolution	8 minutes; full revolutions					
Manual Therapy								
Passive ROM Knee flexion/extension	5 minutes; seated with legs off table	4 minutes; patient supine	5 minutes; patient prone	5 minutes; patient prone				
Soft Tissue Mobilization	5 minutes: transverse friction and retrograde	6 minutes: transverse friction massage and distal quad release	6 minutes; transverse friction and distal quad release	8 minutes; transverse friction and distal quad release	6 minutes; transverse friction and distal quad release	6 minutes; transverse friction and distal quad release	6 minutes; transverse friction and distal quad release *visit 19 10 minutes; STM to medial knee *visit 20	
Quad Stretch Position: Supine w/ soft tissue massage					5 minutes			
Patellar Joint Mobilization						5 minutes; oscillatory; all directions	5 minutes; oscillatory; all directions	
Stretching								
Gastroc Position: standing on slant board		2x30 sec	2x30 sec	2x30sec	2x30sec	2x30sec	2x30sec	
OKC Exercises								
Straight Leg		1x10 with leg in neutral	1x10 with leg in neutral	2x10 with leg in neutral	2x10 with leg in neutral		2x10 with leg in neutral	

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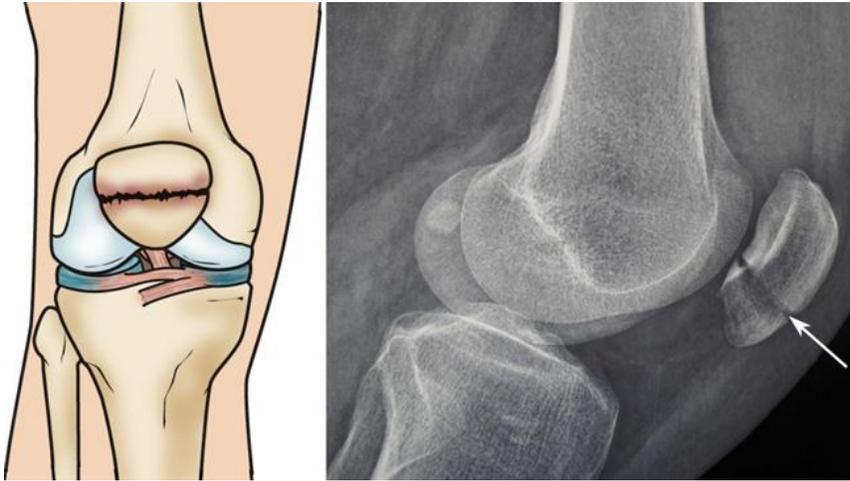
Raise Position: supine Active quad set performed first		1x10 with leg in ER	1x10 with leg in ER	2x10 with leg in ER	2x10 with leg in ER		2x10 with leg in ER	
Short Arc Quad ½ foam roll under right knee		2x15; 3 second holds; 1lbs						
CKC Exercises								
Heel Raises	2x10	2x15	2x15	2x15	2x15	2x15	2x15	
Squats Additional info: In front of mirror with chair behind patient	1x10; against a wall	2x10	2x10	3x10	2x20	2x20	2x20	
Forward Step-Ups	2x10; 4-inch step	2x10; 6-inch step	2x10; 6-inch step	2x10; 6-inch step	2x10; 8-inch step	2x10; 8-inch step	2x10; 8-inch step	
Eccentric Step Down Info: Right foot on step controlling descent				2x10; 4-inch step *initiated on visit 15	2x10; 4-inch step	2x10; 4-inch step *8-inch on visit 19	2x10; 8-inch step	
Leg Press Bilateral Position: supine on Pilates machine		2x15; resistance: 3 red springs	2x15; resistance: 3 red springs	2x15; resistance: 3 red springs				
Side Step Left and Right				6x10 feet; resistance: Yellow TheraBand	6x10 feet; resistance: Yellow TheraBand	6x10 feet; resistance: Red TheraBand	6x10 feet; resistance: Red TheraBand	
Terminal Knee Extension				2x20; resistance: green TheraBand	3x10; resistance: green TheraBand	3x10; resistance: green TheraBand	3x10; resistance: green TheraBand	

