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NARRATIVE REVIEW

Investigating the Diagnosis, Management, and Emerging Therapeutic Advances in Osteoarthritis: A Narrative Review

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ABSTRACT

Osteoarthritis (OA) is a degenerative joint disease and a major cause of chronic pain and disability worldwide, particularly among older adults. It is characterized by progressive articular cartilage degeneration and structural and biochemical changes in subchondral bone, synovium, ligaments, and periarticular muscles. OA is not simply a mechanical “wear-and-tear” disorder; it is now recognized as a multifactorial disease involving mechanical, genetic, metabolic, and low-grade inflammatory processes.

Diagnosis is largely clinical and may be supported by imaging findings such as joint-space narrowing, osteophyte formation, and subchondral sclerosis, while laboratory testing is generally used to exclude inflammatory, infectious, or metabolic arthritides. Management is stepwise: non-pharmacological measures, including exercise and weight loss when appropriate, are foundational; pharmacological therapy may then be added, with topical or oral non-steroidal anti-inflammatory drugs (NSAIDs) commonly used and opioids generally discouraged except in selected circumstances. Intra-articular corticosteroid injections may provide short-term symptom relief, and total joint replacement remains the most effective treatment for appropriately selected patients with end-stage disease. Emerging approaches, including platelet-rich plasma, mesenchymal stem-cell therapies, targeted molecular agents, and disease-modifying osteoarthritis drugs, remain investigational because evidence is inconsistent and disease modification has not been established.

This narrative review summarizes current diagnostic approaches, established management strategies, and emerging therapeutic developments in OA, emphasizing the continued need for reliable biomarkers and effective disease-modifying therapies.

Keywords: Osteoarthritis; Diagnosis; Management; NSAIDs; Joint replacement; Regenerative medicine

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INTRODUCTION

Osteoarthritis (OA) is the most common form of arthritis and a major cause of chronic pain and disability, particularly among older adults. Globally, OA affected an estimated 595 million people in 2020 (7.6% of the world population), representing a 132.2% increase in total cases since 1990, and the burden is projected to approach 1 billion cases by 2050 because of population aging and the rising prevalence of obesity. The largest projected increases are for knee OA (approximately 75%) and hand OA (approximately 50%) [11]. OA is a whole-joint disease involving articular cartilage, subchondral bone, synovium, ligaments, menisci, and periarticular muscles [2].

Low-grade inflammation plays an important role in OA pathogenesis and persistence through inflammatory cytokines, matrix metalloproteinase cascades, and immune processes; synovitis is present in some forms of the disease [3]. OA is therefore not purely degenerative but a multifactorial syndrome influenced by aging, metabolic, inflammatory, genetic, and mechanical factors [1]. Its prevalence is increasing with obesity, longer life expectancy, and sedentary lifestyles, and it commonly affects large weight-bearing joints, particularly the knees and hips.

OA can lead to progressive functional limitation and may adversely affect mental health. It also creates a substantial socioeconomic burden through lost productivity, medication and procedural costs, long-term care, and indirect costs related to work disability and comorbidity [4].

OA is diagnosed primarily from the clinical history and physical examination. First-line management is non-pharmacological and includes therapeutic exercise and weight management when appropriate [6]. Pharmacological therapy is used as an adjunct for persistent symptoms, with intra-articular corticosteroid injections considered in selected patients; when optimized non-surgical treatment is insufficient, total joint replacement remains the most effective treatment for severe symptomatic disease [7]. Newer strategies under investigation include regenerative medicine (PRP and MSCs), novel anti-inflammatory treatments, gene therapy, and disease-modifying osteoarthritis drugs (DMOADs) [2,5], but evidence remains inconsistent and high-quality clinical data are still limited.

This review discusses current approaches to the diagnosis and management of OA, with particular attention to emerging therapeutic strategies.

