

Management of persistent patellofemoral pain conditions using a tricompartmental offloading knee brace: a case series

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Objective: *To describe the utility of a tricompartmental offloading knee brace as an adjunct intervention for managing persistent PFP conditions.*

Clinical features: *Three cases of active adult females with persistent PFP following non-response to conventional and guideline aligned management strategies are presented.*

Intervention and outcomes: *Patients were managed using a tricompartmental offloading knee brace alongside individualized exercise programs for up to 12 weeks. Subjective and objective measures of pain and function were measured at three distinct time points. Each patient reported decreased pain, increased activity tolerance, and demonstrated improvements in both strength and functional performance over the course of the intervention period.*

Gestion des conditions persistantes de douleur patellofémorale à l'aide d'une attelle de genou à effet de décharge tri-compartimentale: une série de cas
Objectifs: *Décrire l'utilité d'une attelle de genou à effet de décharge tri-compartimentale en tant qu'intervention complémentaire pour la gestion des conditions persistantes de douleur patellofémorale.*

Caractéristiques cliniques: *Trois cas de femmes adultes actives présentant une douleur patellofémorale persistante (DPP) après une non-réponse aux stratégies de gestion conventionnelles et des lignes directrices de stratégies de gestion alignées sont présentées.*

Intervention et résultats: *Les patientes ont été prises en charge à l'aide d'une attelle de genou à effet de décharge tri-compartimentale en parallèle à des programmes d'exercices individualisés pendant un maximum de 12 semaines. Les mesures subjectives et objectives de la douleur et de la fonction ont été évaluées à trois moments distincts. Chaque patiente a signalé une diminution de la douleur, une augmentation de la tolérance à l'effort et a démontré des améliorations tant au niveau de la force que du rendement fonctionnel au cours de la période d'intervention.*

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The authors have no disclaimers, competing interests, or sources of support or funding to report in the preparation of this manuscript. The involved patients provided consent for case publication.

Summary: The use of tricompartmental offloading knee bracing alongside exercise therapy may be effective for the management of persistent PFP and should be considered for active adult females if unresponsive to both conventional and guideline aligned treatments.

(JCCA. 2024;68(3):214-223)

KEY WORDS: patellofemoral pain, PFP, management, offloading knee brace, knee orthoses, case series, chiropractic

Introduction

Patellofemoral pain (PFP) is a non-specific pain condition of the anterior knee. It is characterized by generalized pain in the peripatellar or retropatellar regions during activities of lower limb loading, such as squatting, running, stair ascension/descension, sports participation, and prolonged sitting.¹ PFP affects individuals across the entire lifespan, regardless of sex or activity level², with an annual prevalence rate of around 25% commonly reported^{3,4}. The one-year prevalence of PFP within female populations is frequently observed to be nearly double that of males⁴, with the point prevalence of PFP among female adolescent athletes reported to be as high as 28%⁵.

A prominent theory explaining the underlying cause and development of PFP is that chronic compressive overload of the patellofemoral interface may contribute to deleterious changes to the structure and function of retropatellar articular cartilage.^{6,7} While a direct link between PFP and pathology of the patellofemoral joint (PFJ) remains elusive, mechanical overload of articular cartilage has been demonstrated to inhibit pro-adaptive capabilities, leading to substantial structural damage of articular cartilage in chronically overloaded environments.^{7,8} This evidence lends credence to the belief that PFP may exist as a prodromal syndrome to degenerative conditions of the patellofemoral joint, such as retropatellar chondrosis and patellofemoral osteoarthritis (PFOA).^{9,10} As such, it has been proposed that pain-based diagnoses such as PFP should accompany structural diagnoses that may not outright explain pain symptoms, when appropriate or observable.¹¹

Résumé: L'utilisation d'une attelle de genou à effet de décharge tri-compartmentale en parallèle avec une thérapie par l'exercice peut être efficace pour la prise en charge de la douleur patellofémorale persistante et devrait être envisagée chez les femmes adultes actives si elles ne répondent pas aux traitements conventionnels et harmonisés aux lignes directrices.

