Review Article

Distal Approaches in Patellofemoral Pain: A Systematic Review, Part I

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ABSTRACT

Purpose: Increased patellofemoral joint reaction force is the main cause of patellofemoral pain syndrome. Foot pronation causes faulty joint coupling of the lower limb and increases the patellofemoral joint reaction force; accordingly, this study aims to systematically review the effect of the distal interventions on the clinical symptoms and kinematics of patients with patellofemoral pain.

Methods: The search strategy was applied to Google Scholar, PubMed, Science Direct, Medline, Web of Science, and Scopus databases. The search was limited to the English language. The studies were from 2000 to 2022. In 4 stages, the selected articles were screened for systematic review. The quality of the study was evaluated by the Downs and Black scale. Meanwhile, the articles were classified into 3 categories as follows: High, medium, and low quality.

Results: A total of 12 articles were screened for this systematic review. The quality of the study was medium. Meanwhile, 5 articles had medium quality and 7 articles had high quality. The results of the systematic review showed that distal interventions are effective in improving clinical symptoms and correcting the faulty kinematics of the lower limb.

Conclusion: Distal interventions by correcting the faulty joint coupling reduce the patellofemoral joint reaction force and pain. As a result, distal interventions in combination with proximal exercise have a better effect on clinical symptoms.

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Highlights

• Foot pronation causes faulty joint coupling, including tibia internal rotation and hip internal rotation.

• Faulty joint coupling increases the patellofemoral joint reaction force.

• Distal approaches correct the faulty joint coupling.

• Correction of faulty joint coupling reduces patellofemoral joint reaction force and pain.

Plain Language Summary

The foot and ankle play an important role in the patellofemoral pain etiology. Foot pronation through joint coupling causes tibia internal rotation along with hip internal rotation. As a result, the patellofemoral joint reaction force increases. Distal approaches by correcting foot pronation cause normal joint coupling of the lower limb. As a result, the patellofemoral joint reaction force decreases and subsequently reduces the pain. Distal approaches along with proximal interventions can be effective in the clinical symptoms of patients with patellofemoral patients.

Introduction

Chronic pain comprises 15% to 20% of visits to medical clinics [1]. These conditions result in economic losses because of medical care and absence from work [1]. One of the most common painful conditions is patellofemoral pain (PFP) [2]. PFP is one of the most common lower limb disorders, which comprises about 25% to 40% of knee injuries [3–5]. The prevalence of PFP was reported at 29.2% in women and 15.5% in men [6]. The prevalence of PFP in the general population and athletes has been reported at 22.7% and 40%, respectively [7]. The main clinical symptom of PFP is pain aggravation during activities that require knee flexion and increasing activity of the quadriceps muscle [8, 9]. In addition, evidence shows that PFP can be one of the main causes of patellofemoral joint (PFJ) osteoarthritis [2]. Therefore, the high prevalence of PFP highlights the importance of reviewing treatment protocols for this condition.

The cause of PFP is an interaction between anatomical, biomechanical, and psychological factors [10, 11]. One of the most common biomechanical theories of PFP is the increase in PFJ pressure which is related to the faulty kinematics of the lower limbs [12]. In the fourth PFP international consensus statement, the biomechanical factors of PFP were classified into 3 categories as follows: Proximal (hip), local (knee), and distal (foot and ankle) [13]. Proximal factors include hip muscle weakness which increases adduction and internal rotation of the hip [3, 14]. Local factors are related to quadriceps muscle weakness, knee flexion reduction, and knee extensor torque reduction [3, 14]. Distal factors refer to foot and ankle faulty mechanics, including foot pronation in PFP development [3, 14]. In this triple classification, limited studies have focused on the role of distal factors in the treatment of PFP [15, 16]. The structure and function of the foot and ankle during functional movements have a high impact on the mechanics of the proximal joints and change the transmission of ground reaction force to the lower limb joints [3]. In a systematic review, Yalfani et al. (2021) reported factors related to distal, such as pronation and rear-foot eversion as a risk factor for PFP [3]. This faulty kinematics of the foot and ankle may contribute to the development of hip and knee abnormal mechanics and finally to increasing the PFJ pressure [17–19]. Accordingly, therapeutic interventions for the distal can play an effective role in PFP treatment [15]. However, the optimal treatment approach for PFP has not been known and a wide range of interventions, including orthosis, braces, and physical therapy have been suggested [20]. Despite the above-mentioned issues, the results of interventions are challenging and have poor effectiveness in the long term; accordingly, 56.7% of patients report functional limitation and pain 5 to 8 years after treatment [21].

