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Doctoral Capstone Research Case Report

A Multimodal Treatment Approach for a Patient with Medial Compartment Knee Osteoarthritis: a Case Report

Abstract

Knee osteoarthritis is a common degenerative joint condition which tends to be progressive, debilitating and often recalcitrant to treatment. Given the rise in the incidence of knee osteoarthritis in an increasingly younger patient population, along with a more active lifestyle into later years, more effective conservative treatment options are indicated. This case report describes a conservative treatment approach for a woman with moderate knee osteoarthritis involving the medial tibiofemoral joint compartment.

The patient was a 67 year old woman with moderate osteoarthritis involving the medial tibiofemoral joint compartment with associated pain, radiographic changes, knee varus angulation, hip and quadriceps weakness, a body mass index of 26.6 kg/m^2, with difficulty performing functional activities. The patient's clinical status was followed over a 5 month period. The combination of reduction in intrinsic and extrinsic biomechanical loading factors, to the medial compartment of the knee, as well as body weight reduction and supplementation with a chondroprotective compound, may have had cumulative effects, contributing to the patient's symptom reduction and improved lower extremity function.

Key Words: knee varus, osteoarthritis, knee adduction moment, lateral heel wedge, body mass index,

Background

Osteoarthritis of the knee is a common degenerative joint condition affecting approximately 25% of adults over the age of 45 and over one-third of individuals over 65 years of age.[1] Although it can affect all three compartments of the knee, osteoarthritis is more prevalent in the medial compartment involving the medial aspect of the tibiofemoral joint. Given the complexity of knee osteoarthritis, as well as the tendency of the condition to be progressive, recalcitrant to treatment, and debilitating, a more comprehensive treatment approach may be warranted. The purpose of this case report is to describe a conservative treatment approach for a woman with moderate osteoarthritis involving the medial compartment.

While the specific etiology of knee osteoarthritis remains unclear, several potential risk factors have been found to be associated with progression of the condition including: a knee varus alignment of greater than 172˚, body mass index of greater than 30 kg/m^2, and more advanced radiograph findings including a grade 3 or greater on the Kellgren-Lawrence Scale.[2,3] Although it is unclear as to whether muscle weakness precedes the development of knee osteoarthritis or is a consequence, individuals with knee osteoarthritis have been shown to have reduced quadriceps[4,5] as well as reduced hip strength[6] with associated functional impairment.

Increased knee varus produces a knee adduction moment which increases medial compartment joint loading. An increased knee adduction moment has been shown to correlate with the severity of osteoarthritis[7] and also predict radiographic progression of the condition in patients with medial compartment osteoarthritis.[8] Medial compartment osteoarthritis progression leads to articular cartilage breakdown which reduces the medial tibiofemoral joint space.

Reduction of the medial joint space increases knee varus alignment which further increases the knee adduction moment. This cyclical process can perpetuate the condition and hasten the degenerative process.

Use of a lateral heel wedge insert or insole has been advocated to reduce the adduction moment of the knee and reduce medial compartment loading. The biomechanical explanation for this unloading effect relates to a lateral shift in the center of pressure on the foot, thereby reducing the knee adduction moment arm.[9] Kerrigan et al. reported a 6% reduction in knee varus torque with a 5˚ laterally wedged shoe insole.[10] Although a 10˚ lateral wedge reduced knee varus torque by 8%, it was consistently found to be poorly tolerated by study participants.[10] The authors used and recommended a lateral wedge insole extending the full length of the foot as knee varus torque is present throughout the entire stance phase of gait.

Some patients with increased genu varus may demonstrate a visible lateral thrust or sudden lateral movement of the knee with weight bearing. Chang et al reported that knees with visible lateral thrust were a subset of varus-aligned knees with a higher risk for progression of osteoarthritis.[11]

Another biomechanical factor found to influence loading at the medial tibiofemoral joint is a reduced hip abduction moment associated with hip abductor weakness. During the single-limb stance phase of gait, weakness of the hip abductor muscles in the stance limb results in pelvic drop which shifts the body's center of mass toward the swing limb placing more relative weight distribution across the medial compartment of the tibiofemoral joint.[12] Hinman et al. tested hip strength in individuals with medial compartment knee osteoarthritis and reported significant strength deficits of hip extensors, hip external rotators and hip abductors, however,

hip abductor weakness was the only muscle group found to correlate with the extent of radiographic joint erosion.[6] Using 3-dimensional gait analysis and full limb radiographs, Chang et al. reported that a greater hip abduction moment was associated with reduced progression of medial tibiofemoral joint erosion in patients with mild to moderate osteoarthritis over an 18 month period.[12]

