

Original Article

RETRACTED ARTICLE

This article has been retracted. Please refer to the Retraction Notice published by the journal for details.

Management of Knee Pain in Osteoarthritis: A Narrative Review of Current Treatment Options

Tymoteusz Białowas, Dominika Karolak, Natalia Sara Kuśmierowska, Monika Kuś, Grzegorz Słomkowski, Kacper Cholewiński, Daria Valipur Kolti, Milena Polak, Magdalena Natalia Nowak, Konrad Wiśniewski

Medical University of Warsaw, Poland

Abstract. Knee osteoarthritis is a common and progressive musculoskeletal condition that contributes substantially to pain, functional limitation, and reduced quality of life, particularly among middle-aged and older adults. The increasing diversity of available treatments highlights the need for an integrated understanding of their roles in clinical management. This narrative review aims to synthesize current therapeutic strategies for knee pain associated with osteoarthritis and examine their position within a stepwise treatment pathway. Relevant literature published between 2010 and 2025 was identified through PubMed, Google Scholar, and ScienceDirect using keywords related to knee osteoarthritis, pain, risk factors, and treatment. The literature was synthesized across conservative, pharmacological, intra-articular, minimally invasive, and surgical approaches. The findings indicate that exercise, weight management, and lifestyle modification remain the foundation of treatment. Pharmacological therapies provide additional symptom control but may be limited by adverse effects. Platelet-rich plasma and hyaluronic acid represent additional options for persistent symptoms, while genicular artery embolization and radiofrequency-based procedures may help bridge the treatment gap between conventional management and surgery. Total knee arthroplasty remains the definitive option for advanced disease. Overall, knee osteoarthritis management should follow a multimodal, individualized, and stepwise approach according to disease severity, functional limitations, treatment response, and patient characteristics.

Keywords: Knee Osteoarthritis, Knee Pain, Treatment, Management

Corresponding author: Tymoteusz Białowas, Email: tymbial@gmail.com, University of Warsaw, Poland



This work is licensed under a CC-BY

Introduction

Knee pain is one of the most common musculoskeletal complaints encountered in clinical practice and represents an important cause of impaired mobility, functional limitation, and reduced quality of life. The burden of knee pain becomes increasingly significant with advancing age, particularly because persistent symptoms can interfere with walking, climbing stairs, occupational activities, social participation, and the ability to perform daily living activities independently. Globally, it is estimated that knee pain affects up to 654 million individuals, with osteoarthritis (OA) being the most prevalent underlying cause in individuals over 45 years of age, while younger populations are more likely to experience patellofemoral pain syndrome (Duong et al, 2023). In addition to pain, patients frequently report symptoms such as morning stiffness, joint swelling, reduced range of motion, and progressive functional limitations, all of which contribute to decreased mobility and disability (Couch et al., 2025; Hunter & Bierma-Zeinstra, 2019; Wang et al., 2017; Zhang, 2010). The broad clinical impact

of knee OA therefore extends beyond local joint symptoms, as persistent pain and declining physical function may substantially affect patients' independence, productivity, and overall well-being.

Knee osteoarthritis is a chronic and progressive joint disorder with a complex pathophysiological process that cannot be explained solely by articular cartilage degeneration. Multiple structures within the joint, including cartilage, subchondral bone, synovium, ligaments, and surrounding tissues, are involved in the disease process. The pathophysiology of knee osteoarthritis is complex and involves multiple joint structures, including cartilage, subchondral bone, synovium, and surrounding tissues. The disease process is characterized by an imbalance between cartilage synthesis and degradation, leading to the loss of type II collagen and proteoglycans under the influence of matrix-degrading enzymes. Inflammatory mediators such as interleukin-1 β , tumor necrosis factor- α , and interleukin-6 further contribute to joint degeneration and pain perception (Buhaiov & Tarabrin, 2024; Primorac et al., 2021). These biological processes are accompanied by structural changes, including osteophyte formation, synovial inflammation, subchondral bone remodeling, and progressive narrowing of the joint space. Such changes may eventually result in persistent pain, joint stiffness, impaired biomechanical function, and limitations in physical activity.

Although considerable progress has been made in understanding the biological and structural mechanisms of knee OA, the relationship between structural damage and clinical symptoms remains complex. Disease severity observed through imaging does not always correspond directly with the degree of pain and disability experienced by patients, making clinical assessment an essential component of diagnosis and treatment planning. Furthermore, early diagnosis of knee OA remains challenging due to the absence of validated objective diagnostic tools, with clinical assessment still considered the gold standard (Runhaar et al., 2021). This complexity suggests that knee OA should not be approached solely as a structural joint disorder, but rather as a multifactorial condition requiring comprehensive assessment of symptoms, physical function, disease severity, individual characteristics, and associated risk factors.

A number of modifiable and non-modifiable risk factors are associated with the development and progression of knee OA. Obesity is recognized as one of the strongest contributors, with significant associations observed between body mass index (BMI) and the severity of cartilage degeneration (Olesiak et al., 2019). Excessive body weight may increase mechanical loading across the knee joint while also contributing to metabolic and inflammatory processes that may accelerate joint degeneration. Other important risk factors include aging, female sex, previous joint injuries, and mechanical overload resulting from occupational or physical activities (Blagojevic et al., 2010). Additionally, comorbid conditions such as cardiovascular and metabolic diseases are commonly observed in patients with OA, further complicating disease management (Suri et al., 2010). The interaction among these factors creates substantial heterogeneity among patients, meaning that individuals with similar radiographic findings may differ considerably in pain intensity, functional impairment, disease progression, and response to treatment.

The multifactorial characteristics of knee OA have important implications for therapeutic management. Treatment is generally directed not only toward reducing pain but also toward improving physical function, maintaining mobility, controlling modifiable risk factors, delaying structural deterioration, and preserving quality of life. As a result, management of knee pain associated with osteoarthritis has evolved into a comprehensive and multimodal approach. Current treatment strategies generally include conservative interventions such as exercise and weight management, pharmacological therapies including analgesics and non-steroidal anti-inflammatory drugs (NSAIDs), and surgical procedures for advanced cases (Dantas et al., 2021; Primorac et al., 2021). Conservative approaches are generally preferred during the earlier stages because they are less invasive and may provide meaningful improvement in pain and function. Pharmacological treatment may subsequently be introduced when symptoms remain insufficiently controlled, whereas surgical procedures are commonly considered when severe

pain, structural deterioration, and functional impairment persist despite non-operative management.

Nevertheless, each treatment modality presents specific benefits and limitations. Lifestyle modification and structured exercise require sustained patient adherence and may produce variable responses according to disease severity and individual characteristics. Pharmacological therapies may provide symptomatic relief but are not always suitable for prolonged use, particularly among older patients or those with relevant comorbidities. Likewise, surgical management can provide substantial improvement in appropriately selected patients with advanced disease but involves greater invasiveness, recovery requirements, cost, and potential complications. Consequently, a clinically important treatment gap may occur in patients who continue to experience significant symptoms despite conservative and pharmacological treatment but are either not yet appropriate candidates for surgery, unable to undergo surgery, or prefer to delay surgical intervention.