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Leg Press Unilateral Position: supine on Pilates machine				3x10; resistance: 2 red, 1 yellow spring	3x10; resistance: 2 red, 1 yellow spring	3x10; resistance: all springs	3x10; resistance: all springs	
ROM								
Active-Assisted Knee Flexion Position: Seated with legs off table; overpressure applied by opposite leg	4 minutes	4 minutes *not performed on visit 10	4 minutes					
Gait Training								
Level Surface	10 minutes							
Stepping over hurdles	5 minutes							
Balance Training								
Single Leg Balance					2x30 sec; firm surface; eyes open	2x30 sec; airex pad; eyes open	2x30 sec; airex pad; eyes open	

463 **APPENDICES**

464 **Appendix 1: Transverse Fracture of the Patella²⁰**



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466 **Appendix 2: Comminuted Fracture of the Patella²⁰**



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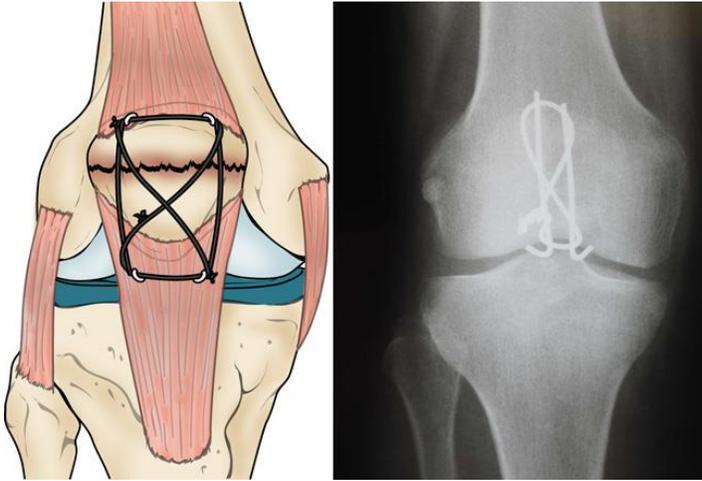
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476 **Appendix 3: ORIF Tension Band Wire Fixation¹⁸**



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478 **Appendix 4a: X-ray of Patient's Right Knee Before Surgical Intervention**



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480 **Appendix 4b: X-ray of Patient's Right Knee After Surgical Intervention**



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482 **Appendix 5: Patient Presentation After Surgical Intervention**



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484 **Appendix 6: Patient Presentation on Visit 2**



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487 **Appendix 7: Lower Extremity Functional Scale¹³**

The Lower Extremity Functional Scale

We are interested in knowing whether you are having any difficulty at all with the activities listed below **because of your lower limb problem** for which you are currently seeking attention. Please provide an answer for **each** activity.

Today, do you or would you have any difficulty at all with:

	Activities	Extreme Difficulty or Unable to Perform Activity	Quite a Bit of Difficulty	Moderate Difficulty	A Little Bit of Difficulty	No Difficulty
1	Any of your usual work, housework, or school activities.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
2	Your usual hobbies, recreational or sporting activities.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
3	Getting into or out of the bath.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
4	Walking between rooms.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
5	Putting on your shoes or socks.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
6	Squatting.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
7	Lifting an object, like a bag of groceries from the floor.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
8	Performing light activities around your home.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
9	Performing heavy activities around your home.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
10	Getting into or out of a car.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
11	Walking 2 blocks.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
12	Walking a mile.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
13	Going up or down 10 stairs (about 1 flight of stairs).	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
14	Standing for 1 hour.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
15	Sitting for 1 hour.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
16	Running on even ground.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
17	Running on uneven ground.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
18	Making sharp turns while running fast.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
19	Hopping.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
20	Rolling over in bed.	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>
Column Totals:		0	0	0	0	0