Quadriceps muscle weakness has also been found to be associated with knee osteoarthritis. As a primary knee stabilizer and shock absorber, weak quadriceps may be a potential contributor to the onset and progression of knee osteoarthritis. Quadriceps muscle strength is also needed during the stance phase of gait to counteract knee adduction moment torque. Without adequate quadriceps tension, knee adduction moment can produce lateral condylar separation known as "lift off". Lateral condylar separation produces greater medial compartment compression which can increase the risk of cartilage degeneration.[13] Although it remains unclear as to whether muscle weakness precedes the development of knee osteoarthritis or is a consequence, there is some evidence to suggest that quadriceps muscle weakness may precede disease onset.[14]

Over the past decade, the average body weight of adults, including those among the elderly population, has steadily increased. Obesity is considered a risk factor for osteoarthritis in weight bearing joints as it increases loading forces on articular cartilage. There is evidence which confirms an association between obesity and knee osteoarthritis.[15,16] Weight reduction has also been shown to reduce the risk of development of osteoarthritis in women.[17] Both the American College of Rheumatology and the European League Against Rheumatism recommend weight loss and exercise for obese patients with knee osteoarthritis. The Arthritis, Diet and Activity

Promotion Trial (ADAPT), an 18 month randomized clinical trial, studied the effects of weight loss and exercise on adults over 60 years of age who were overweight and obese identified by a body mass index of ≥ 28 kg/m^2. Even though weight loss alone did not significantly affect outcomes, when an average weight loss of 5.7% was combined with aerobic and resistance training, study participants demonstrated significant improvement with a 30% reduction in pain and a 24% improvement in self reported physical function,[18] as measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Christensen et al. conducted a systematic review and meta-analysis on the effects of weight reduction in obese patients with osteoarthritis. They analyzed data on 454 patients selected from four randomized clinical trials. They concluded that a weight loss of >5% reduced disability and improved function in overweight patients with knee osteoarthritis.[19]

Glucosamine and chondroitin have received a great deal of attention for their potential chondroprotective properties. Glucosamine is a naturally occurring aminosaccharide and a precursor to glycosaminoglycans, which are constituents of articular cartilage. Chondroitin is a hydrophilic polysaccharide and is a major component of the extracellular matrix of both cartilage and bone. Its hydrocolloid properties are believed to play a role in the compressive resistant properties of articular cartilage. Glucosamine and chondroitin are absorbed in the gastrointestinal tract and shown to be capable of reaching joints as measured by synovial fluid concentrations.[20,21] Although the specific mechanism of action remains unclear, their effects may relate to anti-inflammatory activity,[22] stimulation of proteoglycan and hyaluronic acid synthesis,[23] sparing of osteoblasts within subchondral bone[24] or inhibition of proteolytic enzymes which contribute to degradation of chondrocytes and the cartilage matrix.[25]

There have been several randomized clinical trials which suggest that glucosamine is effective in reducing pain and improving function in patients with knee osteoarthritis.[26,27,28] Reginster et al. conducted a 3 year randomized clinical trial of 212 patients with knee osteoarthritis evaluating the effectiveness of ingesting 1,500 mg of oral glucosamine sulfate as compared to a placebo. They reported that the patients taking glucosamine demonstrated significantly less medial tibiofemoral joint space narrowing as assessed with visual inspection and radiographic digital image analysis.[29] The authors concluded that long-term use of glucosamine sulfate demonstrated symptom-modifying and structure-modifying effects suggesting it could be a disease modifying compound.

Patient Characteristics

Prior to evaluation and treatment, the patient gave her written informed consent and patient privacy was maintained throughout the course of this case report. The patient was a 67 year old female who was referred to outpatient physical therapy by her primary care physician for evaluation and treatment of left knee pain. She had been seen by an orthopedist the prior year, had received a cortisone injection and was diagnosed with knee osteoarthritis via physical examination and standard radiographs.