In response to this treatment gap, considerable attention has increasingly focused on biological and minimally invasive interventions. In recent years, emerging therapies such as platelet-rich plasma (PRP), genicular artery embolization (GAE), and radiofrequency (RF) ablation have been introduced as potential alternatives or adjuncts to conventional treatments (Chlorogiannis, 2024; Gupta et al., 2025; Hong et al., 2019). PRP is intended to provide a biological approach to symptom management through intra-articular administration of autologous platelet concentrates, whereas GAE targets abnormal periarticular neovascularization through selective embolization of genicular arteries. Radiofrequency-based interventions take a different approach by targeting genicular nerves involved in pain transmission. The emergence of these interventions has expanded the therapeutic spectrum available for knee OA and potentially provides additional options between conventional non-operative treatment and definitive surgical intervention.

Recent clinical studies, however, demonstrate that evidence regarding these newer interventions is not entirely consistent. Argut et al. (2024), in a randomized clinical investigation involving patients with mild-to-moderate knee osteoarthritis, found that PRP did not provide additional improvement in pain at 24 weeks compared with exercise alone; exercise alone was also clinically superior to PRP alone for several functional and health-related quality-of-life outcomes. In contrast, another randomized study comparing PRP with hyaluronic acid reported greater improvements in pain, stiffness, and physical function among patients receiving PRP (Ghorbani et al., 2024). These contrasting findings indicate that the clinical effectiveness of PRP may depend on factors such as patient characteristics, comparator treatment, preparation protocols, administration methods, outcome measures, and duration of follow-up.

Similar uncertainty can be observed regarding minimally invasive interventional procedures. A randomized controlled trial evaluating GAE against a sham procedure in patients with mild-to-moderate knee OA found that both groups experienced pain reduction, but the study did not establish a clinically meaningful advantage of GAE over the sham intervention (Van Zadelhoff et al., 2024). Conversely, other prospective evidence has reported sustained improvements following GAE, illustrating the continuing uncertainty surrounding patient selection, procedural techniques, and the magnitude and durability of treatment effects. Radiofrequency intervention has likewise attracted growing clinical interest. A randomized study examining radiofrequency ablation of the genicular nerves demonstrated better pain relief, improved functional outcomes, and increased muscle strength during follow-up among patients with chronic osteoarthritis-related knee pain (Makkar et al., 2024). Taken together, these findings demonstrate that emerging therapies may offer clinically relevant benefits, but the evidence remains heterogeneous across interventions and studies.

The diversity of available treatments and the inconsistent findings reported for several newer interventions create an increasingly complex clinical decision-making environment. Management decisions cannot be based solely on whether an intervention has demonstrated efficacy in an individual study. Clinicians must also consider disease severity, patient age,

comorbidities, previous treatment response, safety, duration of therapeutic benefit, invasiveness, functional goals, and the appropriate timing of escalation from one intervention to another. This is particularly important because treatment decisions for knee OA are generally sequential rather than isolated; a patient may move from lifestyle intervention and exercise to medication, intra-articular treatment, minimally invasive procedures, and eventually surgery as symptoms and functional impairment progress.

However, despite the wide range of available therapeutic options, there is still no clear consensus regarding the most effective treatment strategy, particularly in terms of long-term outcomes and optimal sequencing of interventions. Many studies tend to focus on individual therapies rather than providing an integrated perspective, resulting in limited synthesis of evidence across different treatment modalities. This highlights a gap in the literature regarding a comprehensive understanding of current therapeutic approaches for knee osteoarthritis. The increasing introduction of biological and minimally invasive procedures has further widened this gap because newer treatment options must now be considered alongside established conservative, pharmacological, and surgical approaches.

More specifically, existing evidence is fragmented across different categories of treatment (Dantas et al., 2021; Duong et al., 2023). Studies examining exercise or weight reduction generally focus on conservative outcomes (Dantas et al., 2021; Gibbs et al., 2023), pharmacological studies evaluate individual medications or injections (Cooper, 2019; Da Costa, 2021; Gupta et al., 2025; Primorac et al., 2021), and interventional research often examines a specific procedure such as PRP, GAE, or RF therapy (Chlorogiannis, 2024; Epelboym, 2023; Hong et al., 2019; Oeding et al., 2024). Although such studies provide valuable evidence regarding individual interventions, they do not necessarily clarify how these treatments should be positioned relative to one another within the overall clinical management pathway (Duong et al., 2023; Gibbs et al., 2023). Furthermore, differences in study populations, disease severity, intervention protocols, comparators, follow-up periods, and outcome measures make direct interpretation across treatment modalities difficult (Hong et al., 2019; Epelboym et al., 2023; Chlorogiannis et al., 2024; Gupta et al., 2025). The contrasting findings observed in recent studies of PRP and GAE further demonstrate that the availability of newer therapies does not automatically translate into a clearly defined treatment algorithm (Chlorogiannis et al., 2024; Oeding et al., 2024).

Therefore, the research gap addressed in this review lies not merely in the availability of evidence regarding individual treatments, but in the limited integration of conservative, pharmacological, regenerative, minimally invasive, and surgical approaches into a coherent understanding of contemporary knee OA management. There remains a need to synthesize the therapeutic continuum and critically consider where established and emerging treatments may be positioned within a stepwise management strategy. Such synthesis is particularly relevant in identifying which interventions constitute foundational management, which may serve as adjunctive or transitional options, and which are most appropriately reserved for advanced disease.

The novelty of this narrative review lies in its integrated examination of both established and emerging therapeutic modalities within a single clinical management continuum. Rather than evaluating conservative treatment, medications, intra-articular approaches, minimally invasive interventions, and surgery as independent therapeutic categories, this review places these strategies within a stepwise framework ranging from risk-factor modification and non-invasive treatment to advanced intervention. Particular attention is given to the evolving role of PRP, GAE, and RF therapies as potential options within the therapeutic gap between conventional conservative management and surgical intervention. By incorporating these newer modalities alongside established treatments, the review seeks to provide a more clinically applicable perspective on contemporary management of knee OA.

The urgency of this review is supported by the high burden and progressive nature of knee OA, the diversity of patient characteristics and therapeutic responses, and the rapid expansion

of available treatment options. Without an integrated understanding of the relative roles, benefits, limitations, and appropriate positioning of these treatments, increasing therapeutic choice may create greater uncertainty rather than improving clinical decision-making. A comprehensive synthesis is therefore needed to assist clinicians in understanding the current therapeutic landscape, to support rational and patient-centered treatment escalation, and to identify areas in which evidence remains inconsistent or insufficient. Such understanding may also help direct future research toward comparative effectiveness, long-term outcomes, appropriate patient selection, and the development of more personalized treatment pathways.

Therefore, this study aims to review and synthesize current therapeutic strategies for the management of knee pain associated with osteoarthritis, focusing on conservative, pharmacological, and surgical interventions, as well as emerging treatment modalities. By integrating evidence across these different therapeutic approaches, this narrative review seeks to provide a comprehensive overview of current management options, clarify their potential position within a stepwise treatment pathway, and identify important areas requiring further investigation.