EPIDEMIOLOGY

OA is a major cause of disability among adults [2]. It is most common in older populations but can also occur in younger individuals because of physically demanding work, prior joint injury, or congenital abnormalities [4]. Hundreds of millions of people are affected globally. The knee is the most commonly involved joint, followed by the hip, hand, and spine, and knee OA contributes substantially to OA-related disability-adjusted life years (DALYs).

Age is the strongest risk factor for OA. Other important risk factors include female sex, particularly after menopause, high body mass, systemic metabolic factors, and physically demanding or high-impact occupations [7]. Genetic factors affecting bone and cartilage remodeling have also been implicated. Associations with metabolic syndrome and its components further support the concept that OA has inflammatory and metabolic, as well as mechanical, determinants.

The 2021 Global Burden of Disease study, which included prevalence, incidence, and years lived with disability (YLDs) data from 204 countries and territories, demonstrated a rising OA burden in all regions, particularly among women and in countries with a high sociodemographic index [11]. High body mass index (BMI) and related metabolic factors were important modifiable contributors, reinforcing the importance of exercise and weight management [11]. Figure 1 illustrates the increase from an estimated 256 million cases in 1990 to 595 million in 2020 and a projected 992 million by 2050 [11].

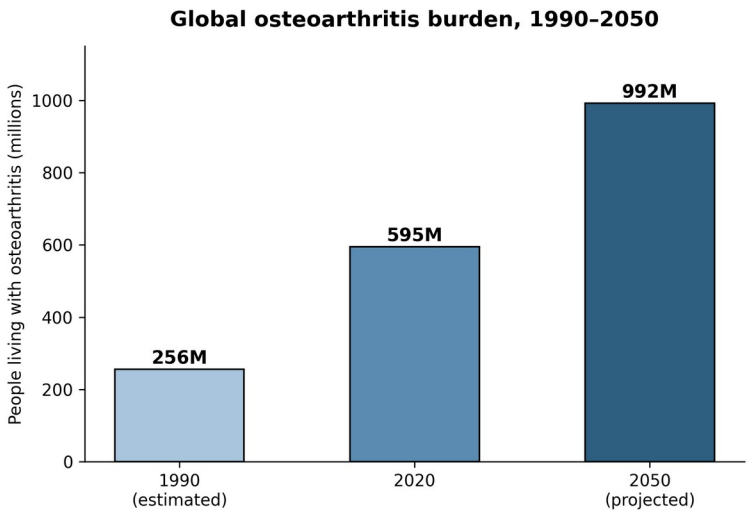

Figure 1. Global burden of osteoarthritis, 1990-2050. The 1990 figure is derived from the reported 132.2% increase in cases to 2020; the 2050 figure is the GBD 2021 study's central projection. Data from GBD 2021 Osteoarthritis Collaborators, The Lancet Rheumatology, 2023.

Life expectancy, lifestyle, occupation, and access to health insurance and health-care services vary by region, producing important geographic differences in the recognized burden of OA. High-income countries may have a higher prevalence of diagnosed OA, whereas low- and middle-income countries may have more undiagnosed disease and fewer resources for rehabilitation and long-term care.

PATHOPHYSIOLOGY

OA disrupts whole-joint homeostasis and affects articular cartilage, subchondral bone, synovium, ligaments, and periarticular muscles [8]. Although traditionally described as a mechanical “wear-and-tear” disease, OA is now understood to involve multiple biochemical pathways in addition to abnormal mechanical loading and low-grade inflammation [2]. The structural differences between a normal and an osteoarthritic joint are summarized in Figure 2.

