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Return To Golf In A 71-Year-Old Female After A Mako Robotic-Arm-Assisted Unicompartmental Knee Arthroplasty Surgery: A Case Report

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The patient signed an informed consent allowing the use of all medical information, pictures, and video footage for this case report and received information on the institution's policies, regarding the Health Insurance Portability and Accountability Act.

Key Words: unicompartmental knee arthroplasty, osteoarthritis, therapeutic exercise, range of motion, golf

Abstract

Background and Purpose: Knee osteoarthritis is the most common joint disorder in the elderly. The prevalence of unicompartmental knee arthroplasties (UKAs) increases by 30% each year. Benefits of UKA's are quicker recovery times and an overall less invasive procedure compared to a total knee arthroplasty (TKA). Robotic-arm-assist surgery has been shown to increase the accuracy of implant positioning compared to traditional surgical techniques. The purpose of this case report was to look at the impact of physical therapy (PT) on outcomes and return to golf in a patient following a Mako robotic-arm-assisted UKA.

Case Description: The patient was a 71-year-old female referred to outpatient PT one week after having a UKA to treat unicompartmental osteoarthritis of her right (R) knee. Her treatment included range of motion (ROM) and strengthening exercises, patellar mobilizations, balance training, patient education, and a home exercise program (HEP). She received PT two to three times a week for eight weeks.

Outcomes: This patient demonstrated improvements in all outcome measures upon self-discharge at week eight despite having had two falls that set her back in her recovery. Right (R) knee active ROM improved (8-111 to 3-126 degrees), Lower Extremity Functional Scale score improved (31/80 to 59/80), and R Single Leg Balance Test without upper extremity support improved (3 to 15 seconds). Right patellar mobility improved in all directions from hypomobile to normal, and strength improved in R hip flexion, knee flexion, and knee extension.

Discussion: This case report suggests that the combination of strength and ROM exercises, patellar mobility, balance training, patient education, and a HEP were beneficial to a patient following a UKA. Further research should be done comparing outcomes and recovery times of UKAs versus TKAs.

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Background and Purpose

Unicompartmental knee arthroplasty (UKA) surgery is used to treat unicompartmental osteoarthritis of the knee. The prevalence of knee osteoarthritis is 30% in those age 60 or older, and is the most common joint disorder in the elderly.[1] Medial UKAs are more frequently performed and make up 90% of the unicompartmental procedures.[2] UKA prevalence has been increasing at a rate of approximately 30% each year.[3] This is a higher rate of growth than the more common total knee arthroplasty (TKA). UKAs now make up 7.7% to 15% of all arthroplasty procedures, with surgeons in the United States performing the fewest compared to other countries.[3] An advantage to a UKA is a quicker recovery and an overall less invasive procedure.[4] Recently this surgery has been completed with a robotic-arm-assist. Bell et al.[4] showed increased accuracy of implant positioning when using a Mako (Stryker, Kalamazoo, MI) robotic-arm-assist compared to traditional surgical techniques. This increase in accuracy is important since inadequate and inaccurate implant positioning can lead to premature failure of the implant.

UKA implants typically last longer than ten years with only 10% of patients needing revisions.[2] Patients choose the UKA procedure over the typical TKA due to the quicker recovery time and therefore quicker return to function. Kleeblad et al.[5] showed an overall satisfaction rate of 91% in patients who received a robotic-arm-assist UKA.

Although there is significant literature to support the benefit of physical therapy (PT) interventions post TKA, there is limited literature on UKAs and PT interventions. There is even less literature on robotic-arm-assisted UKAs and PT interventions. In fact, there is no specific International Classification of Diseases, Tenth Revision (ICD-10) code for a UKA.[3] A systematic review and meta-analysis done by Minns Lowe et al.[6] on TKAs demonstrated success with interventions focused on knee range of motion (ROM), strengthening, gait training, icing, and a

HEP.

Golfing is a relatively low impact sport that encourages cardiovascular health, strength, flexibility, and has a large social aspect.[7] Papaliodis et al.[7] showed good outcomes for return to golf after TKA and total hip arthroplasties, although UKAs were not included in this study it gave clear guidelines for return to golf. Guidelines for return to play after a total joint replacement were as follows: putting at four to six weeks, light chipping at six to 10 weeks, a half swing with iron shots and driving was started at 10 to 12 weeks, a full swing at 12 to 14 weeks, and a full round of golf at six to 10 months. It was recommended that spikeless golf shoes be worn to decrease the rotational force on the knee.

This case report is needed due to the rise in robotic-arm-assisted UKAs and the lack of rehabilitation-based literature surrounding the subject. The purpose of this case report was to look at the impact of PT on outcomes and return to golf following a robotic-arm-assisted UKA.

Patient History and Systems Review

The patient signed an informed consent allowing the use of her medical information and images for this case report. She was a 71-year-old retired Caucasian female seen one week after having a right (R) UKA with a Mako robotic-arm-assist. She was referred to an outpatient PT clinic by her orthopedic surgeon. Prior to this procedure she lived alone and was fully independent with her activities of daily living (ADLs) in her multi-level home and maintained an active lifestyle through golfing, gardening, and biking. She did not require any assistive devices or adaptive equipment and was able to drive and ambulate independently throughout her community. Although, she did have significant R knee pain that began to impact her ADLs and recreational activities. Her chief complaints upon initial evaluation (IE) were R knee pain, knee immobility, and the inability to participate in her normal recreational activities. The primary concern of the patient was being able to return to golf and decreasing difficulty with her ADLs.

Results of systems review are listed in Table 1, and current medications are listed in Appendix 1. She presented with comorbidities of acid reflux, melanoma on the nose nine years prior, anxiety, and bilateral osteoarthritis of her knees and ankles. After same day surgery, she had home health PT for one week that consisted of two visits. The visits consisted of an IE and discharge, but a HEP focusing on knee range of motion (ROM), quadriceps femoris activation, and ankle pumps was given to the patient. This patient chose to get a UKA with a Mako robotic-arm-assist to minimize the amount of surgical trauma to her knee. She hoped this choice would lead to a quick recovery and return to her prior level of function.