Method

This study employed a narrative review approach to provide a comprehensive overview of current knowledge and therapeutic strategies for the management of knee pain associated with osteoarthritis. The narrative review design was selected because the study aimed to integrate and discuss evidence from different types of literature and therapeutic perspectives rather than to answer a narrowly defined clinical question through a systematic review or meta-analysis. The review focused on several key aspects relevant to knee osteoarthritis, including epidemiology, pathophysiology, risk factors, conservative management, pharmacological treatment, minimally invasive interventions, and surgical approaches.

The review was intended to provide a broad clinical perspective on the management of knee osteoarthritis by integrating established therapeutic approaches with more recent treatment developments. Particular attention was given to the progression of treatment from non-invasive and conservative strategies toward pharmacological, interventional, and surgical options, as well as to emerging therapies that may potentially bridge the gap between conventional treatment and surgery.

Literature Search Strategy

Relevant literature was identified through searches of three electronic databases: PubMed, Google Scholar, and Science Direct. These databases were selected because they provide broad coverage of medical, biomedical, and clinical research relevant to osteoarthritis and musculoskeletal disorders.

The primary search strategy used combinations of keywords and Boolean operators related to the condition and its management, including: (“knee pain” OR “knee osteoarthritis”) AND (“treatment” OR “therapy” OR “management”) Additional terms were used to identify literature addressing specific aspects of knee osteoarthritis, including “pathophysiology,” “risk factors,” “rehabilitation,” “exercise,” “weight management,” “non-steroidal anti-inflammatory drugs,” “NSAIDs,” “intra-articular injection,” “platelet-rich plasma,” “hyaluronic acid,” “genicular artery embolization,” “radiofrequency,” “radiofrequency ablation,” and “total knee arthroplasty.”

The search terms were used individually and in combination to obtain literature addressing both the general management of knee osteoarthritis and specific therapeutic modalities. Because this study was designed as a narrative review, the literature search was intended to identify

relevant and representative evidence across the major areas of knee OA management rather than to conduct an exhaustive systematic search of all available publications.

Publication Period

Articles published between 2010 and 2025 were considered in this review. This period was selected to incorporate both established evidence that has contributed to current understanding of knee osteoarthritis and more recent studies reflecting developments in therapeutic management.

Eligibility and Exclusion Criteria

Articles were considered eligible when they met the following criteria: it is published in English, available in full text, published in peer-reviewed scientific literature, focused on knee OA or associated with osteoarthritis or knee osteoarthritis, discussed epidemiology, pathophysiology, risk factors, clinical characteristics, or therapeutic management relevant to knee OA, and provided information relevant to conservative, pharmacological, interventional, or surgical treatment approaches.

Different types of peer-reviewed scientific evidence were considered where relevant to the objectives of the review, including original clinical studies, randomized clinical trials, observational studies, reviews, systematic reviews, meta-analyses, and other clinical literature that contributed to the understanding of current knee OA management.

Studies were excluded when they primarily addressed knee pain unrelated to osteoarthritis, focused predominantly on osteoarthritis affecting joints other than the knee, did not provide information relevant to the clinical management of knee OA, were not available in English or full text, or were not published as peer-reviewed scientific articles. Publications with insufficient relevance to the scope and objectives of the review were also excluded.

Literature Selection

The selection of literature was based primarily on its relevance to the objectives and thematic scope of the review. Titles and abstracts of potentially relevant publications were examined to determine whether the articles addressed knee osteoarthritis and contributed meaningful information regarding the clinical condition or its management. Full-text articles were subsequently considered when their content was directly relevant to one or more areas covered in this review. Greater emphasis was given to studies that contributed to understanding the clinical effectiveness, potential benefits, limitations, and emerging developments associated with different treatment modalities. Literature representing both established treatments and newer therapeutic approaches was included to provide a balanced perspective on the evolving management of knee osteoarthritis.

Data Analysis

A total of 28 articles that met the scope and relevance criteria were included in the narrative review. The included literature was reviewed descriptively and organized according to major themes related to knee osteoarthritis. The evidence was grouped into the following domains: epidemiology and clinical characteristics, pathophysiology, risk factors, conservative management, pharmacological treatment, intra-articular and regenerative therapies, minimally invasive interventions, and surgical management.

For therapeutic management, the evidence was further interpreted according to the position of each intervention within the clinical management pathway. Conservative approaches, including exercise, rehabilitation, weight management, and lifestyle modification, were

considered in relation to their role as foundational treatment. Pharmacological therapies were reviewed with attention to symptom control, effectiveness, and potential limitations associated with prolonged use.

Intra-articular and emerging therapies, including platelet-rich plasma (PRP) and hyaluronic acid (HA), were considered with respect to their potential role in patients with persistent symptoms. Minimally invasive interventions, particularly genicular artery embolization (GAE) and radiofrequency (RF) therapy, were reviewed as developing treatment options that may potentially occupy an intermediate position between conventional non-surgical management and definitive surgical intervention. Surgical management, particularly total knee arthroplasty (TKA), was considered in the context of advanced disease and persistent functional impairment. The findings from the included literature were synthesized narratively by identifying common patterns, differences in reported outcomes, clinical advantages and limitations, and emerging trends across different therapeutic modalities. Particular attention was given to areas in which findings were consistent across the literature as well as areas where evidence remained variable or inconclusive. This approach enabled the review to examine not only individual treatment modalities but also their potential relationship within a multimodal and stepwise approach to the management of knee osteoarthritis.

Results and Discussions

Result

The findings of this review indicate that knee osteoarthritis is a highly prevalent condition affecting a large global population, particularly among individuals over 45 years of age (Duong et al., 2023). Epidemiological evidence further demonstrates that the burden of knee osteoarthritis increases substantially with age and is influenced by demographic, metabolic, and mechanical factors. A large systematic analysis of population-based studies estimated a global prevalence of approximately 16% among individuals aged 15 years and older and 22.9% among those aged 40 years and older, highlighting the substantial public health burden associated with the condition (Cui et al., 2020). The condition is characterized by symptoms such as joint pain, stiffness, swelling, and reduced range of motion, which significantly impact functional ability and quality of life (Couch, 2025; Hunter & Bierma-Zeinstra, 2019; Wang, 2017; Zhang, 2010). These symptoms may progressively restrict walking, stair climbing, occupational activities, and other activities of daily living, thereby increasing disability and dependence among affected individuals.