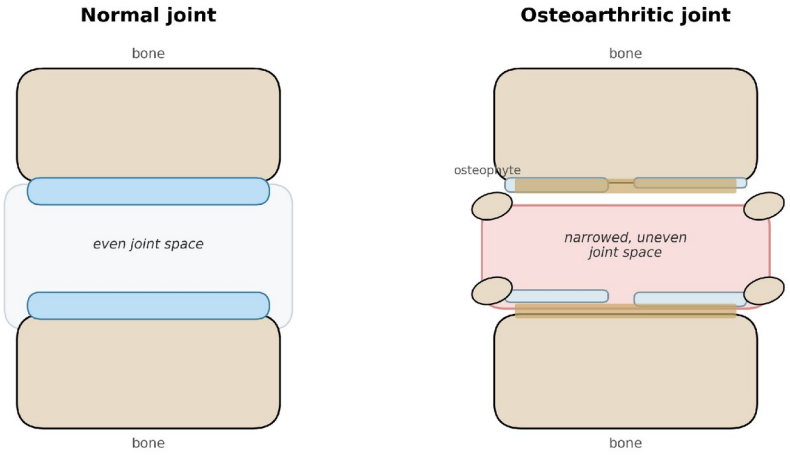

Figure 2. Schematic comparison of a normal joint and an osteoarthritic joint, illustrating cartilage thinning, marginal osteophyte formation, subchondral sclerosis, synovial thickening, and a narrowed, uneven joint space. Original schematic prepared for this review; not to anatomical scale.

Cartilage degeneration is a characteristic feature of OA. Articular cartilage contains chondrocytes that maintain the extracellular matrix through regulated synthesis and degradation of collagen and proteoglycans [7]. In OA, this balance is disrupted, with increased activity of matrix metalloproteinases (MMPs) and aggrecanases contributing to matrix degradation [2]. Low-grade inflammation is also important: cytokines such as interleukin-1 beta (IL-1β), tumor necrosis factor-alpha (TNF-α), and interleukin-6 (IL-6) contribute to cartilage catabolism and synovial inflammation. This inflammatory activity is generally less pronounced than in rheumatoid arthritis but remains biologically relevant.

Subchondral bone is also affected by abnormal mechanical stress and cartilage loss, resulting in sclerosis and microfractures that further alter joint mechanics and contribute to pain and reduced range of motion [7]. Synovial changes include hyperplasia and immune-cell infiltration, which are generally less pronounced than in inflammatory arthritides but can contribute to pain, swelling, and stiffness. Excess weight, malalignment, and previous injury further alter joint loading; over time, instability may increase while surrounding muscles can weaken because of pain and disuse.

CLINICAL PRESENTATION AND RED FLAGS

OA typically presents with gradually progressive joint pain that worsens with use and improves with rest; the pain is often deep, aching, and mechanical in nature. Unlike inflammatory arthritides, OA does not typically cause prolonged morning stiffness, and stiffness usually lasts less than 30 minutes [6]. Over time, range of motion and function may decline, making routine activities increasingly difficult. Commonly affected sites include the hands, spine, hips, and knees.

Patients with knee OA commonly report pain with walking, stair climbing, and prolonged standing. Hip OA may present with groin pain radiating to the thigh and can sometimes be perceived as knee pain. In hand OA, Heberden nodes and Bouchard nodes are bony enlargements of the distal interphalangeal (DIP) and proximal interphalangeal (PIP) joints, respectively. Physical examination may demonstrate bony enlargement, reduced range of motion, joint-line tenderness, and crepitus; instability and deformity may appear in more advanced disease.

Although OA can usually be diagnosed clinically, certain “red flag” features should prompt reconsideration of the diagnosis. These include fever, night sweats or other systemic features, rapid symptom onset, marked inflammatory findings, and pain or disability that is disproportionate to the apparent degree of structural disease. Recognition of these features is important because they may indicate infection, inflammatory arthritis, malignancy, or another alternative diagnosis.

DIAGNOSIS OF OSTEOARTHRITIS

OA is primarily a clinical diagnosis. The UK National Institute for Health and Care Excellence (NICE) guideline recommends diagnosing OA clinically, without imaging, in people aged 45 years or older who have activity-related joint pain and either no morning joint-related stiffness or morning stiffness lasting no longer than 30 minutes [26]. Radiographs and other imaging are not routinely required for a typical presentation. Imaging and laboratory testing are instead reserved for atypical presentations, red flags, diagnostic uncertainty, or suspicion of an alternative diagnosis such as inflammatory, septic, or metabolic arthritis.