(JCCA. 2024;68(3):214-223)

MOTS CLÉS : douleur patellofémorale, DPP, prise en charge, attelle de genou à effet de décharge, orthèses du genou, série de cas, chiropratique

Clinical practice guidelines (CPGs) have been developed specifically for the management of PFP, which recommend that practitioners utilize management strategies such as exercise interventions that target the musculature of both the knee and the hip, patellar taping, foot orthoses, gait retraining, and patient education.¹ In addition, many non-guideline adherent management strategies are also frequently used by allied healthcare professionals, including patellar bracing^{12,13} and referral for intra-articular injections¹⁴. Despite best practice interventional strategies, as many as 40% and 56% of patients diagnosed with PFP continue to report pain at 12-months¹⁵ and 24-months¹⁶ respectively, with more than 50% of individuals reporting poor outcomes five to eight years after initiating care¹⁷. A potential pitfall with many of these best practice interventions is that they fail to sufficiently mitigate the excessive PFJ forces hypothesized to be driving the condition, instead solely addressing the pain response or indirectly modifying joint loads.

Cases of PFP that fail to respond to traditional and CPG-recommended management strategies may, in fact, require a much more direct approach to dissipating compressive joint forces within the PFJ. While strategies such as complete rest, immobilization, and activity cessation may achieve the largest degree of articular cartilage offloading, they are often not feasible nor ideal management options as the reduction in muscle activation may contribute to muscle atrophy and strength loss while also underloading patellofemoral cartilage below the threshold required to stimulate positive adaptations. Tricompartmental offloading knee braces may offer a solution to

this problem by achieving sufficient patellofemoral joint offloading while simultaneously permitting patients to remain active and increase periarticular muscle strength and hypertrophy. This style of knee brace is designed to decrease joint contact forces by providing an assisted knee extension moment.¹⁸ The Levitation® knee brace (Spring Loaded Technology) is one such brace, utilizing a hydraulic spring embedded within the frame of the brace to generate a passive extension moment (Figure 1), which increases linearly with increases in knee flexion angles.¹⁹ This has been shown to reduce quadriceps muscle force requirements during dynamic tasks^{20,21}, contributing to decreased compressive forces across the patellofemoral

joint^{18,20} and providing pain relief in both immediate- and long-term follow-up periods in patients with PFOA^{21,22}. The purpose of this case series is to describe the utility of the Levitation® knee brace as an adjunct intervention alongside exercise therapy for managing persistent PFP conditions in a heterogeneous sample of female patients who were unresponsive to guideline-supported management strategies.

Case series

We describe three cases of active adult females who presented to a multi-disciplinary knee clinic for the management of persistent unilateral PFP after not responding to



Figure 1.

The Spring Loaded Levitation® tricompartamental offloading knee brace. A rigid, step through knee orthoses which utilizes an embedded hydraulic spring to generate a passive extension moment.

conventional and guideline aligned management strategies. Each patient was prescribed a custom-fitted Levitation® knee brace and an individualized home exercise program designed to strengthen the musculature surrounding the knees and hips. Pain and function were monitored using a numerical pain rating scale (NPRS), a PFP-specific questionnaire (KOOS-PF), and a 30-second sit-to-stand test, as recommended by CPGs.¹ Additionally, a floor-anchored dynamometer (Exsurgo® gStrength™) was used to measure peak isometric knee extension forces with the patient seated with a 90° knee flexion angle. Patients attended two follow-up sessions between four and 12 weeks post-baseline, where outcome measures were reassessed, and exercise programming was progressed based on individual needs.