Minimum Level of Detectable Change (90% Confidence): 9 points SCORE: ____ / 80 (fill in the blank with the sum of your responses)

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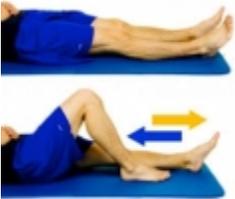
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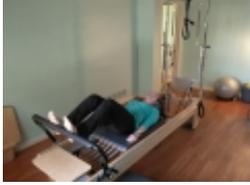
501 Appendix 8: Phase 1 and 2 Exercises²¹

Manual Therapy	
Knee Flexion and Extension	  <p>Active knee flexion with overpressure applied by PT.</p>
Stretching	
Stretching	
Hamstrings	 <p>Performed with the knee immobilizer one in Phase 1 for protection of the surgical site.</p>
Gastroc	 <p>Phase 1:</p>

	<p>Phase 2:</p> 
<p>Open Kinetic Chain Strengthening Exercises</p>	
<p>Gluteal Sets</p>	
<p>Quad Sets</p>	
<p>4-way Ankle</p>	

<p>Straight Leg Raise</p>	
<p>Short Arc Quad</p>	
<p>SLR abduction and adduction</p>	
<p>Clam</p>	
<p>Range of Motion</p>	
<p>Ankle Pumps</p>	
<p>Heel Slides</p>	

<p>AAROM Knee Flexion</p>	 <p>Active knee flexion with overpressure from the opposite leg</p>
<p>Closed Kinetic Chain Strengthening Exercises</p>	
<p>Heel Raise</p>	
<p>Squats</p>	<div style="display: flex; justify-content: space-around;"> <div data-bbox="440 800 688 1045">  <p>Wall Squats</p> </div> <div data-bbox="834 800 1154 1045">  <p>Chair squats</p> </div> </div>
<p>Step-Ups</p>	
<p>Eccentric Step Down</p>	

Leg Press	  <p>Starting position</p> <p>Ending position</p>
TKE	
Single Leg Balance	  <p>Single leg balance on a foam pad</p>

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509 **CARE Checklist**

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CARE Content Area	Page
1. Title – The area of focus and “case report” should appear in the title	1
2. Key Words – Two to five key words that identify topics in this case report	1
3. Abstract – (structure or unstructured) a. Introduction – What is unique and why is it important? b. The patient’s main concerns and important clinical findings. c. The main diagnoses, interventions, and outcomes. d. Conclusion—What are one or more “take-away” lessons?	2
4. Introduction – Briefly summarize why this case is unique with medical literature references.	3-4
5. Patient Information a. De-identified demographic and other patient information. b. Main concerns and symptoms of the patient. c. Medical, family, and psychosocial history including genetic information. d. Relevant past interventions and their outcomes.	5-6
6. Clinical Findings – Relevant physical examination (PE) and other clinical findings	6-7
7. Timeline – Relevant data from this episode of care organized as a timeline (figure or table).	13
8. Diagnostic Assessment a. Diagnostic methods (PE, laboratory testing, imaging, surveys). b. Diagnostic challenges. c. Diagnostic reasoning including differential diagnosis. d. Prognostic characteristics when applicable.	8-9
9. Therapeutic Intervention a. Types of intervention (pharmacologic, surgical, preventive). b. Administration of intervention (dosage, strength, duration). c. Changes in the interventions with explanations.	9-12
10. Follow-up and Outcomes a. Clinician and patient-assessed outcomes when appropriate. b. Important follow-up diagnostic and other test results. c. Intervention adherence and tolerability (how was this assessed)? d. Adverse and unanticipated events.	14-15
11. Discussion a. Strengths and limitations in your approach to this case. b. Discussion of the relevant medical literature. c. The rationale for your conclusions. d. The primary “take-away” lessons from this case report.	15-16
12. Patient Perspective – The patient can share their perspective on their case.	5
13. Informed Consent – The patient should give informed consent.	1,5

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