Laboratory Investigations

There are no disease-specific blood or urine tests for OA. Systemic inflammatory markers such as erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) are typically normal or only mildly elevated; autoimmune serologies may be used when an inflammatory rheumatic disease is suspected. Synovial fluid is usually non-inflammatory in OA and can help distinguish OA from inflammatory or septic arthritis; a white blood cell count below approximately 2,000 cells/μL is typical of non-inflammatory fluid.

Clinical Diagnosis

Clinical evaluation remains central to diagnosis. The American College of Rheumatology (ACR) classification criteria incorporate symptoms, physical examination findings, and, for some joints, radiographic or laboratory features. Common clinical findings include pain with motion, morning stiffness lasting less than 30 minutes, crepitus, reduced range of motion, and bony enlargement, particularly in hand OA.

Imaging

When imaging is indicated because of atypical features, diagnostic uncertainty, or preoperative planning, conventional radiography is generally the first-line imaging modality. Radiographs may show joint-space narrowing, osteophytes, subchondral sclerosis, and subchondral cysts. Radiographic severity can be graded using the Kellgren-Lawrence system from grade 0 (no radiographic features of OA) to grade 4 (large osteophytes, marked joint-space narrowing, severe subchondral sclerosis, and definite bony deformity), as summarized in Figure 3 and Table 1.

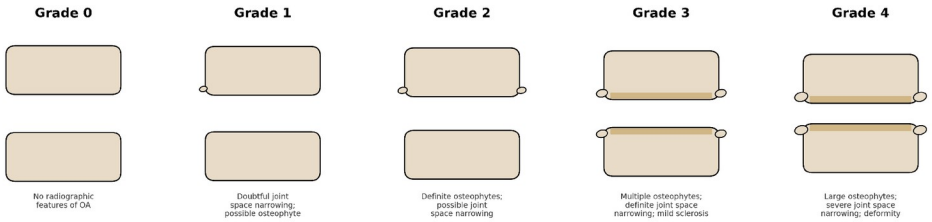

Figure 3. Schematic illustration of the Kellgren-Lawrence radiographic grading system for osteoarthritis, grades 0-4. Original schematic prepared for this review, illustrating progressive joint-space narrowing, osteophyte formation, and subchondral sclerosis; not derived from actual radiographs.

Grade	Radiographic features
0	No radiographic features of osteoarthritis
1	Doubtful joint space narrowing; possible osteophytic lipping
2	Definite osteophytes; possible joint space narrowing
3	Multiple, moderate osteophytes; definite joint space narrowing; some subchondral sclerosis; possible bony deformity
4	Large osteophytes; marked joint space narrowing; severe subchondral sclerosis; definite bony deformity

Table 1. The Kellgren–Lawrence radiographic grading system for osteoarthritis severity.

Magnetic resonance imaging (MRI) can detect cartilage injury, synovitis, and bone-marrow lesions but is not routinely required for diagnosis; it is most useful in atypical or complex cases. Musculoskeletal ultrasound (MSUS) can identify synovial inflammation, effusion, osteophytes, and cartilage abnormalities and can also guide joint procedures.

MANAGEMENT OF OSTEOARTHRITIS

OA requires multimodal management. Treatment aims to relieve pain, improve function, and preserve quality of life. Current guidelines emphasize non-pharmacological interventions as the foundation of care, with pharmacological and intra-articular therapies added according to symptoms, comorbidities, and patient preferences. Surgical management is considered for persistent, function-limiting disease despite optimized non-surgical treatment. This stepwise approach is summarized in Figure 4.