This patient's primary problems were increased R knee pain, decreased R lower extremity strength, and decreased R knee active range of motion (AROM). These impairments were consistent with a post-surgical state due to a R UKA to treat unicompartmental osteoarthritis of the R knee. There was no other differential diagnosis as these conditions were assessed and treated by an orthopedic surgeon. Following a thorough subjective interview and systems review, objective measures were taken to determine the patient's baseline function. The examination included: a ten-point numeric pain rating scale, lower extremity girth measurements, inspection of wound healing, the Lower Extremity Functional Scale (LEFS), observational gait analysis, knee goniometric measures of AROM, gross lower extremity muscle testing via manual muscle testing (MMT), Single Leg Balance Test, and patellar mobility. This patient was a prime candidate for a case report due to her high level of motivation and her highly specific goal of returning to golf.

Examination – Tests and Measures

The results from the tests and measures conducted are in Table 2. The numeric pain rating scale has been proven to be an effective and time saving assessment of pain.[8] This eleven-point scale was used to describe the current, best, and worse pain. Girth measurements, which

have a good inter-rater and intra-rater reliability, were used to assess the amount of swelling around the R knee.[9] Wound inspection is described in Table 1, and the incision can be seen in Figure 1.

The LEFS, which shows excellent test-retest reliability, was used to determine change in ADLs, participation, and quality of life.[10] Gait analysis was done in the facility hallway for approximately ten meters to assess quality of gait. The findings were consistent with current literature that notes an antalgic gait pattern with an increase in knee flexion during weight acceptance.[11] Goniometric measures for knee flexion and extension were performed as described in Norkin and White[12] with the patient in a supine position. Goniometric measures have good reliability for intra-rater and inter-rater reliability.[9]

Overall, MMT of the patient's R LE showed decreased strength. Cuthbert et al.[13] showed that MMT was a reliable and valid measure that was used to determine lower extremity (LE) strength. Two other strategies were used to look at the strength of the quadriceps femoris muscle; as the maximum strength produced for this muscle is significantly less after surgery.[14] A straight leg raise (SLR) was used to assess quadriceps femoris lag. Although this hasn't been cited in the literature, a SLR was performed to determine if there was any excessive knee flexion during the activity that indicated quadriceps femoris weakness. Quadriceps femoris isolated activation was observed through a quadriceps femoris set with the patient in supine. Based on the observation of this exercise and muscle palpation it was concluded that there was a decrease in isolated activation of the right quadriceps femoris when compared to the left.

Although 90.2% of therapists use the Single-Leg Balance Test post joint replacement, it is not recommended to be a standalone measure for assessing balance. In this circumstance, it was used to get a comprehensive assessment of balance, and a gross assessment of weight-bearing tolerance.[15] Superior, inferior, medial and lateral glides were used to assess patellar

mobility and showed hypomobility.

Clinical Impression: Evaluation, Diagnosis, Prognosis

The initial impression of a R UKA with Mako robotic-arm-assist was confirmed through the findings of the initial examination and communication between other practitioners involved in the patient's care. This patient was appropriate for continued outpatient PT due to the functional deficits found during the examination. Using ICD-10 diagnosis codes, the medical diagnoses for this patient were Z47.1, aftercare following joint replacement surgery and M17.11, unilateral primary osteoarthritis of the right knee. The physical therapy diagnosis codes were M25.561, pain in the right knee and R26.2, difficulty in walking, not elsewhere classified.

The patient had a good prognosis due to her prior activity level, normal body mass index (BMI), compliance with therapy, and specific end goals. Harbourne et al.[16] showed that having a higher BMI was a negative prognostic indicator. Since this patient had a normal BMI this set the patient up for better outcomes. Kennedy et al.[17] found that UKAs have shown good functional outcomes for all age groups, however patients over 75 years of age demonstrated a decrease in function ten years after having had a UKA surgery. This patient being under 75 years of age was a positive prognostic indicator.

The patient had predetermined appointments set with her orthopedic surgeon for follow up prior to starting PT. The re-evaluations consisted of: ROM assessment, MMT, functional strength testing, gait assessment, patellar mobility, and the Single Leg Balance Test. Outpatient PT was recommended two to three times a week for 12 weeks. The interventions were focused on gaining R knee ROM, increasing R LE strength, improving balance, and patient education for carry over with a HEP. The patient's goals were to have pain free mobility, return to her prior activities, and return to golf. See Table 3 for short and long-term goals.

Intervention and Plan of Care

This patient obtained PT services from a physical therapist or physical therapist assistant two to three times a week. Communication between the physical therapist and physical therapist assistant was done after every treatment session. The orthopedic surgeon was updated one-month after surgery, at every tenth visit, and at discharge. Electronic medical documentation was completed on WebPT (WebPT, Phoenix, AZ). The patient was given a HEP consisting of ROM and lower extremity strengthening exercises (Figure 2). She was also educated on the importance of icing after activity to decrease swelling, inflammation, and pain as described by Chughtai et al.[18] This patient was compliant during her visits and only missed one appointment. However, she was not consistently compliant with her HEP.

Interventions with their intensity, frequency, duration, and progression for each week are located in Table 4. At the start of PT, the focus was on ROM, quadriceps activation, strengthening, and R LE weight-bearing tolerance. These interventions were important to help restore normal kinematics and strength in the newly acquired ROM. An analysis of experienced and inexperienced golfers done by Choi et al.[19] showed that the ROM needed to perform a golf swing was from 10 degrees to 60 degrees of knee flexion. However, this patient's goal for R knee ROM was greater than this. The surgeon's goal for this patient was to achieve zero degrees of knee extension and 120 degrees of knee flexion to allow her full independence in all functional activities.