The interventions related to the distal are focused on correcting the faulty biomechanics of the lower limbs of PFP patients [15]. Theoretically, these interventions can correct the abnormal biomechanics of PFJ [19]. For example, Hart et al. (2019) investigated the immediate effects of foot orthosis on lower limb biomechanics in PFP patients. The results of this study showed that foot orthoses have little changes in the lower limb kinematics [19]. On the other hand, Saravanakumar et al. (2017), which investigated the

Table 1. PICO index items

Population	Intervention	Comparison	Outcome
Patients with patellofemoral pain	Distal intervention	Control group without receiving intervention/pre-test and post-test design	Clinical symptoms and kinematics of the lower limb

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effect of taping on the distal joint, reported a reduction in pronation and rear-foot eversion angle [22]. The results of clinical trials show that foot and ankle mechanics may be a key factor in the PFP etiology; therefore, it is essential to investigate the effective mechanism of each of the distal interventions to determine a better rehabilitation protocol to improve the clinical symptoms of PFP patients. Accordingly, this study aims to systematically review the effect of the distal interventions on the clinical symptoms and kinematics of PFP patients.

Materials and Methods

Research design

This systematic review follows the PRISMA reporting guidelines. Given the nature of the study, we only reviewed items related to the reporting of review studies [23].

Search strategy

The search strategy was conducted independently by the two researchers (Mohamadreza Ahmadi & Fatemeh Ahadi) from January 2022 to August 2022 in PubMed, Science Direct, Medline, Web of Science, and Scopus databases, limited to the English language. Google Scholar was used as a complementary search engine. In addition, a manual search in the relevant journals was performed to identify articles that may not have been identified in the electronic database search [7]. The search strategy was based on the patient, intervention, comparison, and outcome (PICO) index (Table 1). For wide access to the documentation, we used the combination of MeSH and common terms. Table 2 shows the keywords used in 3 categories (knee, foot, intervention). The term "or" was used to combine synonyms and the term "and" was used to connect categories. Also, the term "not" was used to exclude non-target terms.

Articles selection

We identified eligible articles through a 4-step process. In the first step, all selected articles were saved in the Mendeley software, version 1.19.8 as a reference manager software. Then, the articles were sorted alphabetically and duplicate studies were removed from the library. In the second stage, the titles and abstracts of the articles were screened according to the inclusion and exclusion criteria. In the third stage, the articles were identified that did not provide key information in their title or abstract. At this stage, to remove biases, the full text of the articles was screened by two researchers (Mohamadreza Ahmadi & Fatemeh Ahadi). If there was no agreement between the two researchers (Mohamadreza Ahmadi & Fatemeh Ahadi), the head researcher (Ali Yalfani) would review the articles and make a decision.

Eligibility criteria

The inclusion criteria were as follows: Clinical trials, human studies, articles published in English, comparing the results of distal interventions between experimental and control groups, or pre-test and post-test design. The exclusion criteria were as follows: Case studies, conference articles, articles in other languages than English, surgical interventions, and PFP patients related to special populations.

Quality of studies and data extraction

Two researchers (Mohamadreza Ahmadi & Fatemeh Ahadi) evaluated the quality of studies via the downs and black scale. This scale evaluates 4 sub-groups, namely reporting, internal validity, external validity, and confounding internal validity [24]. The scoring of each question was considered as follows: 0=no and 1=yes. Question 5, which was scored as 0 (no), 1 (somewhat), and 2 (yes)

Table 2. Selected keywords

Category	Keywords
Knee	Anterior knee pain syndrome (MeSH), patellofemoral syndrome (MeSH), pain syndrome (MeSH), patellofemoral (MeSH), patellofemoral pain
Intervention	Training (MeSH), exercise (MeSH), rehabilitation (MeSH), insole (MeSH), taping, foot orthoses (MeSH), foot arch supports (MeSH)
Foot	Pronation (MeSH), flat foot (MeSH), rearfoot eversion, foot (MeSH), distal (MeSH)

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[23, 24]. According to previous studies, the studies were classified into 3 categories, namely high quality (over 70%), medium quality (40% to 69%), and low quality (40%) [25]. The following demographic information was considered: Authors, year, purpose, variable, and outcome. The outcome measures included selected clinical symptoms and lower limb kinematics. To avoid bias in the evaluation, the data extraction of the studies was done independently by two researchers (Ali Yalfani) and was confirmed by the head researcher (Ali Yalfani).

