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Current Concepts in the Management of Patellofemoral Pain Syndrome

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Abstract
Introduction: Patellofemoral pain syndrome (PFPS) is one of the leading causes of knee pain, manifesting itself during daily life activities. This study presents a review on PFPS treatment modalities.
Materials and methods: State of the art review on the treatment of PFPS with grades of recommendation. Active and passive conservative interventions are reviewed, as well as surgical alternatives.
Results: Hip and lower-limb muscle strengthening and stretching are active interventions that provide long-lasting benefits. Passive interventions include patellofemoral joint bracing, kinesiotaping and foot orthoses, and are considered useful coadjuvants to active interventions, with quick relief for patients but usually in the short term. Surgical treatment is only recommended in a small subset of patients with specific anatomic abnormalities in the patellofemoral joint.
Discussion: Conservative treatment remains as the mainstream in the management of patellofemoral pain syndrome.
Level of Evidence: IV, Clinical Review.

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PALABRAS CLAVE
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Ortesis de pie;
Artroscopia

Conceptos Actuales en el Manejo del Síndrome de Dolor Patelofemoral

Resumen
Introducción: El síndrome de dolor patelofemoral (SDPF) es una de las principales causas de dolor de rodilla y se presenta con actividades diarias de la vida cotidiana. Este estudio presenta una revisión de la literatura acerca de las modalidades de tratamiento actual para el SDPF.
Materiales y métodos: Revisión estado del arte acerca del tratamiento del SDPF con grados de recomendación según la evidencia. Se revisan las intervenciones conservadoras activas y pasivas, así mismo las alternativas quirúrgicas.
Resultados: El fortalecimiento de los músculos de la cadera y del miembro inferior, así como el estiramiento, son intervenciones activas que ofrecen beneficios en el largo plazo para el SDPF. Las intervenciones pasivas como las rodilleras, el *kinesiotaping* y las ortesis para los pies, ofrecen alivio rápido pero de corta duración. El tratamiento quirúrgico solamente se recomienda en un subgrupo de pacientes que no han respondido a otros tratamientos y que tienen ciertas anormalidades anatómicas específicas que alteran la articulación patelofemoral.
Discusión: El tratamiento conservador continúa siendo la piedra angular en el tratamiento del síndrome de dolor patelofemoral,
Nivel de evidencia: IV, Revisión Clínica.

Introduction

Patellofemoral pain (PFPS) typically presents as diffuse anterior knee pain that worsens with activities, such as squatting, running, and ascending or descending stairs.[1] It is the leading cause of knee pain, with an estimated incidence of 22/1000 people per year in the United States.[2,3] It mostly affects people in their late teens and early 20s, becoming especially prevalent in physically active individuals, even if no pre-existing functional or structural knee anomalies can be found.[3–6] It affects 1 out of every 4 athletes, mostly females, who have been shown to be twice as prone as male athletes to developing this condition.[6] Although physiotherapy has been proven to be the most effective treatment for this condition, high rates of recurrence are still seen.[6] Approximately one-third of the population presenting with this condition will show complete improvement upon completion of rehabilitation protocols. Thus, PFPS may become a chronic condition in a significant percentage of patients, forcing them into prolonged courses of treatment and complete abandonment of sports and/or physical activity.[3,6,7]

Despite the high incidence of this condition, no definite consensus about its origins has been made. Although it was initially believed to stem from patellar malalignment[8], it is currently proposed that PFPS has a multifactorial origin, including both intrinsic and extrinsic factors in the knee. Intrinsic factors include muscle weakness (more often from the quadriceps and the vastus medialis muscles), abnormal patellar mobility, skeletal malalignment and soft tissue imbalances. Among the extrinsic factors, knee joint overload remains the most significant.[7]

Treating this syndrome can be challenging in some cases. Active interventions have been shown to produce better outcomes and remain, as of this review, the pillar of treatment for PFPS. On the other hand, passive interventions have been proven to be effective as adjuvant measures only in the early stages of PFPS treatment, failing to show significant long-term improvements.[9] Although surgical interventions for PFPS have been proposed as a last resort measure, they remain controversial, as some authors have suggested they do not bring additional benefits.[10,11] This study aims to review the current literature, prioritizing higher-level evidence and the most recent articles regarding the treatment of patients with patellofemoral pain syndrome.