Upon interview, the patient reported she had recently retired as a full-time certified nursing assistant. She reported insidious onset of left medial knee pain which began a few years prior and which had increased within the preceding 6 months. She denied any specific precipitating injury and described her symptoms as “a deep ache” which she rated at 4 out of 10 at best and up to 9 out of 10 at worst on a visual analog scale (with 0 representing no pain and 10 being worst possible pain). Her symptoms were increased with getting up after sitting for longer

than 15 minutes, upon waking in the morning and with weight bearing activities including walking for more than 10 minutes, stair climbing (especially ascending), crouching, and squatting. In addition to left medial knee pain, she reported some mild intermittent left knee swelling and joint crepitus. The patient reported taking 2-3 tablets of 200 mg of over the counter Ibuprofen 2-3 times per day for symptom reduction. Her baseline functional status was assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which has been established to be both reliable and valid with higher scores found to be associated with functional limitations.[30,31] Her baseline score on the WOMAC was 58%.

Examination

The patient was 160 cm tall and weighed 68 kg with a body mass index of 26.6 kg/m^2. Upon inspection, she demonstrated left greater than right sided genu varum measuring 171˚ at the left knee and 176˚ on the right (measured with a 12 inch goniometer with the axis through the center of the patella, and the arms aligned longitudinally through the central tibia and femur).[32] There was mild visible anteromedial knee swelling at the left knee. In standing, observed from the rear, her iliac crests were level without pelvic obliquity or an apparent leg length discrepancy, however, she demonstrated moderate bilateral foot pronation. Thoracolumbar AROM including flexion, extension, bilateral sidebending and rotation were pain-free, symmetrical and within functional limits. From the side, the patient demonstrated appropriate spinal curves including thoracic kyphosis and lumbar lordosis. Passive accessory testing of the thoracic and lumbosacral spine with central posterior-anterior pressures demonstrated normal mobility and did not reproduce symptoms at the spine or lower extremities (LE's). AROM at the left knee measured 0˚ of extension to 123˚ of flexion, compared to 0˚ extension to 135˚ of flexion on the right side.

Joint mobility testing at the tibiofemoral joints including anterior and posterior tibial glides and well as medial and lateral tibial rotation, at 90˚ of knee flexion, was within normal limits and symmetrical bilaterally. The patient reported mild pain at the left knee with both active and passive end-range knee flexion and extension. Patella mobility, including superior, inferior as well as medial and lateral glides, were assessed bilaterally, and found to be within normal limits. Manual muscle testing of the LE's was performed, as described by Kendall et al.,[33] and revealed weakness in the following muscle groups: quadriceps graded 4-/5 on the left and 4/5 on the right, hip abductors 4-/5 left, 4/5 right, hip external rotators 4/5 bilaterally and hip extensors 4+/5 bilaterally. Flexibility was within functional limits at the bilateral LE's except for hip internal rotators with limited hip external rotation measuring 36˚ on the left and 50˚ on the right (measured with an inclinometer at the proximal lateral tibia, tested in sitting with the hip flexed to 90˚). Upon palpation, the patient reported mild to moderate tenderness at the left medial tibiofemoral joint line and left distal femoral condyle. Ligament stress tests at the knee, including varus, valgus, anterior and posterior drawer and Lachman's were negative bilaterally for ligamentous laxity. Knee bulge sign was negative for significant joint effusion.[32] Patellofemoral compression test was negative bilaterally. Gait assessment revealed a somewhat slow tentative ambulatory pattern with reduced stance phase at the left LE. She did not demonstrate any visible signs of lateral thrust at either knee during ambulation. Single leg stance and partial knee squatting maneuvers reproduced left knee symptoms in weight bearing with mild associated joint crepitus elicited at the tibiofemoral joint. Knee radiographs of the left knee, (Figure 1), including standard AP, and lateral views, which had been taken the prior year, revealed mild to moderate osteoarthritis at the medial tibiofemoral joint compartment including a

narrowed joint space, sclerosis of subchondral bone and mild osteophyte formation at the joint margins.

Figure 1 (Radiograph)
Anteroposterior radiograph of the left knee of a 67 y/o female with osteoarthritis. Note moderate medial compartment joint space narrowing and subchondral sclerosis of the proximal tibia.