The analysis of the selected studies demonstrates that the pathophysiology of knee osteoarthritis is multifactorial, involving cartilage degradation, inflammatory processes, and structural joint changes (Buhaiov & Tarabrin, 2024; Primorac et al., 2021). Rather than being considered solely a consequence of mechanical cartilage wear, current evidence increasingly recognizes knee osteoarthritis as a whole-joint disease involving articular cartilage, subchondral bone, synovium, menisci, ligaments, and periarticular structures. This complexity may partly explain why structural abnormalities observed on imaging do not always correspond directly with the severity of pain experienced by patients. Risk factors such as obesity, aging, previous joint injury, and mechanical overload were consistently identified as major contributors to disease development and progression (Blagojevic, 2010; Olesiak et al., 2019; Cui et al., 2020). Consequently, treatment decisions should not rely exclusively on radiographic findings but should also consider symptoms, functional limitations, comorbidities, physical activity, and individual patient characteristics.

Based on the reviewed literature, therapeutic strategies for knee osteoarthritis can be categorized into three main approaches: conservative management, pharmacological treatment,

and surgical or interventional procedures. Conservative management was identified as the first-line treatment, with strong evidence supporting the effectiveness of physical exercise and weight reduction in improving pain and functional outcomes (Dantas et al., 2021; Tudaj et al., 2025). This finding is consistent with international clinical recommendations that place exercise, patient education, and weight management at the foundation of knee osteoarthritis treatment (Bannuru et al., 2019; Gibbs et al., 2023; Kolasinski et al., 2020). Importantly, conservative management should not be regarded merely as an intervention offered before medication or surgery but rather as a continuing component of disease management throughout the clinical course.

Physical exercise may improve muscle strength, joint stability, mobility, and physical function without requiring structural restoration of damaged cartilage. Exercise interventions may include strengthening exercises, aerobic exercise, neuromuscular training, aquatic exercise, or combinations of these approaches. The selection of exercise should therefore be individualized according to functional capacity, disease severity, comorbidities, and patient preference. International guidelines generally support continued exercise because its benefits extend beyond pain reduction to improvements in mobility, physical independence, and overall health (Bannuru et al., 2019; Gibbs et al., 2023). Nevertheless, adherence remains an important consideration because the effectiveness of exercise in routine clinical practice depends greatly on sustained patient participation.

Weight management appears particularly important for patients with knee osteoarthritis who are overweight or obese. Excess body weight not only increases mechanical loading across the knee joint but may also contribute to systemic inflammatory processes associated with osteoarthritis progression. Evidence from the IDEA randomized clinical trial demonstrated that intensive dietary weight loss combined with exercise could reduce knee joint loading and inflammatory markers while improving clinical outcomes in overweight and obese adults with knee osteoarthritis (Messier et al., 2013). These findings reinforce the importance of integrating dietary modification and physical activity rather than viewing weight reduction as an isolated intervention. Most studies emphasize that lifestyle modification plays a critical role in delaying disease progression and reducing the need for invasive interventions.

The consistency of these findings with clinical practice guidelines is important. OARSI recommendations emphasize individualized treatment based on disease characteristics and comorbidities, while the American College of Rheumatology/Arthritis Foundation guideline strongly supports several non-pharmacological strategies, including exercise and weight reduction among overweight or obese patients (Bannuru et al., 2019; Kolasinski et al., 2020). Similarly, a systematic review of clinical practice guidelines showed that exercise, education, and weight management are among the most consistently recommended approaches across high-quality guidelines (Gibbs et al., 2023). This consistency suggests that non-pharmacological management represents the most established component of knee osteoarthritis care despite continuing uncertainty regarding several pharmacological and interventional options.

Pharmacological treatment represents the second-line approach. Non-steroidal anti-inflammatory drugs (NSAIDs) were found to be effective in pain reduction; however, their long-term use is limited due to significant gastrointestinal, cardiovascular, and renal risks (Cooper, 2019; Da Costa, 2021). Therefore, medication selection should consider age, cardiovascular status, renal function, gastrointestinal risk, and concurrent medications. Current recommendations generally emphasize that pharmacological therapies should complement rather than replace exercise, education, and weight management (Bannuru et al., 2019; Bruyère et al., 2019). This is particularly relevant because pharmacological treatment primarily targets symptoms and does not consistently modify the underlying structural progression of osteoarthritis.

In contrast, acetaminophen demonstrated limited clinical effectiveness (Primorac et al., 2021). This finding illustrates an important shift in knee osteoarthritis management, in which treatments traditionally considered relatively safe are increasingly evaluated according to their

actual magnitude of clinical benefit rather than historical prescribing practices. The variation in recommendations between different clinical guidelines also indicates that pharmacological management should be individualized rather than applied through a single standardized medication sequence (Kolasinski et al., 2020; Gibbs et al., 2023).

Emerging therapies, particularly intra-articular injections such as platelet-rich plasma (PRP) and hyaluronic acid (HA), showed promising results, with several studies indicating superior long-term outcomes compared to conventional treatments (Gupta et al., 2025). However, evidence across injection therapies remains heterogeneous. A large systematic review and meta-analysis examining visco supplementation reported only a small reduction in pain compared with placebo, with the magnitude of benefit falling below the prespecified threshold for a clinically important difference (Pereira et al., 2022). Conversely, more recent comparative evidence suggests that PRP may provide greater medium- and long-term improvements in pain and function than corticosteroid or HA injections in selected patients (Bensa et al., 2024). These contrasting findings indicate that intra-articular therapies should not be considered equivalent and that treatment effectiveness may depend on the injected substance, patient selection, disease severity, preparation technique, and duration of follow-up.

The variability in injection outcomes is clinically important because it highlights one of the principal limitations in the existing knee osteoarthritis literature. Differences in PRP preparation, platelet concentration, leukocyte content, number of injections, injection intervals, comparator treatments, and outcome assessment make direct comparison across studies challenging. Therefore, although regenerative and injectable therapies have expanded the therapeutic options available to patients, uncertainty remains regarding optimal patient selection and their precise position within the overall treatment pathway.

Surgical and interventional approaches are generally reserved for advanced stages of the disease. Total knee arthroplasty (TKA) remains the gold standard, providing substantial pain relief and functional improvement (Alzarooni, 2025). Randomized evidence has demonstrated that total knee replacement followed by structured non-surgical treatment can produce greater improvements in pain and function than non-surgical treatment alone among appropriately selected patients with advanced knee osteoarthritis (Skou et al., 2015). However, surgical treatment is also associated with perioperative risks and should therefore be considered after careful assessment of symptom severity, functional impairment, failure of appropriate non-operative treatment, patient expectations, and medical suitability.

The effectiveness of TKA also reinforces the importance of appropriate timing. Surgery performed too early may expose patients to avoidable procedural risks, whereas excessive delay in patients with severe pain and disability may prolong functional impairment and reduce quality of life. Therefore, the transition from non-operative management to arthroplasty should be based on the overall clinical condition rather than radiographic severity alone. This supports a shared decision-making model in which the expected benefits and risks of surgery are balanced against patient preferences and previous responses to conservative treatment.