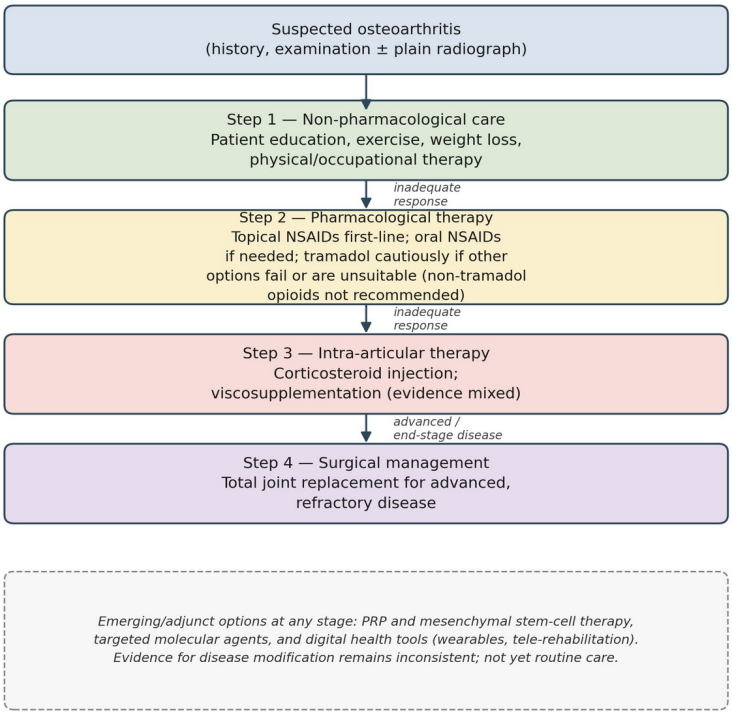

Figure 4. Stepwise algorithm for osteoarthritis management, progressing from non-pharmacological care through pharmacological and intra-articular therapy to surgical management. Emerging or adjunctive options are shown separately because evidence for disease modification remains inconsistent. Original figure prepared for this review and synthesized from the management approaches described in the text.

Step	Options	Key evidence
1. Non-pharmacological	Patient education, aerobic/resistance exercise, weight loss, physical/occupational therapy	Aerobic exercise best modality across pain/function/gait/QoL (217 RCTs, n=15,684) [12]; exercise ≈ NSAIDs/paracetamol for pain (152 RCTs) [13]; IDEA trial: diet+exercise weight loss reduced joint load and IL-6 [14]
2. Pharmacological	Topical NSAIDs: strong for knee and conditional for hand (ACR); oral NSAIDs: strong; acetaminophen: conditional (ACR) and conditionally against in OARSI; non-tramadol opioids: conditionally against; tramadol: conditional	Oral/topical NSAIDs generally more effective than acetaminophen [3]; topical therapy preferred when appropriate because of lower systemic exposure [6,10]
3. Intra-articular	Intra-articular corticosteroid injection for symptomatic knee/hip OA; hyaluronic acid: ACR conditionally against for knee and strongly against for hip; OARSI conditional for selected knee OA patients	Repeated triamcinolone: similar pain outcomes to saline but greater cartilage loss at 2 years [15]; guideline recommendations vary for hyaluronic acid [6,10]
4. Surgical	Total knee/hip replacement for persistent moderate-to-severe pain and functional limitation despite optimized non-surgical management, with radiographic confirmation of OA	Approximately 80-90% of patients report satisfaction after TKA; outcomes are strongly linked to pain/function improvement and expectations [20]

Table 2. Stepwise management of osteoarthritis with supporting evidence.

Non-Pharmacological Management

Major clinical guidelines emphasize non-pharmacological management as a core component of OA care. Exercise, including resistance training, aerobic conditioning, and flexibility work, improves pain, function, and mobility. In a network meta-analysis of 15,684 participants across 217 randomized controlled trials (RCTs), aerobic exercise produced the largest improvements in pain, function, gait performance, and quality of life at short- and mid-term follow-up [12]. Another network meta-analysis of 152 RCTs

(>17,000 participants) found that exercise therapy produced pain relief and functional improvement comparable to oral NSAIDs or acetaminophen, without the systemic adverse-effect burden associated with medication [13].