Intervention

The patient's clinical status and outcome was followed over a 5 month period. The first 2 months included a total of 8 outpatient rehabilitation sessions including issuance of a left lateral heel wedge, bilateral over the counter foot orthotics, open and closed chain hip and quadriceps strengthening exercises as well as education on attaining an appropriate body mass index. As the

patient did not demonstrate any significant capsular restrictions, joint hypomobility or signs of mechanical dysfunction at the spine or lower extremities, specific manual therapy techniques were not included in the treatment plan for this particular patient. The remaining 3 months consisted of home exercises, independent weight reduction efforts, supplementation with oral glucosamine sulphate and continued use of the lateral heel wedge and foot orthotics,

On her first therapy session, following examination, the patient was issued a 5˚ lateral heel wedge, (Figure 2, Apex , Aetrex Worldwide, Inc Teaneck, NJ), on the left side, to reduce tibiofemoral medial compartment joint loading related to the knee adduction moment associated with her increased knee varus angulation.[9] She was also issued bilateral full length semi-rigid over the counter foot orthotics (Powerstep Pro, Stable Step LLC, West Chester, OH) to improve her foot stability and reduce LE biomechanical stress associated with her excessive foot/ankle pronation.

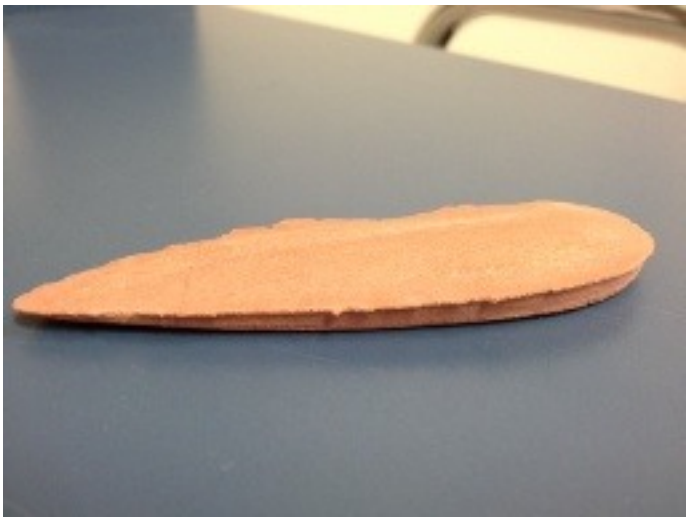

Figure 2 (Heel Wedge)
5 ˚ heel wedge (Apex , Aetrex Worldwide, Inc Teaneck, NJ)

Her remaining 7 outpatient physical therapy sessions occurred on a weekly basis. As the patient was still experiencing moderate knee pain with mild swelling, sessions 2-4, consisted of non-weight bearing quadriceps and hip strengthening exercises including 2 sets of 10 repetitions of supine isometric quad sets with 10 second holds, and 2 sets of 20 repetitions each of side-lying hip abduction, and side-lying hip ER/abduction (clam) with knees and hips flexed to approximately 70˚. A portable biofeedback unit (Myotrac, Thought Technologies, Montreal, Canada) was placed over the patient's mid-quadriceps to assist with neuromuscular control while performing isometric quad sets. Hip internal rotator stretching was also initiated with a "figure 4" style position to address her limited hip external rotation flexibility.

On the days she was not scheduled for outpatient physical therapy, the patient was advised to perform the same exercise regimen at home 1 time per day, and to use a rolled up towel under her knee for the quad sets.

During sessions 5-7, therapeutic exercises were progressed to include addition of a third set each for the isometric quad sets, side-lying hip abduction and side-lying clam exercises. In addition, closed chain exercises were initiated including: modified lunges (with forward leg placed on an 18 cm high step), supine bilateral bridging (with knees flexed to 70˚) and lateral stepping with mini squat (with knees flexed to approximately 30˚). She performed 2 sets of 15 repetitions of bilateral modified lunges, 2 sets 10 repetitions, with 10 seconds holds, of supine bridging and 2 sets each of lateral stepping with mini squat including 3 repetitions of 5 steps to the left followed by 3 repetitions of 5 steps to the right. The patient was instructed to perform these additional closed chain exercises at home, on the days she was not scheduled for outpatient physical therapy, with the same number of repetitions and sets as performed in the clinic. On her

8th session, the patient indicated that her knee symptoms overall were improved which she rated at 1 out of 10 at best and up to 7 out of 10 at worst on the visual analog scale. Her WOMAC score on re-evaluation was 47%. Although her WOMAC score had improved from 58% to 47%, she continued to experience symptoms and difficulty with prolonged standing or walking, getting up after sitting, with stair-climbing and occasionally with sleeping at night.