Additionally, newer minimally invasive techniques, such as genicular artery embolization (GAE) and radiofrequency (RF) therapy, have demonstrated significant effectiveness in pain reduction and functional improvement (Chlorogiannis, 2024; Epelboym, 2023; Hong et al., 2019). These procedures may offer an intermediate therapeutic option for patients who continue to experience clinically significant pain despite conservative or pharmacological treatment but who are not yet candidates for, are medically unsuitable for, or prefer to delay arthroplasty. Recent randomized evidence has further demonstrated that cooled radiofrequency ablation of the genicular nerves can provide significantly greater pain relief than a sham procedure in patients with chronic knee osteoarthritis pain (Kwon et al., 2024). Nevertheless, the durability of these effects and the optimal patient selection criteria require further investigation.

Importantly, the growing availability of minimally invasive interventions should not be interpreted as evidence that every newer procedure should automatically be incorporated into routine treatment. The strength of evidence varies between modalities, and outcomes may be

influenced by patient selection, disease severity, procedural techniques, operator experience, and follow-up duration. This is particularly relevant for GAE and RF therapy, where encouraging pain outcomes need to be interpreted alongside the comparatively smaller evidence base relative to established conservative and pharmacological interventions.

More specifically, existing evidence is fragmented across different categories of treatment. Studies examining exercise or weight reduction generally focus on conservative outcomes (Messier et al., 2013; Gibbs et al., 2023), pharmacological studies evaluate individual medications or injections (Pereira et al., 2022; Bensa et al., 2024), and interventional research often examines a specific procedure such as PRP, GAE, or RF therapy (Kwon et al., 2024). Although such studies provide valuable evidence regarding individual interventions, they do not necessarily clarify how these treatments should be positioned relative to one another within the overall clinical management pathway. Furthermore, differences in study populations, disease severity, intervention protocols, comparators, follow-up periods, and outcome measures make direct interpretation across treatment modalities difficult. The contrasting findings observed in recent studies of PRP and GAE further demonstrate that the availability of newer therapies does not automatically translate into a clearly defined treatment algorithm.

This fragmentation explains why a stepwise treatment framework remains clinically relevant. The reviewed evidence suggests that management should begin with interventions that have favorable benefit-risk profiles, particularly patient education, exercise, and weight management, before progressing to pharmacological strategies based on individual symptoms and comorbidities (Bannuru et al., 2019; Bruyère et al., 2019; Kolasinski et al., 2020). Intra-articular and minimally invasive interventions may subsequently be considered when symptoms remain inadequately controlled, whereas TKA remains an important option for advanced disease associated with persistent pain and major functional limitation (Skou et al., 2015).

Overall, the findings suggest that a multimodal and stepwise approach is essential in the management of knee osteoarthritis, integrating conservative, pharmacological, and interventional strategies to optimize patient outcomes. Importantly, the evidence does not support a one-size-fits-all approach. Clinical management should instead be individualized according to symptom severity, structural disease, age, obesity, comorbidities, functional limitations, previous treatment response, and patient preferences. The convergence of international recommendations around exercise, education, and weight management provides a strong foundation for treatment, while continuing differences regarding medications, injections, and emerging interventions demonstrate the need for individualized clinical decision-making (Bannuru et al., 2019; Kolasinski et al., 2020; Gibbs et al., 2023).

Taken together, these findings suggest that the principal challenge in knee osteoarthritis management is no longer simply the availability of therapeutic options, but determining the most appropriate sequence and combination of interventions for individual patients. Future studies should therefore move beyond evaluating therapies in isolation and directly compare treatment strategies across different disease stages. Standardization of outcome measures, intervention protocols, patient selection criteria, and longer follow-up periods would also improve comparisons between therapeutic modalities. Such evidence would support the development of more precise and clinically applicable treatment algorithms capable of guiding progression from conservative management to pharmacological, minimally invasive, and ultimately surgical intervention when required.

Discussion

The findings of this review demonstrate that knee osteoarthritis (OA) represents a complex clinical condition in which disease burden cannot be understood solely from the presence of structural joint abnormalities. Its high prevalence, particularly among older adults, and its substantial effects on mobility, physical functioning, and quality of life indicate that knee OA should be considered not only as a degenerative musculoskeletal disorder but also as an

important long-term health condition requiring sustained clinical management. The high global burden of knee pain, affecting hundreds of millions of individuals, further emphasizes the need for treatment strategies that are both effective and sustainable over time (Duong et al., 2023). The clinical manifestations of OA, including pain, stiffness, swelling, and functional limitation, also demonstrate that its impact extends beyond structural joint degeneration and directly influences patients' ability to perform daily activities and maintain independence (Wang, 2017; Zhang, 2010).

The multifactorial nature of knee OA provides an important basis for understanding why a single therapeutic modality is unlikely to be sufficient for all patients. From a pathophysiological perspective, knee osteoarthritis involves a progressive imbalance between cartilage degradation and repair mechanisms, driven by mechanical stress and inflammatory mediators (Buhaiov & Tarabrin, 2024; Primorac et al., 2020). Importantly, the relationship between structural abnormalities and clinical symptoms is not always straightforward. Previous studies have highlighted the inconsistency between radiographic findings and patient-reported pain, suggesting that pain perception in OA is not solely determined by structural damage but also influenced by neurovascular and biochemical factors (Buhaiov & Tarabrin, 2024). This discrepancy has important therapeutic implications because treatment decisions based only on structural severity may not adequately represent the patient's clinical experience. Consequently, effective management should consider pain severity, physical function, individual risk factors, comorbidities, and treatment response rather than relying exclusively on anatomical changes.

This multidimensional perspective is also supported by the contribution of several modifiable and non-modifiable risk factors to the development and progression of knee OA. Risk factors such as obesity, aging, and previous joint injury play a critical role in both the onset and progression of OA (Blagojevic et al., 2010; Olesiak et al., 2019). Among these factors, obesity is particularly important because it represents a potentially modifiable target of treatment. Excess body weight may contribute to disease progression not only through increased mechanical loading of the knee joint but also through systemic inflammatory mechanisms. This relationship provides a strong rationale for incorporating weight management and lifestyle modification into the therapeutic pathway rather than considering them merely as supplementary recommendations. In this context, the management of knee OA should begin with modification of factors that may contribute to symptom persistence and disease progression whenever these factors can be addressed clinically.

Consistent with this perspective, the findings of this review support conservative management as the foundation of knee OA treatment. Physical exercise and weight reduction have consistently demonstrated beneficial effects on pain and functional outcomes (Dantas et al., 2021; Tudaj et al., 2025). Their importance extends beyond short-term symptom relief because these approaches can simultaneously address physical function, mobility, muscle performance, and modifiable mechanical risk factors. Conservative treatment therefore should not be interpreted simply as a preliminary stage before medication or invasive intervention. Rather, it represents a central component of long-term OA management that may continue alongside subsequent therapeutic modalities. Early implementation is particularly relevant because waiting until substantial functional deterioration has occurred may reduce opportunities to maintain mobility and prevent progressive deconditioning. These findings therefore support a proactive model of management in which non-pharmacological interventions are introduced early and maintained throughout the course of treatment whenever clinically appropriate.