Results

Articles selection

Overall, 217 articles were extracted from databases, and 58 duplicate articles saved by the Mendely software, version 1.19.8 were removed. After article screening, according to the eligibility criteria, 106 articles were excluded from the review process because of not meeting the inclusion criteria. Then, the full text of 53 articles was reviewed, among which 41 articles were excluded because they did not meet at least two of the inclusion criteria. Therefore, 12 articles were selected for this systematic review (Figure 1).

Quality of studies

A total of 5 studies had medium quality and 7 studies had high quality. The strength of the studies was mainly in reporting. On the other hand, the weakness of studies was in internal validity bias and internal validity-confound. However, the average quality was 62% and the range of the average quality of the studies was from 48 % to 92 %, which indicates the medium quality of the selected articles (Table 3).

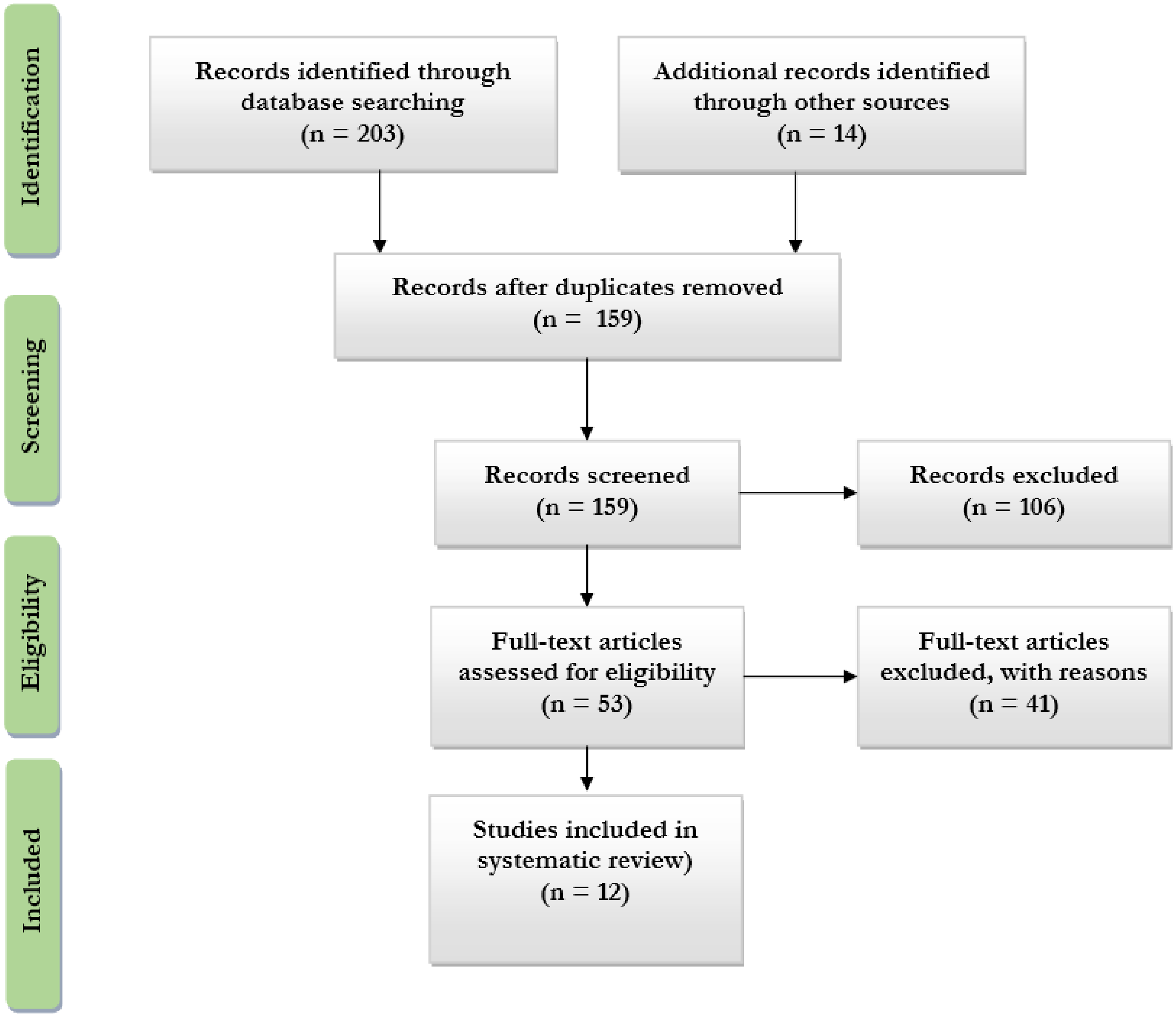

Figure 1. The process of selecting the articles

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Table 3. Results of the quality of studies