Treatment overview

Physiotherapy has been considered the gold standard in PFPS management.[12] Both open kinetic chain (OKC) and closed kinetic chain (CKC) exercises have yielded similar, significant results on pain reduction in PFPS patients.[13] Other nonoperative treatments include kinesiotaping and patellar braces. Both devices aim to correct the lateral sliding of the patella with favorable outcomes in the short term.[14,15] Foot orthotics have also been proposed, aiming to correct foot anomalies, such as ankle eversion and excessive foot pronation.[16] Finally, surgery may be useful in a limited number of patients that have failed the conservative management.[10,17]

Pharmacologic Therapy

Limited or contradictory evidence supports the use of pharmacologic treatment for PFPS, either with oral NSAIDs or intraarticular steroids. Thus, its application has been generally discouraged.[18]

Recommendation C: Pharmacologic treatment is useful in the short term for patients with PFPS.

Physical Therapy

Muscle Strengthening

Over the years, muscle weakness has been considered the leading contributing factor to PFPS onset. Therefore, most of the available literature on the topic has focused on that specific factor. Currently, the question of which muscular group has the most influence on PFPS onset remains controversial, as the answer could potentially determine a more focused and effective course of treatment for PFPS patients.

Numerous arguments have been made for quadriceps-strengthening protocols being effective and beneficial in the management of PFPS patients, both on their own as well as combined with hip strengthening exercises. Eapen et al. conducted a case-series study in 8 males and 12 females to evaluate the effectiveness of isotonic eccentric quadriceps training, at the end of which a significant decrease in pain and increase in function were found among study subjects, probably as a result of improved PF joint mechanics.[19] The PF joint contact area is another issue that can potentially be addressed by quadriceps-strengthening protocols. In a case series of 6 healthy participants and 9 PFPS patients, Chiu et al. concluded that quadriceps strengthening increases the PF joint contact area, thus reducing mechanical stress in the joint and providing significant symptom relief.[20]

Hip-strengthening exercises have also been regarded as highly beneficial in the management of PFPS patients. In a nonrandomized clinical trial of 28 sedentary female patients who were under either a hip-strengthening program compared to no exercise, Khayambashi et al. found a significantly greater improvement in pain and functionality for the first group.[21] Other authors have suggested that hip muscles may have a similar or even larger influence on the clinical outcomes of PFPS patients. Fukuda et al. conducted a randomized controlled trial (RCT) in fifty-four sedentary women and concluded that adding posterolateral hip-strengthening exercises to knee-musculature stretching and strengthening decreased pain and enhanced functionality in PFPS patients in a more effective manner and longer term than knee-focused exercises alone.[22] In a similar RCT, Dolak et al. compared hip-strengthening protocols and knee-strengthening protocols in thirty-three women, finding that both are effective at reducing pain and enhancing functionality in PFPS patients. However, hip-strengthening exercises achieved lower pain levels in patients earlier than knee-strengthening protocols.[23] Additionally, Ferber et al. conducted an RCT in 199 men and women to compare knee and hip strengthening protocols and came to a similar conclusion. Both protocols produced similar beneficial effects in PFPS patients when compared over a 6-week period of time, with hip strengthening exercises improving pain and function earlier than knee-strengthening exercises[24]. Other authors have gone as far as suggesting that hip-strengthening exercises should be considered the cornerstone of PFPS treatment. In another nonrandomized clinical trial, Khayambashi et al. compared hip and knee strengthening protocols in eighteen men and eighteen women, with a significant improvement in the hip-strengthening group, as its effects appeared to be longer lasting than the results obtained in the knee-strengthening group.[25]