However, conservative treatment does not provide sufficient symptom control for every patient, creating the need for additional pharmacological management. Non-steroidal anti-inflammatory drugs (NSAIDs) remain among the most effective pharmacological options for pain relief, but their therapeutic value must be balanced against the risks associated with prolonged use, including gastrointestinal, cardiovascular, and renal complications (Da Costa, 2021). This creates an important clinical dilemma: medications capable of providing meaningful symptom reduction may not always be appropriate for continuous or long-term use, particularly

in older adults or patients with multiple comorbidities. In contrast, acetaminophen has demonstrated only minimal clinical benefit, which raises questions regarding its effectiveness as a principal analgesic strategy for knee OA (Primorac et al., 2021). Furthermore, the limited effectiveness and potential risks associated with opioid therapy reduce its suitability as a routine approach to chronic OA-related pain (Osani et al., 2021). Taken together, these findings indicate that pharmacological therapy is best considered as one component of a broader treatment strategy rather than as an isolated long-term solution.

The limitations of conventional pharmacological approaches have contributed to increasing interest in intra-articular and regenerative therapies. Platelet-rich plasma (PRP) and hyaluronic acid (HA) have emerged as potential options for patients whose symptoms remain inadequately controlled through conservative management and conventional medication. Evidence suggesting favorable longer-term outcomes compared with corticosteroid treatment has increased clinical interest in these interventions (Gupta et al., 2025). Their potential importance lies not only in symptom reduction but also in their possible role within the therapeutic interval between non-invasive management and more invasive procedures. Nevertheless, these therapies should not automatically be interpreted as replacements for foundational conservative treatment. Instead, they may be more appropriately positioned as adjunctive or transitional interventions for selected patients, particularly when conventional strategies do not achieve adequate clinical improvement. This positioning highlights the concept of a “treatment gap” in knee OA, referring to patients who remain symptomatic despite conservative and pharmacological treatment but who are not yet appropriate candidates for definitive surgery.

The existence of this treatment gap is particularly important because not all patients with persistent symptoms are immediately suitable for surgical intervention. Total knee arthroplasty (TKA) remains the definitive treatment for advanced knee osteoarthritis and is widely recognized as the gold standard for patients with severe disease (Alzarooni, 2025). Its effectiveness in reducing pain and restoring function supports its continued role in end-stage OA. However, the decision to proceed with arthroplasty must consider several factors, including disease severity, functional impairment, patient expectations, comorbidities, surgical risk, recovery requirements, and the response to previous treatment. In addition, cost, postoperative rehabilitation, recovery time, and potential complications limit the appropriateness of surgery as an early therapeutic option. Consequently, optimizing non-surgical treatment remains clinically important, particularly for patients who wish to delay surgery, are medically unsuitable for operative treatment, or have symptoms that are substantial but not yet sufficient to justify arthroplasty.

Within this context, minimally invasive interventional techniques have become increasingly relevant. Genicular artery embolization (GAE) and radiofrequency (RF) ablation have demonstrated effectiveness in reducing pain and improving function in patients with knee OA (Chlorogiannis, 2024; Epelboym, 2023; Hong et al., 2019; Zhang et al., 2023). These approaches differ fundamentally from conventional pharmacological therapies because they target specific mechanisms involved in pain generation or transmission. Their clinical relevance is therefore particularly apparent among patients who continue to experience pain despite conservative and pharmacological approaches but are not ready for, or cannot undergo, surgical treatment. Rather than replacing conventional management or TKA, these interventions may occupy an intermediate position within the therapeutic pathway. This evolving position supports a broader shift away from a simple conservative-versus-surgical model toward a more graduated continuum of therapeutic options.

When the different treatment modalities are considered collectively, the findings of this review indicate that knee OA management is better conceptualized as a stepwise therapeutic continuum rather than a choice between isolated interventions. At the initial stage, treatment should emphasize risk-factor modification, physical exercise, weight management, and other conservative strategies aimed at improving function and reducing symptoms. Pharmacological treatment may then be incorporated when additional symptom control is required. For patients

with persistent symptoms, intra-articular or regenerative therapies may provide additional therapeutic options, followed in selected cases by minimally invasive interventions such as GAE or RF. Surgical management, particularly TKA, remains an important definitive option when disease reaches an advanced stage and previous management is no longer sufficient to maintain acceptable pain control and physical function.

Importantly, this sequence should not be interpreted as a rigid algorithm that applies identically to all patients. The heterogeneity of knee OA means that treatment escalation should depend on individual characteristics, including symptom severity, functional limitations, radiographic and clinical findings, comorbid conditions, previous treatment response, age, lifestyle, and patient preferences. Some patients may obtain adequate long-term control through conservative management alone, whereas others may require earlier pharmacological or interventional treatment. Similarly, an intervention that is appropriate for one patient may provide limited benefit or carry unacceptable risks for another. This reinforces the need for personalized clinical decision-making in which therapeutic choices are based on the balance between expected benefit, treatment burden, safety, invasiveness, and individual goals.

The findings also highlight the importance of avoiding an exclusively symptom-oriented approach to knee OA management. Pain reduction remains an important therapeutic goal, but successful management should additionally consider physical function, mobility, participation in daily activities, quality of life, and the ability to delay or avoid unnecessary invasive procedures. From this perspective, the effectiveness of treatment should not be evaluated solely according to short-term changes in pain intensity. Long-term functional outcomes, treatment durability, safety, patient satisfaction, and the possibility of maintaining independence should also be incorporated into clinical evaluation and future research.

Overall, the evidence reviewed in this study supports a comprehensive, multimodal, and individualized approach to knee osteoarthritis management. Conservative management remains the therapeutic foundation, pharmacological therapy provides additional symptom control, regenerative and minimally invasive interventions may help address the treatment gap, and surgical intervention retains an essential role for advanced disease. The value of these approaches lies not in identifying a single treatment that is universally superior, but in determining how different therapeutic modalities can be appropriately integrated according to disease severity and individual patient needs.

Future research should therefore move beyond the evaluation of isolated interventions and place greater emphasis on direct comparisons between therapeutic modalities, long-term clinical outcomes, optimal timing of treatment escalation, and appropriate patient selection. Further investigation is also required to clarify the long-term role of newer interventions and determine how they can best be incorporated into existing treatment pathways. The development of personalized treatment algorithms integrating clinical characteristics, functional outcomes, risk profiles, and patient preferences may ultimately provide a more effective framework for clinical decision-making in knee osteoarthritis.

Conclusions

The management of knee pain associated with osteoarthritis requires a comprehensive, multimodal, and individualized approach because no single therapeutic strategy is suitable for all patients. The findings of this narrative review indicate that conservative management, particularly physical exercise, weight management, and lifestyle modification, should remain the foundation of treatment. Pharmacological therapy can provide additional symptom control, although its use must be balanced against potential adverse effects and limitations in long-term effectiveness.

For patients with persistent symptoms despite conventional treatment, intra-articular and regenerative therapies may provide additional therapeutic options. Minimally invasive interventions, including genicular artery embolization and radiofrequency-based procedures, may also have an important role in addressing the treatment gap between conservative management and definitive surgery. Meanwhile, total knee arthroplasty remains an essential treatment option for patients with advanced disease, severe pain, and substantial functional impairment when non-surgical approaches are no longer sufficient.