Due to the patient's ongoing knee symptoms, functional limitations and the chronic nature of her condition, the patient was educated on weight reduction strategies and supplementation with a chondroprotective compound including oral glucosamine and or chondroitin sulfate as a means to further reduce medial compartment joint loading[17,18,19] and articular cartilage erosion[23,24,25] respectively.

The patient was educated on the importance of attaining an appropriate body mass index, for her overall health, and to reduce joint loading forces at her knee. Basic weight reduction principles were emphasized including smaller portioned meals consisting of fruits, vegetables, whole grains and lean protein as well as reduction in refined sugars and saturated fatty foods. She was also advised to perform at least 30 minutes per day of aerobic exercise such as walking, swimming, or biking. The patient agreed to begin a walking program and indicated that she lived near a college with an outdoor public track with an attenuating rubberized surface which she could use. She was advised to wear supportive footwear (including her bilateral foot orthotics and 5˚ left lateral heel wedge insert) and begin with 15 minutes of walking twice per day and progress up to 30 minutes as tolerated.

The patient was advised to take an oral supplement with at least 1,500 mg of glucosamine and or 1,200 mg of chondroitin sulfate. The patient chose Joint Support Powder (Now Foods, Bloomingdale, IL) containing glucosamine sulfate which was available at a local health food store.

Outcome

The patient returned 3 months later for a follow up appointment, to allow for re-assessment of her condition including her present symptoms and self reported functional abilities. She reported consistent compliance with her home exercise program, use of lateral heel wedge insert, foot orthotics and daily supplementation with oral glucosamine. The patient indicated that she had been walking approximately 5 times per week and had progressed up to 30 minutes of ambulation at the local college track without significant knee symptoms. When asked about her diet, she reported that she had been trying to eat better and stated that she had "cut back on sweets".

Upon reassessment, the patient weighed 65 kg with a weight loss of 2.7 kg and a body mass index of 25.5 kg/m^2, representing a 4% overall weight reduction. Manual muscle testing revealed increased strength at the quadriceps grading 4+/5 bilaterally, and at the hip abductors grading 4+/5 on the left and 5-/5 on the right. The patient rated her symptoms at 0 out of 10 at best and up to 5 out of 10 at worst and had discontinued use of the over the counter Ibuprofen. Although she still identified some residual symptoms with stair climbing, squatting and with getting up after prolonged sitting, she reported reduced overall left knee symptoms and improved tolerance to ADL's and ambulation. Her follow up WOMAC score was 25% which represented a 33% improvement since initial evaluation.

Discussion

The rise in the prevalence of obesity coupled with an aging population may contribute to the increase in knee osteoarthritis. As the condition tends to be progressive, many patients ultimately opt for a total knee replacement. However, due to the risk of complications, expense, and potential for breakdown or loosening of the implants, total knee replacement is generally reserved for older patients with more advanced disease.

Whereas the specific etiology of knee osteoarthritis remains unclear, it appears to be a multi-factorial condition involving a combination of biomechanical, neuromuscular and histological changes ultimately leading to articular cartilage breakdown. Given the complexity of knee osteoarthritis, as well as the tendency of the condition to be recalcitrant and lead to functional impairment, a more comprehensive treatment approach may be warranted. This case report involving a 67 year old woman with moderate knee osteoarthritis involving the medial compartment, demonstrated symptom reduction and improvement in self reported LE functional activities with a combination of hip abductor and quadriceps strengthening, body weight reduction, use of a lateral heel wedge, foot orthotics and supplementation with oral glucosamine. Even though this case report only involved a single patient over a relatively short time frame, treatment benefits may have been attributed to cumulative effects.