Study	Reporting										External Validity			Internal Validity–Bias							Internal Validity–Confounding						Power	Total	Quality
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		
Collins et al. 2008 [5]	0	1	1	1	0	0	1	0	0	0	1	1	1	0	1	0	1	1	1	1	1	1	1	0	0	1	1	17	M
Collins et al. 2008 [5]	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	0		1	1	1	1	1	1	1	1	1	1	23	H
Mills et al. 2012 [38]	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	0	23	H
Boldt et al. 2013 [11]	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1	0	0	13	M
Lack et al. 2014 [27]	1	1	1	1	1	1	1	0	1	1	1	0	1	0	0	0	1	1	1	1	1	0	1	1	1	1	0	20	H
Matthews et al. 2017 [37]	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	23	H
Saravanakumar et al. 2017 [22]	1	1	1	1	0	1	0	0	1	0	1	0	1	0	0	0	1	1	1	1	1	0	0	0	1	1	0	15	M
Mølgaard et al. 2018 [15]	1	1	1	1	1	1	1	0	1	1	1	0	1	0	1	0	1	1	1	1	1	1	0	0	1	1	1	21	H
Burston et al. 2018 [4]	1	1	1	1	1	1	1	0	1	1	1	0	1	0	0	0	1	1	1	1	1	0	0	0	1	1	0	18	M
Hart et al. 2020 [19]	1	1	1	1	1	1	1	0	0	1	1	0	1	0	0	0	1	1	1	1	1	0	0	0	1	1	0	17	M
Matthews et al. 2020 [2]	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	23	H
Kim et al. 2022 [16]	1	1	1	1	2	1	1	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	25	H

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H: High; M: Medium.

Table 4. Demographic information

Authors/Year	Purpose	Variables	Outcome
Collins et al. 2008 [5]	The efficacy of foot orthoses and physiotherapy in PFP patients	AKPS, pain	Given the long-term improvement observed in all treatment groups
Collins et al. 2008 [5]	The efficacy of foot orthoses in the management of PFP	Pain, AKPS	The results of the study showed the effectiveness of optimal treatment for the management of PFP patients
Mills et al. 2012 [38]	The efficacy of short-term foot orthoses in the treatment of PFP and evaluate the ability of foot posture measures to predict the outcome	Pain, AKPS	The results of the study showed orthoses provide greater improvements in AKPS
Boldt et al. 2013 [11]	The effects of medially wedged foot orthoses on hip and knee joint transverse and frontal plane mechanics	Knee and hip kinematics	The medially wedged foot had minimal effect on knee and hip joint mechanics
Lack et al. 2014 [27]	The immediate effects of prefabricated foot orthoses on hip and knee kinematics	Hip and knee kinematics	The reductions in hip adduction, and knee internal rotation immediately following orthoses application
Saravanakumar et al. 2017 [22]	The effect of elastic tape on MLA in PFP patients	AKPS, MLA, calcaneal eversion	The taping procedure is increased the MLA and reduced Calcaneal eversion
Matthews et al. 2017 [37]	They determine if those PFP patients and greater mid-foot width mobility will report better outcomes from foot orthoses when compared to hip exercise	Pain, KOOS, kujala	The results of the study showed the effectiveness of optimal treatment for the management of PFP patients
Mølgaard et al. 2018 [15]	The effect of knee-targeted exercise versus distal interventions in PFP patients	Pain, KOOS	The addition of foot-targeted exercises and foot orthoses was more effective than knee-targeted exercises alone in PFP patients
Burston et al. 2018 [4]	They investigate the kinematics and kinetics of the knee between PFP patients and healthy subjects when using a foot orthosis	Knee kinematics and kinetic	The PFP patients had a significantly longer single limb stance time, greater maximum knee flexion angle, greater range of flexion, greater coronal and transverse plane range of motion
Matthews et al. 2020 [2]	The effects of foot orthoses relative to hip exercises in the management of PFP patients	Knee and hip kinematic, pain	Both hip exercises and foot orthoses offer similar outcomes in reducing pain and improving function
Hart et al. 2020 [19]	The immediate effects of prefabricated foot orthoses on hip, knee, and ankle joint kinematics	Hip, knee, and ankle kinematics	Foot orthoses had small immediate changes in the ankle joint. Effects at the knee and hip were minimal
Kim et al. 2022 [16]	The effect of foot intervention, TJM, and FCS on PFP	Dynamic valgus index, pain, anterior knee pain scale	The blended intervention has a positive effect on reduced DKV and reduced pain

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Abbreviations: PFP: Patellofemoral pain; AKPS: Anterior knee pain scale; MLA: Medial longitudinal arch; DKV: Dynamic knee valgus; TJM: Talonavicular joint mobilization; FCS: Foot core strengthening.