Overall, the current evidence supports a stepwise therapeutic continuum in which treatment should be progressively adjusted according to disease severity, symptom burden, functional limitations, comorbidities, previous treatment response, and patient preferences. The clinical value of knee osteoarthritis management therefore lies not in identifying a universally superior intervention, but in selecting and combining therapeutic modalities that are most appropriate for each patient.

Further research is needed to clarify the long-term effectiveness and comparative benefits of established and emerging therapies, determine the optimal timing of treatment escalation, and identify patients who are most likely to benefit from specific interventions. The development of evidence-based and personalized treatment pathways may ultimately improve clinical decision-making, functional outcomes, and quality of life among individuals with knee osteoarthritis.

References

- Alzarooni, A. (2025). Operative Considerations in Total Knee Arthroplasty. Cureus.
- Argut, S. K., Celik, D., Ergin, O. N., & Kilicoglu, O. I. (2024). Does the Combination of Platelet-rich Plasma and Supervised Exercise Yield Better Pain Relief and Enhanced Function in Knee Osteoarthritis? A Randomized Controlled Trial. *Clinical Orthopaedics and Related Research*, 482(6), 1051–1061. <https://doi.org/10.1097/CORR.0000000000002993>
- Bannuru, R. R., Osani, M. C., Vaysbrot, E. E., Arden, N. K., Bennell, K., Bierma-Zeinstra, S. M. A., Kraus, V. B., Lohmander, L. S., Abbott, J. H., Bhandari, M., Blanco, F. J., Espinosa, R., Haugen, I. K., Lin, J., Mandl, L. A., Moilanen, E., Nakamura, N., Snyder-Mackler, L., Trojjan, T., ... McAlindon, T. E. (2019). OARSI guidelines for the non-surgical management of knee, hip, and polyarticular osteoarthritis. *Osteoarthritis and Cartilage*, 27(11), 1578–1589. <https://doi.org/10.1016/j.joca.2019.06.011>
- Bensa, A., Sangiorgio, A., Boffa, A., Salerno, M., Moraca, G., & Filardo, G. (2024). Corticosteroid injections for knee osteoarthritis offer clinical benefits similar to hyaluronic acid and lower than platelet-rich plasma: a systematic review and meta-analysis. *EFORT Open Reviews*, 9(9), 883–895. <https://doi.org/10.1530/EOR-23-0198>
- Blagojevic, M., Jinks, C., Jeffery, A., & Jordan, K. P. (2010). Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. *Osteoarthritis and Cartilage*, 18(1), 24–33. <https://doi.org/10.1016/j.joca.2009.08.010>
- Bruyère, O., Honvo, G., Veronese, N., Arden, N. K., Branco, J., Curtis, E. M., Al-Daghri, N. M., Herrero-Beaumont, G., Martel-Pelletier, J., Pelletier, J. P., Rannou, F., Rizzoli, R., Roth, R., Uebelhart, D., Cooper, C., & Reginster, J. Y. (2019). An updated algorithm recommendation for the management of knee osteoarthritis from the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis and Musculoskeletal Diseases (ESCEO). *Seminars in Arthritis and Rheumatism*, 49(3), 337–350. <https://doi.org/10.1016/j.semarthrit.2019.04.008>
- Buhaiov, O., & Tarabrin, O. (2024). Modern view of mechanisms of chronic pain syndrome in patients with knee joint damage. *Journal of Education, Health and Sport*, 53, 242–255. <https://apcz.umk.pl/JEHS/article/view/51752>

- Chlorogiannis, D. D. (2024). *Knee pain improvement after genicular artery embolization*. Radiologie.
- Cooper, C. (2019). *Safety of Oral Non-Selective NSAIDs in Osteoarthritis*. Drugs & Aging.
- Couch, J. L., King, M. G., De Oliveira Silva, D., Whittaker, J. L., Bruder, A. M., Serighelli, F., Kaplan, S., & Culvenor, A. G. (2025). Noisy knees - knee crepitus prevalence and association with structural pathology: a systematic review and meta-analysis. *British Journal of Sports Medicine*, 59(2), 126–132. <https://doi.org/10.1136/bjsports-2024-108866>
- Cui, A., Li, H., Wang, D., Zhong, J., Chen, Y., & Lu, H. (2020). Global, regional prevalence, incidence and risk factors of knee osteoarthritis in population-based studies. *EClinicalMedicine*, 29–30. <https://doi.org/10.1016/j.eclinm.2020.100587>
- Da Costa, B. R. (2021). *Effectiveness and safety of NSAIDs and opioid treatment*. BMJ.
- Dantas, L. O., Salvini, T. de F., & McAlindon, T. E. (2021). Knee osteoarthritis: Key treatments and implications for physical therapy. *Brazilian Journal of Physical Therapy*, 25(2), 135–146. <https://doi.org/10.1016/j.bjpt.2020.08.004>
- Duong W.M., Ding, C., Culvenor, A.G., Hunter, D.J. V. O. (2023). Evaluation and treatment of knee pain: A review. *JAMA*. <https://doi.org/10.1001/jama.2023.19675>
- Epelboym, Y., Mandell, J. C., Collins, J. E., Burch, E., Shiang, T., Killoran, T., Macfarlane, L., & Guermazi, A. (2023). Genicular artery embolization as a treatment for osteoarthritis related knee pain: A systematic review and meta-analysis. *CardioVascular and Interventional Radiology*, 46(6), 760–769. <https://doi.org/10.1007/s00270-023-03422-0>
- Ghorbani, O., Mahdibarzi, D., & Yousefi-Toodeshki, P. (2024). Comparison of the short-term effect of intra-articular hyaluronic acid and platelet-rich plasma injections in knee osteoarthritis: a randomized clinical trial. *Journal of Preventive Medicine and Hygiene*, 65(2), E214–E220. <https://doi.org/10.15167/2421-4248/jpmh2024.65.2.3270>
- Gibbs, A. J., Gray, B., Wallis, J. A., Taylor, N. F., Kemp, J. L., Hunter, D. J., & Barton, C. J. (2023). Recommendations for the management of hip and knee osteoarthritis: A systematic review of clinical practice guidelines. *Osteoarthritis and Cartilage*, 31(10), 1280–1292. <https://doi.org/10.1016/j.joca.2023.05.015>
- Gupta, N., Khatri, K., Lakhani, A., Dahuja, A., Randhawa, A., Bansal, V., & Bansal, K. (2025). Long-term effectiveness of intra-articular injectables in patients with knee osteoarthritis: A systematic review and Bayesian network meta-analysis. *Journal of Orthopaedic Surgery and Research*, 20, 227. <https://doi.org/10.1186/s13018-025-05574-w>
- Hong, T., Wang, H., Li, G., Yao, P., & Ding, Y. (2019). Systematic Review and Meta-Analysis of 12 Randomized Controlled Trials Evaluating the Efficacy of Invasive Radiofrequency Treatment for Knee Pain and Function. *BioMed Research International*, 2019. <https://doi.org/10.1155/2019/9037510>
- Hunter, D. J., & Bierma-Zeinstra, S. (2019). Osteoarthritis. *The Lancet*, 393(10182), 1745–1759. [https://doi.org/10.1016/S0140-6736\(19\)30417-9](https://doi.org/10.1016/S0140-6736(19)30417-9)
- Kolasinski, S. L., Neogi, T., Hochberg, M. C., Oatis, C., Guyatt, G., Block, J., Callahan, L., Copenhaver, C., Dodge, C., Felson, D., Gellar, K., Harvey, W. F., Hawker, G., Herzig, E., Kwoh, C. K., Nelson, A. E., Samuels, J., Scanzello, C., White, D., ... Reston, J. (2020). 2019 American College of Rheumatology/Arthritis Foundation Guideline for the Management of Osteoarthritis of the Hand, Hip, and Knee. *Arthritis Care and Research*, 72(2), 149–162. <https://doi.org/10.1002/acr.24131>
- Kwon, H. J., Kim, C. S., Kim, D. H., Shin, J. W., Choi, D., & Choi, S. S. (2024). Effectiveness of the Cooled Radiofrequency Ablation of Genicular Nerves in Patients with Chronic Knee Pain Due to Osteoarthritis: A Double-Blind, Randomized, Controlled Study. *Medicina (Lithuania)*, 60(6). <https://doi.org/10.3390/medicina60060857>
- Makkar, J. K., Warrier, G., Ghai, B., Chhabra, M., Sarkar, P. K., Goni, V. G., & Khurana, B. J. K. (2024). Effect of radiofrequency ablation of genicular nerves on the isokinetic muscle strength of knee joint in patients with osteoarthritis knee: a randomized double-blind sham