Other authors have included additional muscular groups in rehabilitation protocols, such as trunk and core muscles. Baldon et al. found in an RCT of thirty-one women that PFPS rehabilitation protocols, including hip, trunk and quadriceps exercises, were more beneficial for PFPS patients in terms of pain reduction, function, strength and PF joint kinematics than quadriceps strengthening alone.[26] Earl-Boehm et al. suggested that core-muscle strengthening can be beneficial even in patients with a higher degree of baseline knee pain and activity, meaning that these exercises could be effective in patients with a high degree of wear and tear in their PF joint.[27] Some authors, however, such as Saad et al., could not find differences in the visual analog scale (VAS) for anterior knee pain in an RCT comparing hip-strengthening and quadriceps-strengthening groups. However, the groups were small (n = 10 in each group), suggesting they were possibly underpowered.[28]

In conclusion, most recent evidence supports hip-strengthening exercises as a fundamental part of PFPS rehabilitation protocols, mostly in combination with quadriceps and lower-limb strengthening. Additionally, trunk and core strengthening exercises have emerged in recent years as an intriguing method of treatment for PFPS and should be further researched in the future, as they have already proven to be beneficial for PFPS patients.

Recommendation A: Strengthening is useful in PFPS treatment, including CORE, hip and knee strengthening.

Muscle stretching

Lower-limb muscle stretching has been widely used in conjunction with muscle strengthening in the management of PFPS patients, as it has been shown to provide quick relief of symptoms, even quicker than strengthening, ranging between 1 and 3 weeks postintervention. In a case-series study of 50 PFPS patients, Peeler et al. showed that a 3-week quadriceps stretching program decreased knee pain and increased functionality.[29] On the other hand, Avraham et al. found in their RCT of thirty patients in 3 groups of treatment that hip-musculature stretching and strengthening showed similar results to strengthening alone, although it was probably underpowered.[30] Furthermore, there could be differences between dynamic and static lower limb stretching. Lee et al., in a 2020 RCT study of 46 patients with inflexible hamstrings divided into two types of stretching (static stretching, n = 25; dynamic stretching, n = 21) with additional strengthening, found that a dynamic hamstring-stretching program was significantly better in terms of knee pain severity, muscle activation and quality of life (QOL) postintervention.[31]

In 2011, Mason et al. conducted an RCT of forty-one patients and sixty knees divided into four groups (infrapatellar taping, quadriceps strengthening, quadriceps stretching and control), finding better results in quadriceps strengthening and stretching compared to knee-taping or the control group in terms of pain relief and function.[32] Moyano et al. conducted an RCT study of 74 patients with PFPS and found that proprioceptive neuromuscular facilitation (PNF) combined with aerobic exercise produced better results than

classic muscle stretching, with an increase in function and range of movement of the PF joint, as well as a decrease in knee pain over a 4-month period.[33]

In conclusion, stretching is an essential therapeutic intervention in the management of PFPS, given its quick symptom relief as well as ability to address muscular deficiencies involved in the self-perpetuation of the syndrome. PNF is also being proposed as a newer, superior alternative to classic muscle-stretching exercises; as such, further research is recommended.

Recommendation A: Stretching plays a role in PFPS treatment, especially as a strengthening coadjuvant.

Passive interventions

Taping

Patellofemoral (PF) joint taping remains an intriguing and controversial alternative of care for PFPS patients. Despite its frequent use as a quick-acting, short-term, pain relief method, the evidence surrounding it is highly contradictory. Most studies on the subject attribute differing degrees of benefit to PFPS patients who receive PF joint taping in any of its forms or variations.

To study taping, Osorio et al. compared two different techniques of PF joint taping in a crossover RCT of twenty patients: the Spider technique and the McConnell technique. They found that either method by itself was capable of producing a decrease in pain and an increase in peak strength during quadriceps extension.[34] Meanwhile, studies such as Mason et al. (RCT, n = 41), Kuru et al. (nonrandomized RCT, n = 30) and Demirci et al. (RCT, n = 35) have found PF joint taping to be useful and beneficial in PFPS management with regard to pain control (both at rest and during activity), PF joint strength, functionality and quality of life.[32,35,36] However, these studies assessed taping in combination with different additional interventions, such as physiotherapy or electric muscle stimulation (EMS), unlike Osorio et al., who evaluated taping on its own.