Case 1

An 18-year-old female former competitive gymnast presented with a 15-month history of right anterior knee pain and crepitus. She reported constant burning to sharp peri-patellar pain with concomitant allodynia over the anteromedial aspect of the knee, which restricted her participation in both competitive and recreational activities. Her symptoms emerged nine months following medial patellofemoral ligament (MPFL) reconstructive surgery at 16 years-of-age, performed due to a history of recurrent patellar dislocations. She rated the peak daily intensity of her pain as 8/10 on the NPRS, with aggravating factors including squatting, running, and stair ascension. Frequent episodes of painful knee catching, crepitus, and swelling, as well as occasional pain-related giving-way, were reported. Previous management for this complaint included prescription NSAID medications, therapeutic knee exercises, patellar mobilizations, and patellar repositioning knee braces, all without meaningful improvements. Orthopaedic follow-up dismissed further surgical intervention as a viable management option. Her self-reported goal of care was to improve her exercise tolerance to allow for a return to participation in recreational sporting activities.

Upon examination, the patella was observed to be positioned centrally, with visible atrophy of the vastus medialis oblique muscle (VMO). Active and passive knee flexion and extension ranges of motion (ROM) were full and symmetrical to the unaffected limb, with pain recreated during active knee extension and both active and passive

knee flexion. Resisted knee extension at both 0° and 45° of knee flexion also recreated the presenting complaint, as did sit-to-stand and squat functional tasks. Excessive tissue tension of the rectus femoris muscle was palpated, and increased sensitivity of the tissues overlying the VMO and medial femoral condyle, suggestive of hyperalgesia and allodynia, were noted via digital palpation in comparison to the contralateral limb. No neurological deficits were identified. Patellar compression, grind, and apprehension orthopaedic tests all reproduced the presenting complaint, and a 9/9 Beighton Score was observed. Right knee radiographs demonstrated patella alta and trochlear dysplasia with no definitive degenerative changes, while magnetic resonance imaging demonstrated post-surgical development of full-thickness chondral denudation over the patellar apex and medial patellar facet.

The patient was diagnosed with right knee PFP secondary to post-surgical patellar facet chondrosis. A plan of management consisting of patellar mobilization, myofascial release therapies, and electroacupuncture was initiated at a frequency of twice per week for four weeks with sporadic patient follow up over eight additional weeks. A knee and hip focused home exercise program was also prescribed at a frequency of three to four times per week.

After 12 weeks of management, the patient reported minor improvements in pain and function, with no meaningful clinically important difference (MCID) achieved on the NPRS²³ or the KOOS-PF.²⁴ At this point, the Levitation® knee brace was prescribed to more directly decrease PFJ compressive forces and lessen knee pain during tasks of daily living and physical activity. The patient was instructed to wear the brace during periods of standing, ambulation, and exercise, including the continuation of her home exercise strengthening program. On the day of brace fitment, a series of patient-reported and functional outcome measures were administered (Table 1). These outcome measures were re-administered at 4- and 8-week follow-ups.

After four weeks of intervention using the Levitation® knee brace as an adjunct to strengthening exercises, the patient reported her peak knee pain over the previous week to have decreased to 4/10 on the NPRS, with decreased knee stiffness, pain, and PFJ crepitus while wearing the brace. She further reported the brace had allowed for improved adherence to her home exercise program and that decreases in both allodynia and hyperalgesia oc-

curred, which was confirmed via palpation of the antero-medial knee.

After eight weeks, the patient reported her peak knee pain over the preceding week to have further decreased to 3/10 on the NPRS, allowing for an overall increase in physical activity, including the resumption of short-distance running and recreational soccer. She further reported improved pain-free walking distance, increased pain-free squat depth, and zero pain during activities of daily living, even without the assistance of the knee brace. Over the course of the 8-week intervention period, improvements were observed in all outcome measures, meeting the MCID thresholds of 1.2 for the NPRS²³ and 16 for the KOOS-PF,²⁴ as well as the minimal detectable change (MCD) threshold of 2.5 repetitions for 30-second sit-to-stand²⁵ (Table 1). Absolute knee extension strength of the involved limb improved by 4.29 Kg (18.9%), and inter-limb strength symmetry increased from 73.6% to 82.8%. No additional therapeutic interventions were reported over the 8-week intervention period.

Table 1.

Subjective and objective outcome measures for Patient 1 at baseline, 4-weeks, and 8-weeks.