Chen et al.[20] identified many negative impacts of a fixed flexion deformity or lack of knee extension. With a fixed flexion deformity, the quadriceps muscle has to work harder during all activities. This increase in force can cause anterior knee pain due to abnormal kinematics and loading on the patellofemoral joint. This lack of extension also impacts walking as a fixed knee flexion deformity results in decreased walking velocity and an increase in energy expenditure.

Overall, a fixed flexion deformity greater than ten degrees was associated with a poorer prognosis.[20]

Extension ROM was first completed in the supine or long sitting position. A strap or towel was used around the ball of the patient's R foot. The foot was pulled back into dorsiflexion to stretch the gastrocnemius (as it crosses the tibiofemoral joint) with emphasis on getting as much knee extension as possible. Other extension ROM exercises were performed in weight-bearing with a standing incline calf stretch and a hamstring stretch on the stairs (Appendix 2). The patient needed cues from the therapist to keep her heels down during the incline calf stretch, and to keep the knee in extension as much as possible during the hamstring stretch. The recumbent bike was used to increase ROM of the knee and to increase cardiovascular endurance.

Flexion ROM is important for many functional activities such as descending stairs.[21] Knee flexion ROM was addressed through non-weight-bearing heel slides with a static hold at the end. A strap or towel was used by the patient to apply overpressure at the end knee flexion range. The patient was also instructed to complete weight-bearing knee flexion rocking on stairs with a hold at the end to try to increase R knee flexion ROM.

Patellar mobility was also addressed during the first three weeks of PT. Superior, inferior, medial and lateral glides were performed with the patient in the supine position. No studies have been completed regarding the importance of patellar mobility in patients with UKAs, and there is limited literature on patellar mobility and TKAs. Ohko et al.[22] found that inferior patellar mobility was associated with knee flexion angles. Specifically, those who had greater inferior patellar mobility had greater knee flexion angles.

Quadriceps activation and strength were prioritized during the first half of PT. Ishii et al.[23] determined that quadriceps strength was lacking in patients who had TKAs when compared to those the same age who had no procedure. This decrease in strength was still present at mid and

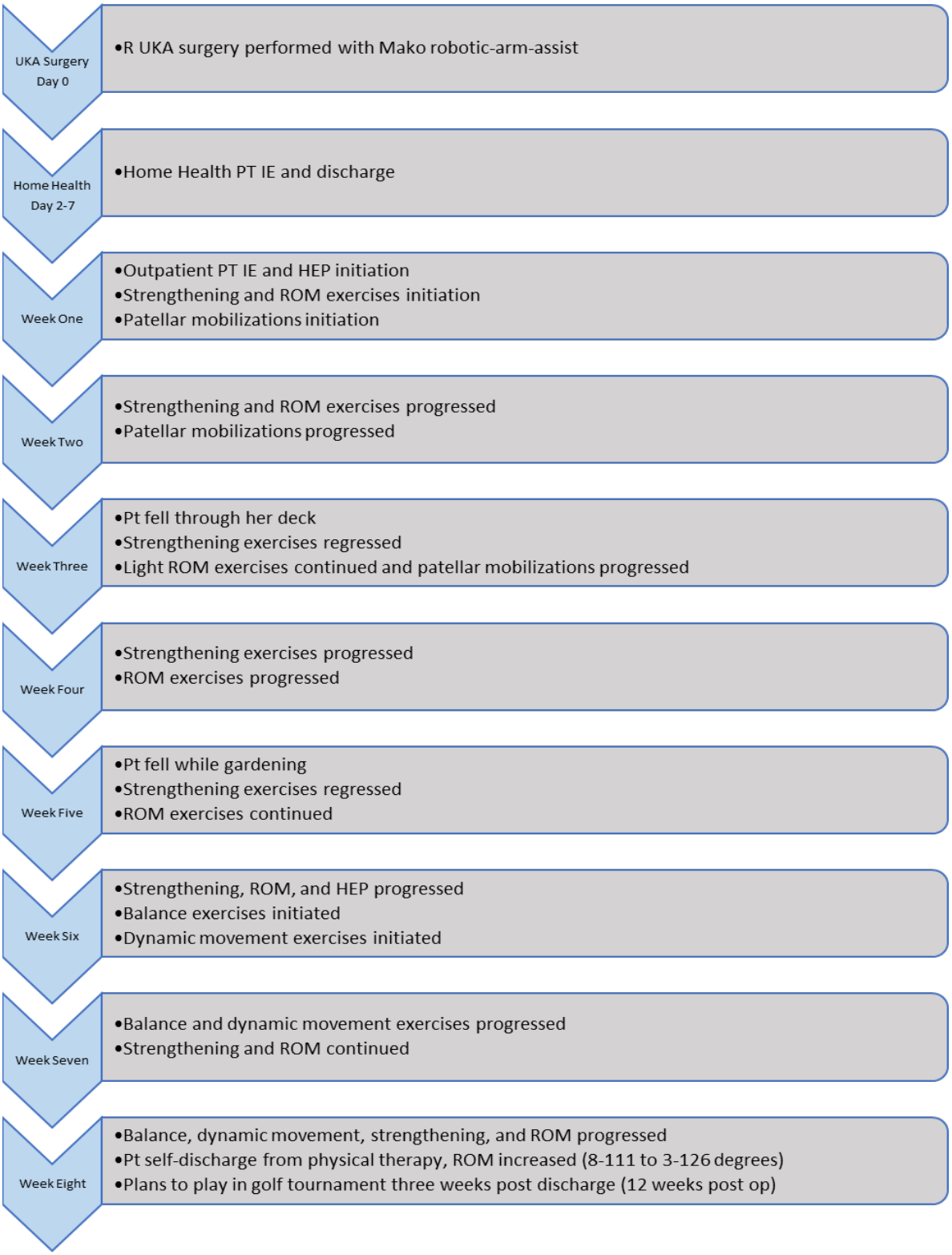
long term follow up assessments. Quadriceps activation was addressed through quadriceps sets with the patient in a supine position. Due to the lack of knee extension, a towel roll was placed behind the knee during this activity. The therapist palpated the quadriceps muscle to ensure proper activation. Strength was first addressed through open kinetic chain (OKC) exercises and further progressed to closed kinetic chain (CKC) as the patient progressed through treatment. Straight leg raises were one of the first OKC exercises introduced. Standing exercises also worked on OKC strengthening as well as weight acceptance since they were completed bilaterally. These exercises consisted of hip abduction, hip extension, marching, and gluteal kicks**.** The CKC exercises included: mini squats, heel raises, step ups, sidestep ups, and step downs. All exercises were progressed by increasing repetitions or resistance and based on patient tolerance and clinical decision making. Weight acceptance exercises were performed through completion of the standing exercises and single leg stance balance exercises.