Other researchers are less optimistic about PF joint bracing. The studies led by Akbas et al. (RCT, n = 31) and Ghourbanpour et al. (RCT, n = 30) evaluated the addition of taping to physiotherapy, finding that coadjuvant PF joint taping was not more effective than physiotherapy in the rehabilitation of PFPS patients.[37,38] Furthermore, Barton et al.'s expert consensus suggested that PF joint taping should be tailored to the specific patient to which it would be applied to optimize its efficacy.[9] Even then, the efficacy of tailored PF joint taping on a long-term basis remains uncertain, adding yet another layer of complexity to its use in a clinical practice setting and the decision-making around it.

Regardless, PF joint taping continues to be widely used in clinical practice as a means to provide quick PFPS symptom relief, with a systematic review showing that medially directed patellar taping provides immediate pain reduction.[15] However, it must be kept in mind that the effect of taping is rather short-lasting, and additional measures must be taken for the long-term management of PFPS symptoms and disease progression.

Recommendation B: Patellofemoral taping provides immediate pain relief in the short term.

Foot Orthoses

As with taping, foot orthoses have also been used over the years as a routine treatment for PFPS. Collins et al. found in their RCT involving 179 patients with PFPS that foot orthoses were superior to placebo (flat inserts), even in the long term (52 weeks); however, improvement was similar to physiotherapy, and the addition of foot orthoses to physiotherapy showed no difference in outcomes compared to using only physiotherapy or only foot otrhoses.[39] Molgaard et al. showed in an RCT involving 40 patients with excessive calcaneal eversion that adding foot exercises and orthoses to knee targeted exercises had better outcomes than performing only knee-targeted exercises at 4 months. However, this favorable difference was no longer seen at the 12-month follow-up when both groups showed similar results.[40] After analyzing data from Collins et al.[39] it was suggested by Vicenzino et al.[41] that foot orthoses should be specifically tailored for a select group of patients. Specifically, those who matched at least three of the following characteristics showed better results: age (>25), height (<165 cm), a difference in mid-foot width from nonweight bearing to weight bearing (>10.96 mm) and worst pain visual analog scale (<53.25 mm). The pretest success rate of foot orthoses increased from 40% to 86% when the patient had three of these factors (positive likelihood ratio 8.8; 95% CI 1.2 to 66.9).[41]

Recommendation A: Foot orthoses are useful in the treatment of PFPS, especially in patients with certain characteristics.

Bracing

The use of knee braces in PFPS treatment has shown favorable results. Lun et al. (RCT, n = 136) found similar favorable results between patellar bracing and a home-exercise program after 12 weeks, with no additional benefit when assigning both treatments together.[42,43] Meanwhile, Petersen et al. (RCT = 156) compared supervised physiotherapy with and without patellar brace, finding improvement in both groups at 6 and 12 weeks and with better results for bracing in some of the KOOS subscales, in the Kujala score, climbing stairs and playing sports. This difference between groups diminished at the 1 year follow-up.[42,43] However, there is conflicting evidence regarding this treatment.[15]

Recommendation B: Patellar bracing is a useful treatment or coadjuvant in the short-term management of patients with PFPS.

Surgical management

Sanchis-Alfonso et al. wrote that patients with anterior knee pain are at high risk of receiving surgical treatment with little or no scientific basis simply because it is a musculoskeletal pathologic entity with poorly understood

etiopathogenesis.[44] Surgery may be performed with minimally invasive procedures, such as peripatellar synovectomy or resection of synovial hypertrophy around the inferior pole of the patella, while open surgeries include rotational osteotomies or tibial tuberosity osteotomies. It is also important to establish whether patellofemoral pain is secondary to instability, which might require a different surgical treatment approach.