The hip abductors, in particular the gluteus medius, is important in stability and function of the hip and pelvis and also, as described, can influence the loading characteristics affecting the tibiofemoral joint. As patients with knee osteoarthritis may not always be appropriate for higher level weight bearing exercises, it is important to select exercises which not only target the affected musculature but also which will be well tolerated. Distefano et al tested gluteus medius activation with surface electromyography (EMG) during a variety of both weight bearing and

non-weightbearing exercises. With non-weight bearing exercises, they reported significant EMG signal amplitudes with side-lying hip abduction and side-lying hip clam exercises. With weight bearing exercises, they reported higher recruitment patterns with single-limb exercises compared to bilateral and generally lateral movements produced higher gluteus medius activation than forward movements.[34] Philippon et al tested gluteus medius activation with indwelling wire EMG and ranked peak amplitudes of 13 hip exercises on a continuum from low to high. They classified hip abductor exercises into 3 categories including low level or phase 1, moderate level or phase 2 and higher level or phase 3.[35] As the patient in this case report initially presented with pain, joint tenderness and swelling, we initiated hip exercises in a non-weight bearing position with side-lying hip abduction and side-lying hip clam exercises. As her symptoms improved, we were able to progress to higher level exercises including standing forward lunges and lateral stepping into her rehabilitation program.

While the patient only reduced her body mass index by 4% (rather than 5% as described by Christensen et al.[19]), the use of the 5˚ lateral heel wedge to reduce the knee adduction moment,[9,10] hip strengthening to increase the hip abduction moment,[6,12]quadriceps strengthening to attenuate knee compressive forces and reduce knee lateral condylar separation,[13,14] and use of foot orthotics to improve foot stability, may have had collective biomechanical effects which contributed to her symptom reduction and functional improvement.

Glucosamine and chondroitin remain popular and show continued promise as chondroprotective compounds.[23,24,28,29] However, more recently, their efficacy has been called into question following subsequent systematic reviews and meta-analysis attempting to synthesize data from multiple studies.[36,37] Although these compounds were generally reported to

be less effective, the studies were criticized for data analysis from heterogeneous trials. Habashi et al. analyzed the pharmacokinetic properties of glucosamine and indicated that most of the commercially available products tested were found to contain substantially lower levels of the active ingredient than reported by the manufacturer on the label.[38] Most of the studies on glucosamine have not tested products for dose potency or bioavailability. Habashi et al. suggested that under dosing is likely to have limited clinical effects reported in many of the studies on glucosamine and chondroitin.[38]

Given the recalcitrant nature and potential debilitating effects of knee osteoarthritis, combined with limited disease modifying options, even more modest chondroprotective effects of glucosamine and or chondroitin may justify their use in patients with knee osteoarthritis. Their anti-inflammatory[24] and potential proteoglycan synthesizing properties,[25] coupled with their low risk profile and relatively low cost make them a viable adjunctive treatment of patients with knee osteoarthritis.

Therapeutic exercise has been found to be effective in improving pain and function in patients with knee osteoarthritis[39] and is recommended by the American College of Rheumatology. Persistent knee joint pain and effusion have been shown to alter proprioceptive input and inhibit quadriceps strength and neuromuscular control.[40,41] As a primary knee stabilizer and shock absorber, reduced quadriceps strength and neuromuscular control may result in increased joint forces and torque applied to the knee, which over time, may be a potential contributor to the onset and progression of knee osteoarthritis.

Healthy articular cartilage responds favorably to progressive loading with adaptive thickening, however, individuals with osteoarthritis of the knee may have deleterious effects with

loading including chondral degradation.[42,43] The challenge physical therapists face is that, to date, there are no clinical guidelines with respect to optimal joint loading parameters in patients with knee osteoarthritis.

This case report describes a conservative treatment approach for a 67 year old woman with moderate knee osteoarthritis involving the medial tibiofemoral joint compartment. Treatment emphasized a reduction in loading forces at the knee associated with, a knee adduction moment, hip abduction moment and attenuation of loading forces with body weight reduction and with improved quadriceps strength. Additionally, the use of oral glucosamine sulphate was included for its chondroprotective properties. By addressing potential biomechanical loading effects occurring proximally at the hip, distally at the foot/ankle and directly at the knee, loading forces at the medial compartment may have been more effectively reduced. However, this is a single case report with multiple variables, without supporting data to ascertain whether the results were due to any one of the interventions, their combination or the cyclical nature of the patient's condition. Further research into the efficacy of a more comprehensive treatment approach for patients with medial compartment knee osteoarthritis, as described in this case report, is warranted.

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