Outcome Measure	Baseline	4-weeks	8-weeks
NPRS	8	4*	3*
KOOS-PF	25.00	38.64	45.45*
Ipsilateral knee extension (kg)	22.62	20.99	26.91
Contralateral knee extension (kg)	30.75	29.98	32.50
30-second sit-to-stand (reps)	10	12	14‡

* = meaningful clinically important difference (MCID); ‡ = minimal detectable change (MDC).

Case 2

A 59-year-old female avid recreational skier and mountain biker presented with a ten-year history of progressive, insidious onset right anterior knee pain and crepitus. She reported sharp, activity-related retropatellar pain with generalized intermittent knee stiffness, which greatly limited her participation in all recreational sporting activities. No prior history of knee injury was noted. She rated the peak daily intensity of her pain as 3/10 on the NPRS, with aggravating factors including squatting, stair descension, and sit-to-stand tasks. The patient also reported morning stiffness of less than 30 minutes duration, post-activity knee swelling, and painful retro-patellar crepitus with

a catching sensation upon weight-bearing knee flexion. Previous management for this complaint included intra-articular corticosteroid and viscosupplementation injections, therapeutic knee exercises, and multiple “off-the-shelf” and custom knee braces. Of all treatment modalities, only corticosteroid injections were reported to provide meaningful symptomatic relief. Her self-reported goal of care was to return to skiing, running, and mountain biking without pain-related limitations.

Upon examination, the patella was observed to be centrally positioned without obvious periarticular muscle atrophy or joint effusion. Active and passive knee flexion and extension ROM were full and symmetrical to the unaffected limb, with pain recreated by end-range flexion overpressure. Resisted knee extension recreated the presenting complaint, as did sit-to-stand and squat functional tasks. Tenderness upon palpation was elicited along the patellofemoral joint lines, and both patellar compression and grind orthopaedic tests reproduced the presenting complaint. Recent knee radiographs demonstrated severe osteoarthritis, isolated to the patellofemoral compartment of the knee.

The patient was diagnosed with PFOA with persistent right knee PFP. A plan of management consisting of the prescription of a Levitation® knee brace for use during physical activity, in addition to a hip- and knee-focused home exercise program to be performed at a frequency of three to four times per week for the duration of the study period, was initiated. Patient-reported and functional outcome measures were administered on the day of brace fitting, with these outcome measures re-administered at 6- and 12-week follow-ups.

After six weeks, the patient reported that her peak knee pain over the preceding week had increased to 6/10 on the NPRS following participation in a two-day ski camp. Despite the activity-related increase in pain, she reported that the brace was beneficial, noting that she could not have attempted the ski camp without it. She further reported having started running pain-free with the assistance of the knee brace before the pain flared up, an activity she was unable to do previously.

After 12 weeks, the patient reported that her peak knee pain over the previous week improved to 2/10 on the NPRS. She noted that she had returned to skiing as often as four times per week, with mild anterior knee pain onset only after consecutive ski days and resolv-

ing within 24 hours. She reported that her right knee felt stronger, citing the home exercise program and increased activity levels as the major contributors.

Over the course of the 12-week intervention period, improvements were observed in all outcome measures, however only the MCID threshold was met for KOOS-PF.²⁴ Absolute knee extension strength of the involved limb improved by 6.50 Kg (13.6%), and inter-limb strength symmetry increased from 73.7% to 91.0% (Table 2). The patient reported having received a corticosteroid injection, requisitioned by a sports medical physician, one day before the six-week follow-up, which led to noticeable and rapid pain reduction following her knee pain flare-up. No additional therapeutic interventions were reported during the 12-week intervention period.

Table 2.

Subjective and objective outcome measures for Patient 2 at baseline, 6-weeks, and 12-weeks.

Outcome Measures	Baseline	6-weeks	12-weeks
NPRS	3	6	2
KOOS-PF	47.73	61.36	63.64*
Ipsilateral knee extension (kg)	15.60	-	22.10
Contralateral knee extension (kg)	21.16	-	24.28
30 second sit-to-stand (reps)	16	16	18

* = meaningful clinically important difference (MCID); ‡ = minimal detectable change (MDC).