Outcome measuring

The results of the systematic review of 12 studies are described in Table 4.

Discussion

The purpose of this systematic review was to investigate the effect of distal interventions on selected clinical symptoms and kinematics in PFP patients. The results of this study showed that distal interventions lead to the improvement of the clinical symptoms and correction of the faulty mechanics of the lower limbs of PFP patients. Foot pronation causes abnormal movements of the lower limb which is associated with increased loading of the PFJ [19, 26]; therefore, it seems that distal interventions by changing foot biomechanics have kinematic effects on lower limbs and change of the PFJ biomechanics [15, 17, 27] All the joints/segmental of the body interact with each other through the kinetic chain. As a result, the faulty movement of a joint/segment affects the movements of other parts [3]. Of note, the talus and tibia have a coupling movement and the increase in foot pronation leads to an increase in the tibia's internal rotation [27, 28]. Then, to maintain the normal arthrokinematics of the knee, the hip has increased internal rotation. This compensatory movement pattern causes dynamic knee valgus (DKV) [3].

DKV is a multiple conditions, including adduction and internal rotation of the hip, knee abduction, internal rotation, and anterior displacement of the tibia and ankle eversion [29]. DKV leads to an increase in PFJ reaction force (PFJRF), which is known as the main cause of PFP etiology [30]. The PFJRF is resultant of two quadriceps tendon forces and patella tendon force. The amount of the PFJRF depends on the amount of quadriceps muscle force and knee flexion angle [3, 31]. In this regard, it has been reported that a 10% increase in the DKV angle increases the PFJ pressure by 45% [30]. As a result, since during movement, the forces are transferred from the foot and through the kinetic chain to the knee [23]; distal approaches may reduce the force's actions on the PFJ and thus reduce pain.

Distal interventions, by correcting the foot posture, lead to correcting faulty lower limb kinematics and reducing the PFJRF [15, 19]. For example, it has been suggested that anti-pronation orthoses may prevent these faulty movement patterns and subsequently reduce pain [27]. The results of orthotic interventions showed that ankle dorsiflexion and eversion are reduced [19]. Dorsiflexion and ankle eversion are components of foot pronation [32]. As a result, reducing the pronation and rear-foot eversion angle through the coupling mechanism reduces the tibia internal rotation, internal rotation, and adduction of the hip [22, 27]. In this regard, a relationship between increased foot pronation and the etiology or exacerbation of PFP has been reported [22]. Hip adduction is an indicator for predicting pain intensity and function level [3, 33, 34]. In addition, the hip internal rotation is the primary cause of the external tracking of the patella along with increasing the PFJRF [3, 33, 34]. On the other hand, reducing hip adduction can correct the compensatory function of the iliotibial band and external retinaculum in addition to reducing the quadruped lateral forces. Finally, this mechanism increases the contact area of the PFJ and as a result, reduces the lateral pressure forces on the patella and finally reducing of the knee pain [22, 35].

Foot pronation in the initial stance phase is responsible for the response to loading and force attenuation during impact [7]. In a meta-analysis, Ahmadi (2022) reported that PFP patients tend to increase the loading rate [24]. Orthoses reduce the loading and vertical impact rates, which is expected to reduce PFJ loading [15]. The faulty kinematics in PFP patients change the transmission forces from the ground and the plantar pressure distribution impairment. In people who perform repetitive activities with high intensity, it causes increased pain, discomfort, and injuries [23]. In a review study, it was reported that patients have a high medial-foot loading pattern that is transferred to the knee through a kinetic chain [23]. It is concluded that knee loading and PFJ depend on plantar loading patterns [36]. As a result, orthosis during activities with high loading can significantly reduce the medial-foot loading and subsequently reduce pain [15, 37, 38].

5. Conclusion

Distal interventions can correct the faulty kinetic chain of the lower limb by correcting the foot posture. As a result, by correcting the faulty mechanics of the lower limb, the PFJ pressure force is reduced and subsequently, the pain and physical limitations are reduced. It seems that distal interventions in combination with proximal exercise have a more comprehensive effect on PFJ biomechanics. Also, distal interventions with a small effect size can have a high effect in the long term.

Study limitation

There were 3 limitations in the literature review. The low sample size examines the immediate effect of interventions, such as orthosis, and non-randomization which may affect the results. Therefore, we recommend researchers to consider these limitations in future studies.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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