In 2007, Kettunen et al. conducted an RCT study in 56 patients comparing the effectiveness of surgery plus 8-week physical rehabilitation compared to 8-week physical rehabilitation alone.[10] Arthroscopic surgery included resection of medial plicae, abrasion of chondral lesions and shaving inflamed synovium. They found that surgery did not add a benefit to conservative treatment at the 9-month follow-up. Furthermore, the authors followed the study subjects over a 5-year period, at the end of which they produced another research paper in which the initial conclusion that surgery was no better than exercise in PFPS was confirmed.[11] Meanwhile, Dannawi et al. reported in their case series (n = 32) that, in patients with PFPS with extensor mechanism malalignment, Elmslie-Trillat osteotomy showed poor clinical results.[45]

Other sources of pain that could benefit from surgery should be explored with a complete physical exam and with appropriate imaging. Patients with patellar maltracking owing to an increased TT-TG distance can benefit from a tibial tubercle osteotomy (TTO), as shown by Tigchelaar et al. in a case series of thirty patients with patellofemoral pain.[46] In that study, patients with a TT-TG distance $\geq$ 15 mm were subjected to TTO, showing that both pain and function improved significantly after a 10-year follow-up.

Increased patellar tilt is also related to PFPS, as it increases the pressure on the lateral facet, subjecting it to increased wear and tear. This condition can be addressed with either lateral retinacular release (LRR) or lateral retinacular lengthening (LRL) surgery. Pagenstert et al. ran an RCT study in 2012 to compare the outcomes of fourteen patients who underwent LRR surgery against fourteen patients who were subjected to LRL surgery.[47] After a 2-year follow-up, the authors concluded that the lengthening surgery group experienced better clinical and anatomical outcomes than the release group. Furthermore, 5 patients in the lateral release group had medial subluxation in comparison with no cases in the lengthening group. This paper suggests that lengthening the lateral retinaculum is a superior surgical option for PFPS patients with increased patellar tilt.

Derotational osteotomies have been studied when there is an association between pain and increased femoral anteversion or external tibial torsion. Imhoff et al. showed a case report of a patient with PFPS and patellar instability who was treated successfully with distal femoral derotation.[48] Stevens et al. found in their case series that sixteen patients who underwent knee surgery before torsion were recognized and subsequently treated by means of rotational osteotomy of the tibia and/or femur, significantly improving pain at the 59-month follow-up.[49] Manilov et al. studied sixty knees requiring high tibial derotation osteotomy because of PFPS associated with increased external tibial torsion (>30°) in their case series, finding significant improvement in functional scores and pain in a mean 66-month follow-up.[50] However, these were case series studies without a comparison group.

Recommendation B: Lateral retinacular lengthening can be indicated in patients with PFPS associated with increased patellar tilt and poor response to conservative treatment.

Recommendation C: Denotational osteotomies may be useful to treat PFPS when rotational deformities are present, with no response to conservative treatment.

Conclusions

The current management of PFPS must be mainly conservative and multimodal, working on hip and quadriceps muscle strengthening and stretching, with hip-focused rehabilitation having the best level of evidence. Additionally, passive interventions, such as knee joint taping, bracing and foot orthotic devices, could potentially be used as fast-acting means of pain relief for PFPS patients. Nevertheless, these devices should only be used on an individualized, case-by-case basis, as not all patients could potentially benefit from their use. Finally, surgical treatment may only be a potentially viable option in patients with failed conservative treatment and specific anatomical problems that may affect the PF joint and can be corrected with operative treatment.

Even if our knowledge about conservative treatment may seem well rounded and definite, many unknowns remain regarding the management of PFPS. Core-strengthening exercises and PNF-enhanced stretching programs have shown fairly promising results as new proposed methods of PFPS rehabilitation and, as such, warrant further research. Passive interventions, such as taping and bracing, are also in need of more robust, standardized studies, while foot orthotic devices have higher-level evidence. All of this, along with PFPS's high incidence among the general population and its impact on the quality of life of those who suffer from it, makes PFPS a supremely relevant and interesting topic of research in orthopedics for further investigations.

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Conflict of interest

The authors declare no conflict of interest.

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