Case 3

A 55-year-old active female presented with a 20-month history of progressive, insidious left anterior knee pain and crepitus. She reported constant dull and achy retro-patellar pain, which limited her participation in her usual walking group and group exercise class activities. Her complaint first appeared following increased walking volume; no prior knee injury or surgery was reported. She rated the peak daily intensity of her pain as 8/10 on the NPRS, with aggravating factors including stair ascension and descension, deep knee flexion, and distance walking. She denied any instances of knee swelling, catching, or giving way. Previous management for this complaint included over-the-counter (OTC) pain medications, patellar mobilizations, patellar taping, patellar repositioning knee bracing, therapeutic knee exercises, and intra-articular viscosupplementation and platelet-rich plasma injections. Only rest from physical activity and OTC pain medica-

tion were identified to provide symptomatic relief. Her self-reported goal of care was to return to regular participation with her walking group, uninhibited by knee pain.

Upon examination, patellar lateralization was observed bilaterally with no obvious periarticular muscle atrophy or joint effusion. Active and passive knee flexion and extension ROM were full and pain-free bilaterally, with a positive patellar “J-sign” noted on the left. Resisted knee extension recreated the presenting complaint, as did single leg squatting to a depth of 45° knee flexion. Tenderness upon palpation was elicited along the medial and lateral patellofemoral joint lines, and both patellar compression and grind orthopaedic tests reproduced the presenting complaint. Ligament integrity tests of the knee and patella demonstrated no excessive joint laxity and recent knee radiographs demonstrated no evidence of osteoarthritis or other abnormalities.

The patient was diagnosed with left knee chondromalacia patella with persistent PFP. A plan of management consisting of using a Levitation® knee brace in addition to a knee- and hip-focused home-based exercise rehabilitation and strengthening program at a frequency of three to four times per week was prescribed. Patient-reported and functional outcome measures were administered on the day of brace fitment, with these outcome measures readministered at four- and nine-week follow-ups.

After four weeks of intervention, the patient reported her peak knee pain over the previous week to have improved to 2/10 on the NPRS, noting reduction in knee pain during flat-ground walking and both stair ascension and stair descension. She further reported greater pain-free walking distance and duration while wearing the knee brace.

After nine weeks, the patient reported her peak knee pain remained plateaued at 2/10 on the NPRS, with stair descension and squatting activities identified as the only mildly aggravating activities. Flat ground walking and stair ascension were no longer painful. She further noted a decreased dependence on the knee brace, using it only during strenuous walking and stair-climbing tasks, and had decreased her reliance on OTC medications for pain management both during and after activity.

Over the course of the nine-week intervention period, improvements were observed in all outcome measures (Table 3), surpassing the MCID thresholds for NPRS²³ and KOOS-PF,²⁴ as well as the MDC threshold for the

30-second sit-to-stand.²⁵ Absolute knee extension strength of the involved limb improved by 5.23 Kg (68.4%), and inter-limb strength symmetry increased from 38.1% to 50.4%. Other than OTC pain medication, no additional therapeutic modalities were reported during the nine-week intervention period.

Table 3.

Subjective and objective outcome measures for Patient 3 at baseline, 4-weeks, and 9-weeks.

Outcome Measure	Baseline	4-weeks	9-weeks
NPRS	8	2*	2*
KOOS-PF	25	68.18*	70.45*
Ipsilateral knee extension (kg)	7.65	10.34	12.88
Contralateral knee extension (kg)	20.10	25.55	25.56
30 second sit-to-stand (reps)	9	12	13‡

* = meaningful clinically important difference (MCID); ‡ = minimal detectable change (MDC).

Discussion

The management of PFP presents a challenge for clinicians, owing to a poor understanding of the specific tissues responsible for pain generation, a symptom-based diagnostic criteria, and a large degree of heterogeneity in case presentation.¹ The three cases detailed in this case series exemplify the heterogeneity often observed among female patients with PFP.^{2,12,13} Despite overlapping diagnoses, the three patients varied with regards to age, activity level and type, symptom severity and duration, aggravating factors, and prior therapeutic approaches. This degree of heterogeneity may present a point of confusion for managing clinicians as few conditions present so consistently with such a diverse constellation of clinical features.