Weight loss is an important treatment goal for patients with OA who are overweight or obese, and even modest reductions in body weight can lessen mechanical loading on weight-bearing joints [11]. In the IDEA randomized trial, 454 older adults with knee OA who were overweight or obese were assigned to diet, exercise, or combined diet-and-exercise interventions. The combined intervention produced the greatest weight loss, lower knee compressive forces and IL-6 levels, and greater improvements in pain and function [14]. These findings support both biomechanical and inflammatory mechanisms through which weight reduction may improve OA outcomes.

Patient education and active participation in treatment can improve self-management, while physical and occupational therapy can help reduce disability and maintain mobility.

Pharmacological Therapy

Pharmacological therapy is symptomatic rather than disease modifying and is used as an adjunct to exercise and weight management. Acetaminophen (paracetamol) was historically considered first-line, but its role has been downgraded: the 2019 ACR/Arthritis Foundation guideline conditionally recommends it, whereas the 2019 OARSI guideline conditionally recommends against its routine use in knee OA, reflecting modest efficacy and concerns with prolonged use [6,10]. Oral and topical NSAIDs are generally more effective analgesics than acetaminophen. Topical NSAIDs are strongly recommended for knee OA by the ACR/Arthritis Foundation and are preferred when local treatment is appropriate because of lower systemic exposure; for hand OA, the ACR recommendation is conditional [3,6,10]. Oral NSAIDs are strongly recommended for hand, hip, and knee OA, but cardiovascular, gastrointestinal, renal, and drug-interaction risks should be considered, using the lowest effective dose for the shortest appropriate duration. Opioid therapy is generally discouraged because of modest long-term benefit and substantial toxicity and dependency risks. The ACR/Arthritis Foundation guideline conditionally recommends against non-tramadol opioids and conditionally recommends tramadol when other pharmacological and non-pharmacological therapies are ineffective, contraindicated, or not tolerated [6].

Intra-Articular Therapies

Intra-articular corticosteroid injections are recommended for symptomatic knee and hip OA in current ACR guidance, but benefit is generally short term. In a 2-year randomized trial of patients with knee OA and synovitis, intra-articular triamcinolone and saline produced similar pain outcomes, while the triamcinolone group had greater cartilage thickness loss on MRI (0.21 mm versus 0.10 mm) [15]. These findings support avoiding routine frequent repeat injections. Hyaluronic acid viscosupplementation remains controversial: the 2019 ACR guideline conditionally recommends against it for knee OA and strongly recommends against it for hip OA, whereas OARSI conditionally recommends it for selected patients with knee OA depending on comorbidity status [6,10].

Surgical Management

For advanced OA, total knee and hip replacement are the most effective treatment options. Total joint replacement is considered for patients with persistent moderate-to-severe pain and functional limitation that substantially impairs quality of life despite an adequate trial of non-surgical management, together with radiographic confirmation of OA. Radiographic severity alone, without corresponding symptoms, is not an indication for surgery. Patient-reported outcomes after total knee arthroplasty (TKA) are generally favorable, although they are less consistently positive than after total hip replacement. Overall satisfaction after TKA is approximately 80-90%; improvement in pain and function is strongly associated with satisfaction, whereas unmet expectations and preoperative anxiety or depression are associated with dissatisfaction [20]. These findings underscore the importance of realistic preoperative counseling and appropriate patient selection. Access to total joint replacement remains unequal globally.