- controlled clinical trial. *Pain Medicine (United States)*, 25(12), 738–748. <https://doi.org/10.1093/pm/pnae077>
- Messier, S. P., Mihalko, S. L., Legault, C., Miller, G. D., Nicklas, B. J., DeVita, P., Beavers, D. P., Hunter, D. J., Lyles, M. F., Eckstein, F., Williamson, J. D., Carr, J. J., Guermazi, A., & Loeser, R. F. (2013). Effects of intensive diet and exercise on knee joint loads, inflammation, and clinical outcomes among overweight and obese adults with knee osteoarthritis: *The IDEA randomized clinical trial*. *Jama*, 310(12), 1263–1273. <https://doi.org/10.1001/jama.2013.277669>
- Oeding, J. F., Varady, N. H., Fearington, F. W., Pareek, A., Strickland, S. M., Nwachukwu, B. U., Camp, C. L., & Krych, A. J. (2024). Platelet-Rich Plasma Versus Alternative Injections for Osteoarthritis of the Knee: A Systematic Review and Statistical Fragility Index–Based Meta-analysis of Randomized Controlled Trials. *American Journal of Sports Medicine*, 52(12), 3147–3160. <https://doi.org/10.1177/03635465231224463>
- Olesiak, B., Przedborska, A., & Raczkowski, J. W. (2019). Degeneration grade of a femoropatellar joint and functional status of a knee joint. *Pedagogy and Psychology of Sport*, 5(2), 44–55. <https://doi.org/10.12775/PPS.2015.05.02.003>
- Osani, M. C., Lohmander, L. S., & Bannuru, R. R. (2021). Is There Any Role for Opioids in the Management of Knee and Hip Osteoarthritis? A Systematic Review and Meta-Analysis. *Arthritis Care and Research*, 73(10), 1413–1424. <https://doi.org/10.1002/acr.24363>
- Pereira, T. V., Jüni, P., Saadat, P., Xing, D., Yao, L., Bobos, P., Agarwal, A., Hincapié, C. A., & Da Costa, B. R. (2022). Viscosupplementation for knee osteoarthritis: systematic review and meta-analysis. *Bmj*, 378. <https://doi.org/10.1136/bmj-2022-069722>
- Primorac, D., Molnar, V., Matišić, V., Hudetz, D., Jeleč, Ž., Rod, E., Čukelj, F., Vidović, D., Vrdoljak, T., Dobričić, B., Antičević, D., Smolić, M., Miškulin, M., Čačić, D., & Borić, I. (2021). Comprehensive review of knee osteoarthritis pharmacological treatment and the latest professional societies' guidelines. *Pharmaceuticals*, 14(3), 205. <https://doi.org/10.3390/ph14030205>
- Runhaar, J., Kloppenburg, M., Boers, M., Bijlsma, J. W. J., & Bierma-Zeinstra, S. M. A. (2021). Towards developing diagnostic criteria for early knee osteoarthritis: Data from the CHECK study. *Rheumatology*, 60(5), 2448–2455. <https://doi.org/10.1093/rheumatology/keaa643>
- Skou, S. T., Roos, E. M., Laursen, M. B., Rathleff, M. S., Arendt-Nielsen, L., Simonsen, O., & Rasmussen, S. (2015). A Randomized, Controlled Trial of Total Knee Replacement. *New England Journal of Medicine*, 373(17), 1597–1606. <https://doi.org/10.1056/nejmoa1505467>
- Suri, P., Morgenroth, D. C., Kwok, C. K., Bean, J. F., Kalichman, L., & Hunter, D. J. (2010). Low back pain and other musculoskeletal pain comorbidities in individuals with symptomatic osteoarthritis of the knee: data from the osteoarthritis initiative. *Arthritis Care & Research*, 62(12), 1715–1723. <https://doi.org/10.1002/acr.20324>
- Tudaj, O., Sajewicz, K., Mazur, A., Kaczmarek, M., Grochowska, W., Dylik, A., Kalisiak, J., Kalas, W., Strzałkowska, P., & Dulęba, J. (2025). Treatment methods for knee osteoarthritis - A literature review. *Quality in Sport*, 42, 60948. <https://doi.org/10.12775/QS.2025.42.60948>
- Van Zadelhoff, T. A., Bos, P. K., Moelker, A., Bierma-Zeinstra, S. M. A., Van Der Heijden, R. A., & Oei, E. H. G. (2024). Genicular artery embolisation versus sham embolisation for symptomatic osteoarthritis of the knee: a randomised controlled trial. *BMJ Open*, 14(10). <https://doi.org/10.1136/bmjopen-2024-087047>
- Wang, X., Jin, X., Blizzard, L., Antony, B., Han, W., Zhu, Z., Cicuttini, F., Wluka, A. E., Winzenberg, T., Jones, G., & Ding, C. (2017). Associations between knee effusion-synovitis and joint structural changes in patients with knee osteoarthritis. *Journal of Rheumatology*, 44(11), 1644–1651. <https://doi.org/10.3899/jrheum.161596>
- Zhang, W. (2010). EULAR evidence-based recommendations for the diagnosis of knee

osteoarthritis. *Annals of the Rheumatic Diseases*.
<https://doi.org/10.1136/ard.2009.113100>

RETRACTED