As each patient in the current report had previously undergone unsuccessful management efforts using a variety of techniques (the majority of which were supported by CPGs¹), a decision to trial a Levitation® knee brace as an adjunct modality to regular care was made jointly between the providing clinician and the patient despite recommendations against knee orthoses in recent CPGs.¹ Current CPGs provide a recommendation against the use of knee braces, sleeves, and straps, based on the absence of high quality evidence to support these interventions.¹ Despite this, the decision to trial the Levitation® knee brace was made on the theoretical notion that the

spring-loaded mechanism within the brace may reduce PFJ compressive loads, thereby reducing symptoms and improving exercise tolerance. Additionally, a paucity of reported or conjectural adverse or consequential effects of donning this type of brace further supported this decision.

During the course of management, each patient demonstrated functional improvements beyond the MCID as measured using the KOOS-PF (Tables 1-3).²⁴ Furthermore, two of the three patients demonstrated changes exceeding the MCID and MDC for the NPRS²³ and 30-second sit-to-stand test²⁵, respectively, whereas the third had initially presented with the most favourable pain and function levels of the cohort and thus experienced smaller relative improvements. Perhaps most importantly, all three of the patients reported successful completion of their pre-management goals of returning to activity without pain-based limitations and subjective satisfaction with their course of care. Of note, two patients were able to maintain pain-free activity despite decreased knee brace use, suggesting that long term reliance on the brace may not be necessary. As PFP is primarily a symptom-based diagnosis¹, measures of subjective symptom intensity and symptom-based functional limitations are key to understanding how patients progress through management plans.

Although not previously explored in PFP populations, the Levitation® knee brace employed in the current report has previously been demonstrated to provide symptomatic relief in multi-compartmental knee OA patients both in acute²¹ and chronic²² time scales. During braced conditions of a sit-to-stand task, knee OA patients demonstrated significantly reduced quadriceps muscle activity, patellofemoral and tibiofemoral joint loads and reported reductions in pain compared to non-braced conditions.^{18,20} Modeling studies have also demonstrated that the spring-loaded mechanism found in this Levitation® knee brace provides a passive knee-extension moment sufficient enough to significantly reduce quadriceps tendon forces and compressive joint loads during active lower limb tasks.^{19,20} As PFJ pressure is suspected to be a primary contributor to the presentation of PFP, authors have postulated that the unloading effect produced by this type of bracing solution may be appropriate for PFP patients in addition to those with multicompartmental knee OA.²⁰

Although there is no current consensus on specific mechanisms underpinning the development of PFP,

leading hypotheses suggest that aberrant lower limb kinematics may play a role in the development of pathological patellofemoral joint loading patterns.^{6,26} Increases in medial femoral rotation, hip adduction, and knee abduction during activities such as squatting, running, and stair climbing have been linked to both the presence²⁶⁻²⁹ and development^{30,31} of PFP. Furthermore, these kinematics, in addition to the presence of lateral patellar displacement and tilt, have been observed to decrease patellofemoral joint contact area, resulting in an increase in focal articular surface pressures.²⁶ Chronic increases in pressure on the retro-patellar surface have been suggested to overwhelm the pro-adaptive capacity of these structures, leading to articular cartilage overload and, eventually, structural damage such as that seen in PFOA.^{6,26} Although an important distinction exists between PFP and PFOA from a diagnostic perspective, PFOA has repeatedly been suggested to be a sequela to PFP,³² and a relationship has been observed between individuals undergoing arthroplasty for PFOA and a history of adolescent PFP (OR = 2.31).¹⁰

Although the scope of this report prohibits concluding that the use of the Levitation® knee brace in the management of these patients is directly responsible for the positive outcomes, it provides a precedent for clinicians to consider the utility of this type of modality as an adjunct to regular conservative care of PFP cases. Additionally, it establishes a line of inquiry into the possible mechanisms through which the Levitation® knee brace may have interacted with the other components of the management plan of these patients to produce the favourable results measured.