As treatment progressed to six weeks after surgery, more sport specific and higher intensity exercises were added. The surgeon's protocol cleared sport specific training at 10 weeks post operatively and return to sport at 12 weeks post operatively. Jackson et al.[24] found that out of a group of subjects who had a TKA, 57% returned to golf in six months and 94% still enjoyed golfing with less pain. Although this study was done on patients undergoing TKAs, it allows for comparison of this patient's potentially quicker return to golf having had a UKA.

The later portion of PT focused on further strengthening, balance exercises, and agility exercises that promoted dynamic movement. Balance exercises included: standing with feet together, tandem stance, and single leg stance. These exercises were progressed through the use of an Airex balance pad size: 19.7" by 16.1" by 2.4" (Performance Health, Warrenville, IL), having her move her upper extremities, having her add head movements, or having her close her

eyes. The exercises that promoted dynamic movement included: walking high knees, butt kicks, side steps, and tandem walking forward and backward.

Timeline



Outcomes

Tests and measures completed during the IE were again performed for a progress note at week four and a discharge note at week eight (Table 2). All tests and measures showed improvements throughout the eight-week course of PT. The patient's R knee active ROM improved from 8-111 to 3-126 degrees. Her score on the LEFS improved from 31/80 to 59/80 and her time on the R Single Leg Balance Test went from 3 to 15 seconds. Her R patellar mobility improved in all directions from hypomobile to normal mobility, and strength improved to 5/5 in R hip flexion, knee flexion, and knee extension. The patient achieved all goals that were agreed upon by herself and the therapist at the start of treatment. She did not achieve her personal goal of returning to golf during the course of PT, as this was restricted by the surgeon's protocol of not returning to golf until 12 weeks post-operatively. The patient self-discharged herself from PT at eight weeks of treatment (nine weeks post-operatively) because she felt she was able to do all the functional activities she wanted except for being able to play golf. However, at discharge she did verbalize she had plans to compete in a nine-hole charity golf tournament, which was at exactly 12 weeks after surgery when her surgeon's restrictions would be lifted.

The patient was transparent with her HEP compliance throughout the course of PT. She was adherent at the beginning of treatment but did have some moments of noncompliance when she was frustrated that she couldn't play golf. With some motivational interviewing techniques, she was able to overcome her self-identified obstacles and demonstrated better compliance with her HEP. She verbalized good understanding as well as demonstrated proper performance of her HEP upon discharge and was instructed to continue these exercises in preparation for her golf tournament.

The patient did have two unanticipated events that set her back during PT. The first

happened during the third week when she fell through part of her rotten deck. This event caused increased R knee pain, stiffness, significant bruising and gave her an antalgic gait pattern. She was advised to follow up with her orthopedic surgeon and was cleared shortly after doing so. This set back resolved a week after the fall. A second fall happened at week five when she tripped on a vine while gardening. This event also resulted in the regression of exercises, increased R knee pain, and stiffness. Her knee pain resolved between treatment sessions and exercises were able to be progressed again. Despite two setbacks, she was able to meet her goals and was appropriate for discharge from PT.

Discussion

This case report demonstrated its intended purpose by explaining the outcomes of PT and return to golf in a patient who had a robotic-arm-assisted UKA. Despite limited research on UKAs, recommended interventions of therapeutic exercise, ROM exercises, patellar mobilizations, balance exercises, and gait training for patients having had a TKA appeared beneficial for this patient. This was evident as the patient demonstrated improvements in all subjective and objective outcome measures with the utilization of the previously mentioned interventions.

A strength of this case report was the patient's attitude towards exercise and compliance with her HEP. Despite her brief period of noncompliance, her overall compliance enabled a quicker progression of exercises. She was always willing to work hard in PT to achieve her specific goals. A limitation of this case report was that sport specific training was not cleared by the surgeon until 10 weeks post operatively. The patient self-discharged herself from PT after eight weeks of treatment, which was nine weeks post-operatively. Therefore, no sport specific exercises were performed. However, some dynamic movement activities were performed beginning at week six of PT that could be translated into some aspects of golf. At the point of

self-discharge, the patient felt like she was ready to play golf in a charity golf tournament, which was scheduled for three weeks after discharge or twelve weeks post-operatively.

The research on PT rehabilitation for patients following a Mako robotic-arm-assisted UKA is lacking. There is no literature to compare outcomes and recovery times for patient's having had a UKA versus a TKA. This literature could be helpful when determining a proper course of treatment for a patient with unicompartmental knee osteoarthritis. The positive outcomes of this case report and improvement in all outcome measures suggest that research on this subject should be done to determine best practice when treating this patient population.