EMERGING THERAPIES AND FUTURE DIRECTIONS

Although symptom management has improved, no pharmacological therapy has yet been proven to modify OA disease progression. This gap has driven interest in regenerative medicine and molecular targets intended to slow disease rather than only relieve symptoms. Platelet-rich plasma (PRP) and mesenchymal stem-cell (MSC) therapies have attracted substantial interest because of proposed anti-inflammatory and reparative effects. A 2023 meta-analysis of 24 RCTs (n=1,344 across knee, hip, ankle, and temporomandibular-joint OA) found greater reductions in pain with PRP than with control treatments [16], although these findings concern symptoms rather than structural disease modification. Evidence for MSC therapy is more equivocal: a 2024 meta-analysis reported improved pain and function at 12 months compared with placebo [17], whereas a large four-arm phase 3 randomized trial of 440 patients found that three cell-based injections were not superior to corticosteroid injection, or to one another, for knee OA pain at 12 months [18]. Reported benefits from PRP and MSC studies therefore remain primarily symptomatic, and a structural disease-modifying effect has not been established. Variation in product preparation, dosing, and patient selection also limits generalizability. Current ACR guidance strongly recommends against PRP and stem-cell injections for hip and knee OA outside routine guideline-supported care [6].

Targeted molecular therapies have also been investigated. Agents directed against interleukin-1 beta (IL-1β) or tumor necrosis factor-alpha (TNF-α) have not demonstrated clear clinical benefit in OA [9]. Other disease-modifying osteoarthritis drug (DMOAD) strategies target cartilage and matrix biology. Sprifermin, a fibroblast growth factor-18 analogue, produced a dose-dependent increase in total femorotibial cartilage thickness on MRI over 2 years compared with placebo in more than 500 patients with knee OA, but without a

clear symptom-modifying effect over the same period [19]. This illustrates the persistent disconnect between structural and symptomatic outcomes in DMOAD development. Scaffold-based cartilage repair and other regenerative technologies are also under investigation.

Not all emerging strategies have produced positive clinical results. Anti-nerve growth factor (NGF) monoclonal antibodies such as tanezumab demonstrated analgesic efficacy: in a 24-week phase III trial of 849 patients with hip or knee OA and persistent pain despite standard analgesics, tanezumab 5 mg improved pain, physical function, and patient global assessment compared with placebo [22]. However, the broader development program identified a dose-dependent risk of rapidly progressive OA. In March 2021, a joint FDA advisory committee voted 19-1 against the proposed risk-mitigation strategy being sufficient to ensure that benefits outweighed risks [23]. Tanezumab therefore illustrates how a genuine efficacy signal may fail to translate into clinical use when structural safety concerns remain unresolved.

Senolytic agents, which aim to eliminate senescent cells that may contribute to local inflammation and cartilage degradation, have also been investigated. Early phase I findings for UBX0101 were encouraging, but a subsequent phase II study of 183 patients with knee OA found no significant separation from placebo on the primary pain outcome at 12 weeks, after which development was discontinued [24]. These results were reported by the manufacturer rather than in a full peer-reviewed trial publication and should therefore be interpreted cautiously. Cell and gene therapy has followed an equally complex trajectory. TissueGene-C (TG-C/Invossa), an allogeneic chondrocyte-based gene therapy designed to deliver transforming growth factor beta 1 (TGF-β1) to the joint, was placed on FDA clinical hold in 2019 after a discrepancy in the identity of a key cell component. Trials later resumed, but topline results reported in 2026 indicated that the first US phase III trial failed to meet its co-primary endpoints for pain and function at 12 months [25]. Because these results were reported through a news source rather than a peer-reviewed publication, they should also be interpreted cautiously pending full publication. Collectively, these mixed and negative findings highlight the substantial placebo response in OA trials, the absence of validated biomarkers to identify likely responders, and the difficulty of achieving disease modification without unacceptable structural harm. They also underscore the importance of prioritizing peer-reviewed evidence over sponsor announcements when evaluating emerging therapies.

Precision-medicine approaches based on OA phenotypes and endotypes are also emerging. Proposed frameworks classify patients into clinically relevant subgroups, such as inflammatory or metabolic phenotypes, with the aim of tailoring therapy using clinical, biomarker, or imaging characteristics.