Some clinicians may resist the prescription of spring-loaded braces out of fear that the assisted knee extension may precipitate further weakness about the joint due to muscular disuse. As a relationship has been observed between longitudinal changes in knee extension torque and the WOMAC scale (a questionnaire based patient reported outcome of knee osteoarthritis related pain and function),³³ concern for patients' force production capacity is founded. Specifically, a 3.7% decrease in quadriceps strength has been associated with MCID reduction in WOMAC scores on a 4-year follow-up of 2651 female knee osteoarthritis patients.³³ Although there are no longitudinal evaluations of the effect of this type of brace on quadriceps strength, all three of the patients pre-

sented in this report demonstrated increases in ipsilateral isometric knee extension torque (18.9%, 13.6%, 68.4%) as well as reductions in knee extension torque asymmetry. One potential explanation of this observation is that the patients experienced symptom relief from the brace to the extent that they were able to participate in their home-based and recreational exercise activities at intensities and volumes higher than otherwise possible. Although no specific measures of exercise adherence were employed in this study, all patients reported an improved subjective tolerance to exercise and volume of activity. This perspective may permit clinicians to consider the utility of tricompartmental offloading knee braces not as a remedy to the underlying pathomechanics of PFP, but rather as a supportive adjunct to an active care model.³⁴ Similar approaches are already commonplace in the management of PFP cases in the form of injection therapies, where various pain-relieving injectables are utilized for the express purpose of reducing pain and discomfort in an attempt to improve exercise compliance.¹⁴

Limitations

The heterogeneity present in the demographics and management of the three subjects discussed presents a major limitation of the current report. The subjects vary widely in age, structural diagnoses, primary activities, and previous therapeutic approaches. Furthermore, in addition to the bracing protocol and home-based rehabilitation program provided, the subjects differed greatly in the adjunct therapies they received during the study period. Although each patient received prescriptions for rehabilitation programs, the programs differed slightly between each patient, and no specific measure of exercise adherence was conducted. Patient 1 received manual therapy, including joint mobilizations, myofascial tissue release, and electroacupuncture, Patient 2 received a corticosteroid requisitioned by a sports medicine physician during week six of the 12-week study period, and Patient 3 self-medicated with over-the-counter NSAIDs for pain management. A further limitation is that the total study time differed between each case and was relatively short compared to the typical time course of the PFP condition, which may be ongoing for years.^{15,16} As there was no control group present, it is difficult to conclude that the changes observed over the study period were a result of the interventions applied, or of natural history. As such, the

long-term effectiveness of the management plan cannot be assumed. Additionally, although peak knee extension strength appeared to increase in all three cases, the short follow-up period does not provide an indication of long-term strength adaptations in this population. Further investigations into the effect of long-term tricompartmental offloading knee brace use on pain, function, exercise adherence, and strength in a PFP population and potential adverse reactions are warranted.

Summary

This case series details the clinical experience of three active females diagnosed with PFP who were prescribed a Levitation® knee brace as an adjunct management tool alongside guideline-aligned hip- and knee-focused exercise therapy. Although knee orthoses are not recommended for managing PFP by CPGs, using an orthosis in these cases was justified due to the patients' lack of response to previous management strategies and the low-risk profile associated with knee bracing. The proposed relationship between elevated PFJ reaction forces and the development of PFP provides theoretical support for using a tricompartmental offloading knee brace in patients suffering from PFP. Bracing represents a low-risk adjunct to conventional treatment strategies in the management of chronic PFP cases. A previous study employing the Levitation® knee brace in multi-compartmental knee OA patients demonstrated trends towards decreases in activity-related pain and increases in total activity time over a nine-month period.²² The inclusion of a tricompartmental offloading knee brace in the management of PFP may provide patients with increased opportunities to perform pain-free exercise and thereby improve compliance in first-line management strategies such as hip and knee strengthening rehabilitation programs.

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