References

1. Rönn K, Reischl N, Gautier E, Jacobi M. Current surgical treatment of knee osteoarthritis. *Arthritis*. 2011;2011:454873. doi:10.1155/2011/454873
2. Ollivier M, Abdel MP, Parratte S, Argenson J. Lateral unicondylar knee arthroplasty (UKA): Contemporary indications, surgical technique, and results. *Int Orthop*. 2014;38(2):449-455. doi: 10.1007/s00264-013-2222-9
3. Riddle DL, Jiranek WA, McGlynn FJ. Yearly incidence of unicompartmental knee arthroplasty in the united states. *J Arthroplasty*. 2008;23(3):408-412. http://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=105773158&site=ehost-live&scope=site
4. Bell SW, Anthony I, Jones B, MacLean A, Rowe P, Blyth M. Improved accuracy of component positioning with robotic-assisted unicompartmental knee arthroplasty: data from a prospective, randomized controlled study. *J Bone Joint Surg.* 2016;98(8):627-635. doi: 10.2106/JBJS.15.00664
5. Kleeblad LJ, Borus TA, Coon TM, Dounchis J, Nguyen JT, Pearle AD. Midterm survivorship and patient satisfaction of robotic-arm-assisted medial unicompartmental knee arthroplasty: a multicenter study. *J Arthroplasty*. 2018;33(6):1719-1726. doi: 10.1016/j.arth.2018.01.036
6. Minns Lowe CJ, Barker KL, Dewey M, Sackley CM. Effectiveness of physiotherapy exercise after knee arthroplasty for osteoarthritis: systematic review and meta-analysis of randomized controlled trials. *BMJ*. 2007;335(7624):812. http://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=105960219&site=ehost-live&scope=site

7. Papaliodis DN, Photopoulos CD, Mehran N, Banffy MB, Tibone JE. Return to golfing activity after joint arthroplasty. *Am J Sports Med*. 2017;45(1):243-249. doi: 10.1177/0363546516641917
8. Stratford PW, Spadoni G. The reliability, consistency, and clinical application of a numeric pain rating scale. *Physiother Can*. 2001;53(2):88-114. http://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=106852039&site=ehost-live&scope=site
9. Jakobsen TL, Christensen M, Christensen SS, Olsen M, Bandholm T. Reliability of knee joint range of motion and circumference measurements after total knee arthroplasty: Does tester experience matter? *Physiother Res Int*. 2010;15(3):126-134. doi: 10.1002/pri.450
10. Lower Extremity Functional Scale. Shirley Ryan AbilityLab - Formerly RIC. https://www.sralab.org/rehabilitation-measures/lower-extremity-functional-scale#osteoarthritis. Accessed June 26, 2019.
11. Millar LJ, Banger M, Rowe PJ, Blyth M, Jones B, Maclean A. O 017 - A five-year follow up of gait in robotic assisted vs conventional unicompartmental knee arthroplasty. Gait Posture. 2018;65:31-32. doi: 10.1016/j.gaitpost.2018.06.035
12. Norkin C, White DJ. *Measurement of joint motion, 5e: A guide to goniometry.* Philadelphia: F. A. Davis Company; 2016. http://ebookcentral.proquest.com/lib/uneedu/detail.action?docID=4734145
13. Cuthbert SC, Jr GG. On the reliability and validity of manual muscle testing: A literature review. *Chiropract Osteopathy*. 2007;15(4):1-23. http://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=106297370&site=ehost-live&scope=site

14. Vahtrik D, Gapeyeva H, Aibast H, et al. Quadriceps femoris muscle function prior and after total knee arthroplasty in women with knee osteoarthritis. *Knee Surg Sports Traumatol Arthrosc*. 2012;20(10):2013-2021. doi: 10.1007/s00167-011-1808-2

15. Study says more 'collaboration and consistency' needed between PTs and surgeons in TKA, THA measures. *PT MOTION*. 2018:48. http://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=129713389&site=ehost-live&scope=site

16. Harbourne AD, Sanchez-Santos M, Arden NK, Filbay SR. Predictors of return to desired activity 12 months following unicompartmental and total knee arthroplasty. *ACTA ORTHOP*. 2019;90(1):74-80. doi: 10.1080/17453674.2018.1542214

17. Kennedy JA, Matharu GS, Hamilton TW, Mellon SJ, Murray DW. Age and outcomes of medial meniscal-bearing unicompartmental knee arthroplasty. *J Arthroplasty*. 2018;33(10):3153-3159. doi: //doi-org.une.idm.oclc.org/10.1016/j.arth.2018.06.014

18. Chughtai M, Sodhi N, Jawad M, et al. Cryotherapy treatment after unicompartmental and total knee arthroplasty: A review. *J Arthroplasty*. 2017;32(12):3822-3832. doi: 10.1016/j.arth.2017.07.016

19. Choi A, Sim T, Mun JH. Quasi-stiffness of the knee joint in flexion and extension during the golf swing. *J Sports Sci*. 2015;33(16):1682-1691. doi: 10.1080/02640414.2014.1003591

20. Chen JY, Loh B, Woo YL, Chia S, Lo NN, Yeo SJ. Fixed flexion deformity after unicompartmental knee arthroplasty: How much is too much. *J Arthroplasty*. 2016;31(6):1313-1316. doi: 10.1016/j.arth.2015.12.003

21. Bjerke J, Ohberg F, Nilsson KG, Foss OA, Stensdotter AK. Peak knee flexion angles during stair descent in TKA patients. *J Arthroplasty*. 2014;29(4):707-711. doi: 10.1016/j.arth.2013.07.010

22. Ohko H, Ota S. Relationship between inferior patellar mobility and knee flexion angle in community dwelling elderly female. *Osteoarthritis Cartilage*. 2017;25:S400. doi: 10.1016/j.joca.2017.02.687

23. Ishii Y, Noguchi H, Sato J, Sakurai T, Toyabe S. Quadriceps strength impairment in the mid- to long-term follow-up period after total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc*. 2017;25(11):3372-3377. doi: 10.1007/s00167-016-4333-5

24. Jackson JD, Smith J, Shah JP, Wisniewski SJ, Dahm DL. Golf after total knee arthroplasty: Do patients return to walking the course? *Am J Sports Med*. 2009;37(11):2201-2204. doi: 10.1177/0363546509339009

Table 1: Systems Review

Systems Review	
Cardiovascular/Pulmonary	Not impaired
Musculoskeletal	R LE: impaired R Knee AROM: limited flexion and extension R LE Gross strength: impaired R Patellar mobility: hypomobile L LE: not impaired
Neuromuscular	Gait: impaired R SLS: 3 seconds on firm surface L SLS: 10 seconds on firm surface
Integumentary	Incision on anterior aspect of R leg 10 cm long, from distal femur to proximal tibia. Incision on mid femur 2 cm long. Incision on mid tibia 2 cm long. Incision sites clean and healing well. (Figure 1.) Increased swelling in R knee
Communication	Not impaired
Affect, Cognition, Language, Learning Style	Not impaired Learning style: visual and auditory

R=right, L=left, LE=lower extremity, AROM=active range of motion, SLS=single leg stance

Table 2: Tests and Measures

Tests & Measures	Initial Evaluation Results	Progress Note: 4 weeks	Discharge Note: 8 weeks
Numeric Pain Rating Scale (0-10)	Current: 2 Best: 0 Worst: 3 Pain description: continuous	Current: 4 Best: 0 Worst: 4 Pain description: continuous	Current: 0 Best: 0 Worst: 2 Pain description: continuous
LE Girth Measurements Mid patella: mid-point of patella Mid-thigh: 10 cm above superior pole of patella Mid-calf: 10 cm below inferior	R mid patella: 40 cm R mid-thigh: 49.5 cm R mid-calf: 37.5 cm L mid patella 37.5 cm L mid-thigh: 45 cm L mid-calf: 37 cm	R mid patella: 39cm R mid-thigh: 48cm R mid-calf: 37cm L: NT	R mid patella: 38.5cm R mid-thigh: 47cm R mid-calf: 36.5cm L: NT

pole of patella			
Wound Inspection	Clean and healing well	Wound closed no signs of infection	Wound closed no signs of infection
LEFS	31/80, 61.25% disabled	39/80, 51.25% disabled	59/80, 26.25% disabled
Gait Analysis	Antalgic, lacking full R knee extension at heel strike, lacking proper heel strike and toe off, lacking hip extension, with toe out on right, and decreased stride length on R.	Antalgic, lacking proper heel strike and toe off, lacking hip extension, with toe out on right, and decreased stride length on R.	Toe out on right side and lacking proper hip extension. Stride length equal and proper heal strike and toe off.
Goniometric AROM (knee extension-flexion)	R: 8-111 degrees L: 3-135 degrees	R: 3-119 degrees	R: 3-126 degrees
Manual Muscle Testing	R hip flexion: 4/5 R hip abduction: 5/5 R hip adduction: 5/5 R knee flexion: 4+/5 R knee extension: 4/5 *mild pain with MMT R ankle dorsiflexion & plantarflexion: 5/5 L LE: all 5/5	R hip flexion: 4+/5 R hip abduction: 5/5 R hip adduction: 5/5 R knee flexion: 5/5 R knee extension: 5/5 R ankle dorsiflexion & plantarflexion: 5/5 L LE: all 5/5	R LE: all 5/5 L LE: all 5/5
Functional & Observational Strength Testing	R SLR negative for quadricep femoris lag. Decreased quadricep femoris contraction on R.	R SLR negative for quadricep femoris lag. Normal quadricep femoris contraction on R.	R SLR negative for quadricep femoris lag. Normal quadricep femoris contraction on R.
Single Leg Balance Test (without upper extremity support)	R SLS: 3 seconds L SLS: 10 seconds	R SLS: 10 seconds	R SLS: 15 seconds
Patellar Mobility	R patella superior, inferior, medial, lateral glides all hypomobile	Normal patellar mobility	Normal patellar mobility

LE=lower extremity, R=right, L=left, NT= not tested, LEFS= Lower Extremity Functional Scale, AROM=active range of motion, MMT=manual muscle testing, SLR=straight leg raise, SLS=single leg stance

Table 3: Short- and Long-Term Goals

Short- & Long-Term Goals	
Short Term Goals: 4 weeks	**Long Term Goals: 8 weeks**
Pt will be compliant and independent with HEP.	Pt will demonstrate full R LE strength (5/5) in order to assist her with stair ambulation.
Pt will show a 9-point increase in her LEFS from a 31 to a 40 to demonstrate a clinically important difference.	Pt will demonstrate equal knee ROM in order to enable her to be unrestricted in her recreational activities.
Pt will have a fluid and pain free gait pattern with no AD to demonstrate a symmetrical and appropriate gait pattern.	Pt will be unrestricted in ADL's, ambulation, and recreational activities with pain < 2/10 on 0-10 pain scale

Pt=patient, HEP=home exercise program, LEFS=Lower Extremity Functional Scale, AD=assistive device, LE=lower extremity, ROM=range of motion, ADL's=activities of daily living

419 **Table 4: Interventions by Week**

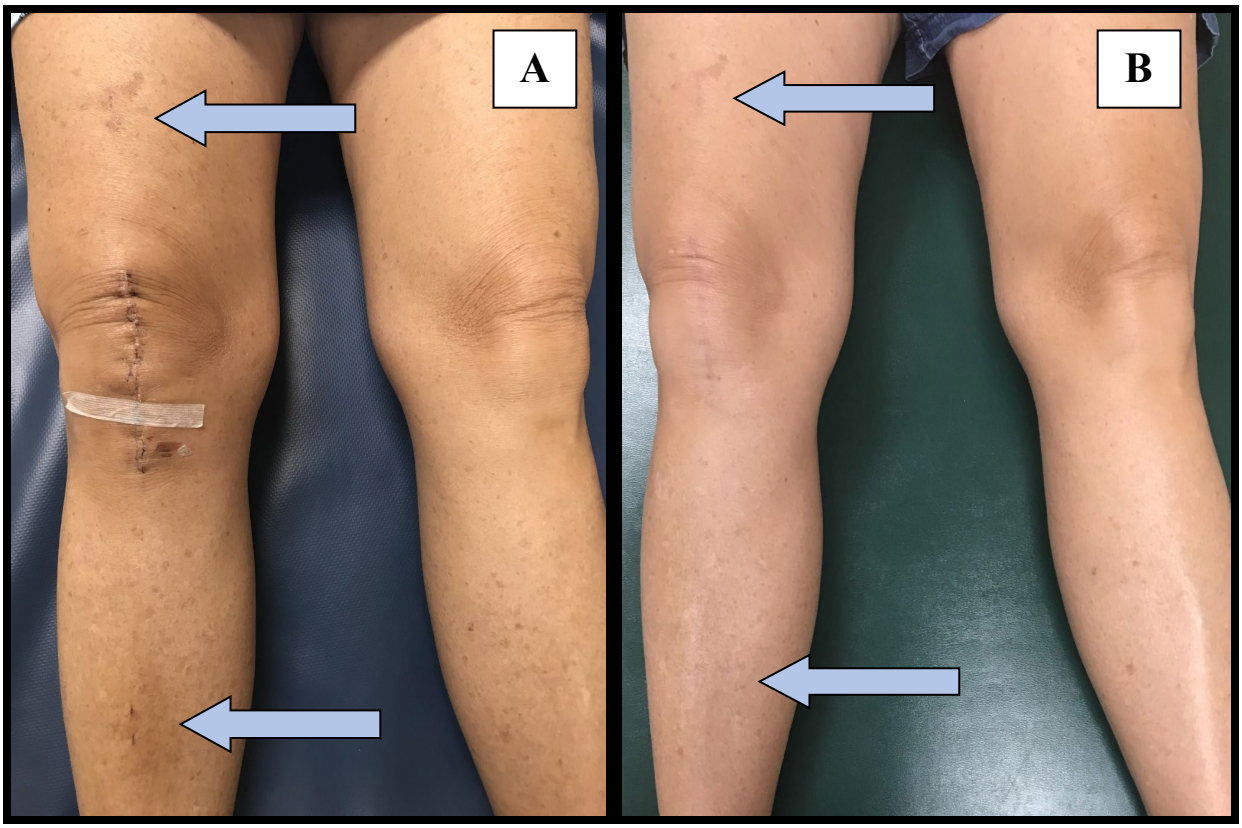
Interventions	Week One	Week Two	Week Three	Week Four	Week Five	Week Six	Week Seven	Week Eight
Recumbent bike	5 min warm up	5 min warm up	5 min warm up	5 min warm up	5 min warm up	5 min warm up	5 min warm up on upright bike	5 min warm up on upright bike
Standing incline calf stretch	2 x 30 sec	2 x 30 sec	2 x 30 sec	2 x 30 sec	2 x 30 sec	dc	dc	dc
Hamstring stretch on stairs	2 x 30 sec	2 x 30 sec	2 x 30 sec	2 x 30 sec	2 x 30 sec	dc	dc	dc
Knee rocking flexion on stairs with hold at end	10x 2 x 30 sec	10x 2 x 30 sec	10x 2 x 30 sec	10x 2 x 30 sec	10x 2 x 30 sec	dc	dc	dc
Terminal knee extension with ball against wall and progressed to TheraBand resistance	10x	green band x 10	12x	blue band x10	blue band x 10	blue Band x 12	blue band x 15	dc
Patellar mobilizations: superior, inferior, medial, lateral	grade 2 10x each direction	grade 3 10 x each direction	grade 4 10x each direction	dc	dc	dc	dc	dc
Long sitting gastrocnemius towel stretch	2 x 30 sec	2 x 30 sec	2 x 30 sec	2 x 30 sec	2 x 30 sec	2 x 30 sec	2 x 30 sec	2 x 30 sec
Supine quadricep set	10x with 3 sec hold	12x with 3 sec hold	12x with 3 sec hold	Held due to time	10x with 2 second hold	dc	dc	dc

Straight leg raises	10x	10x	12x	15x	15x	10x .5# ankle weight	15x .5# ankle weight	10x 1# ankle weight
Bridge	10x	10x	12x	15x	10x	10x with green band	12x with green band	10x with blue band
Heel slides	10x with 30 sec hold at end	10x with 30 sec hold at end & strap overpressure	10x with 30 sec hold at end & strap overpressure	10x with 30 sec hold at end & strap overpressure	8x with 30 sec hold at end & strap overpressure	10x with 30 second hold at end & strap overpressure	10x with 30 second hold at end & strap overpressure	10x with 30 second hold at end & strap overpressure
Hooklying hip adduction ball squeezes	10x	12x	12x	dc	dc	dc	dc	dc
Side lying hip abduction	10x	10x	10x	12x	10x	10x .5# ankle weight	12x .5# ankle weight	10x 1# ankle weight
Seated hamstring curls with green TheraBand	10x	12x	12x	weighted hamstring curls with 2 plates x10 both legs	weighted hamstring curls with 2 plates x 10 both legs	4 plates x10 with both legs 2 plates x 10 on R leg	4 plates x 12 both legs 2 plates x 10 on R leg	5 plates x 10 both legs 3 plates x 10 on R leg
Leg press	n/a	n/a	n/a	2 plates x10 with both legs	1 plates x 10 with both legs	3 plates x 10 with both legs 1 plate x 10 with R leg	3 plates x 12 with both legs 1 plate x 12 with R leg	4 plates x 10 with both legs 2 plates x 10 with R leg
Standing open kinetic chain exercises*	10x	12x	12x	15x	10x	12x with .5# ankle weight	10x on foam pad	10x with 1# ankle weight on foam pad
Standing heel raises	10x	12x	12x	15x	15x	15x	dc	dc
Standing toe raises	10x	12x	12x	15x	dc	dc	dc	dc
Mini squats	10x	10x	12x	12x	8x	10x	12x	12x
Step ups	n/a	6” x10	6” x10	8” x12	4” x 10	6” x 10	6” x 12	8” x 10

Sidestep ups	n/a	6” x10	6” x10	6” x12	4” x 10	6” x 10	6” x 12	8” x 10
Step downs	n/a	6” x10	held due to increased pain	6” x12	4” x 10	4” x 10	6” x 8	8” x 8
Single leg stance	n/a	2 x 30 sec	held due to increased pain	2 x 30 sec	held due to increased pain	2 x 30 sec	2 x 30 sec on foam pad	2 x 30 sec on foam pad
Feet together on foam pad	n/a	n/a	n/a	n/a	n/a	2 x 30 sec with arm movement	2 x 30 sec with eyes closed	2 x 30 sec with eyes closed
Tandem stance	n/a	n/a	n/a	n/a	n/a	2 x 30 sec	2 x 30 sec on foam pad	2 x 30 sec on foam pad with eyes closed
Walking high knees	n/a	n/a	n/a	n/a	n/a	2 x 40’	2 x 40’ with .5# ankle weight	2 x 40’ with 1# ankle weight
Walking butt kicks	n/a	n/a	n/a	n/a	n/a	2 x 40’	2 x 40’ with .5# ankle weight	2 x 40’ with 1# ankle weight
Side stepping	n/a	n/a	n/a	n/a	n/a	2 x 40’	2 x 40’ with pink band	2 x 40’ with green band
Tandem walking	n/a	n/a	n/a	n/a	n/a	2 x 20’	2 x 40’	2 x 40’ forward and backward

min=minute, sec=seconds, ”=inches, R=right, #=pound, ’=feet, dc=discontinued, n/a= not applicable
*Standing open kinetic chain exercises standing hip abduction, hip extension, marching, and butt kicks.

Figure 1: Incision, Two Weeks Post-Operatively and Nine Weeks Post-Operatively



A: Two weeks post-operatively. Note the arrows highlighting the unique superior and inferior incisions caused by the Mako robotic-arm-assisted surgery. There are two 1-centimeter (cm) incisions at both superior and inferior arrows. The middle incision is 10cm long. These superior and inferior incisions are where the pins, which are connected to the arrays are inserted. These arrays send information to the infrared camera to help with implant accuracy that is based off of previous computed tomography scans.
B: Nine weeks post operatively.

Figure 2: Home Exercise Program

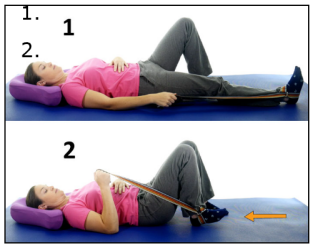
Calf Stretch in Long Sitting

Sit on the floor or bed with your legs straight out in front of you. You can bend the leg you are not stretching towards you. Put a belt, towel, or dog leash around the ball of your foot.

Keep your back and knee straight, and relax your ankle. Pull your foot towards you with the strap until you feel a stretch.

Reps: 2-3 | Sets: 1-2 | Which Side: Both | Hold Time: 30 seconds | How Often: 2-3 times per day

Heel Slide with Strap



Lie down with your leg straight out and a belt or strap around your foot.

Use your strap to help slide your heel up towards your buttocks as far as you comfortably can bending your knee, and then slowly slide it back down.

Reps: 10-15 | Sets: 2-3 | Which Side: Both | Hold Time: 1-2 seconds | How Often: 2-3 times per day

Bridging

Lie on your back with your knees propped up and your feet flat on the floor or bed.

With your arms by your side, push your hips up off the floor or bed until you make a straight line with your body, and then slowly come back down.

Reps: 10-15 | Sets: 2-3 | Hold Time: 1-2 seconds | How Often: 2-3 times per day

Quad Sets

Sit with your leg straight out in front of you. Place a rolled up towel under your knee.

Push your knee down into the towel and hold.

Reps: 10-15 | Sets: 2-3 | Which Side: Both | Hold Time: 3-5 seconds | How Often: 2-3 times per day

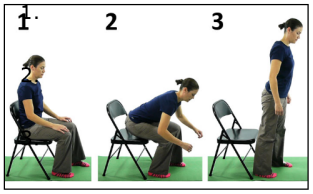
Seated Knee Props

Sit in a chair and keep your back straight.

Take a bag of soup cans or a bag of potatoes, and place it just above your knee. Prop your leg up on a table or chair, and relax your leg.

Hold Time: 3-5 minutes | How Often: 2-3 times per day

Sit to Stand



Spread your feet out about shoulder width apart. Scoot to the edge of the chair, and slide your stronger leg back slightly.

Lean forward with your upper body until you feel your bottom starting to come off the chair.

Push up with your legs, and stand up.

Straight Leg Raise Supine

Lie down on your back and bend one leg up. Straighten out the leg you want to exercise. Pull your toes towards you to lock out your knee.

Keeping your knee straight, lift the leg to the height of the other, and slowly come back down.

Reps: 10-15 | Sets: 2-3 | Which Side: Both | Hold Time: 1-2 seconds | How Often: 2-3 times per day

Appendix 1: Medications

Medications	
Medication	**Indication**
Escitalopram	Anxiety
Pantoprazole	Acid Reflux
Oxycodone	Pain
Tylenol	Pain
Aspirin	Pain
Ibuprofen	Pain
Colace	Constipation

Appendix 2: Standing Incline Calf Stretch and Hamstring Stretch on Stairs

476 **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
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.	4
6. **Clinical Findings** – Relevant physical examination (PE) and other clinical findings	5
7. **Timeline** – Relevant data from this episode of care organized as a timeline (figure or table).	11
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.	5
9. **Therapeutic Intervention** a. Types of intervention (pharmacologic, surgical, preventive). b. Administration of intervention (dosage, strength, duration). c. Changes in the interventions with explanations.	8
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.	12
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.	13
12. **Patient Perspective** – The patient can share their perspective on their case.	13
13. **Informed Consent** – The patient should give informed consent.	1

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