Digital technologies, including wearable devices and telerehabilitation platforms, are playing an increasing role in OA management. A randomized controlled trial in knee OA found no significant difference in pain or function outcomes between telerehabilitation and conventional office-based physical therapy, supporting telerehabilitation as a feasible option when in-person services are limited [21]. Digital tools may also assist with monitoring physical activity, exercise adherence, function, chronic-disease management, and patient engagement. Future OA research is likely to focus on earlier detection, validated markers of disease progression, and therapies capable of true disease modification.

Therapy	Mechanism	Strongest evidence to date	Status
Platelet-rich plasma (PRP)	Growth factors/cytokines; anti-inflammatory, pro-repair	24 RCTs, n=1,344: reduced pain scores versus control across knee/hip/ankle OA [16]	Used off-label; not first-line; preparation and dosing are not standardized
Mesenchymal stem cells (MSC)	Anti-inflammatory, immunomodulatory, cartilage-repair signaling	18 RCTs: superior pain/function vs placebo at 12 months [17]; largest phase 3 RCT (n=440) vs corticosteroid found no superiority of any cell-based product at 12 months [18]	Investigational; substantial heterogeneity in cell source, preparation, and dosing
Sprifermin (FGF-18, DMOAD)	Stimulates chondrocyte proliferation/cartilage matrix synthesis	FORWARD trial, n>500: dose-dependent increase in cartilage thickness on MRI at 2 years [19]	Structural benefit shown; no clear pain/function benefit; not approved
Anti-NGF antibody (tanezumab)	Blocks nerve growth factor pain signaling	Phase III, n=849: improved pain, function, and patient global assessment versus placebo [22]	FDA advisory committee voted 19-1 against the proposed risk-mitigation strategy; not approved [23]
Senolytic (UBX0101)	Selective clearance of senescent chondrocytes	Phase I findings were encouraging; phase II, n=183: no separation from placebo on the primary pain outcome at 12 weeks [24]	Development discontinued
Gene/cell therapy (TG-C/Invossa)	Allogeneic chondrocytes transduced to express TGF-β1	Korean approval revoked (2019) after cell-line mislabelling; phase III topline (2026) missed co-primary endpoints [25]	Primary US phase III trial reported unsuccessful; full peer-reviewed results pending [25]

Table 3. Overview of emerging and investigational osteoarthritis therapies, including negative and inconclusive trial results.

CONCLUSION

OA is a common, multifactorial joint disease and a leading cause of pain and disability worldwide. Its etiology includes mechanical, inflammatory, genetic, and metabolic factors, with structural changes affecting articular cartilage and other joint tissues. Diagnosis is

usually clinical and may be supported by radiography or, in atypical cases, MRI, while laboratory tests are used primarily to exclude alternative inflammatory, infectious, or metabolic conditions.

The primary goals of OA management are to relieve pain and preserve function. Treatment is multimodal, combining non-pharmacological, pharmacological, intra-articular, and surgical interventions according to disease severity, comorbidities, and patient preferences. Total joint replacement remains the most effective option for appropriately selected patients with advanced disease. Regenerative and molecular therapies are being actively investigated, but no therapy has yet demonstrated a consistently proven disease-modifying effect sufficient for routine clinical use. Digital technologies may increasingly support remote monitoring, rehabilitation, and long-term patient engagement.

Important challenges remain, including the absence of a reliably disease-modifying therapy, heterogeneity in clinical phenotypes and treatment response, and unequal access to care. Further research should prioritize validated biomarkers for early diagnosis and disease monitoring, improved patient stratification, and more effective individualized strategies to preserve long-term quality of life and functional status.

ABBREVIATIONS

OA, osteoarthritis; ACR, American College of Rheumatology; BMI, body mass index; CRP, C-reactive protein; DALY, disability-adjusted life year; DIP, distal interphalangeal; DMOAD, disease-modifying osteoarthritis drug; ESR, erythrocyte sedimentation rate; FDA, US Food and Drug Administration; IL-1β, interleukin-1 beta; IL-6, interleukin-6; MMP, matrix metalloproteinase; MRI, magnetic resonance imaging; MSC, mesenchymal stem cell; MSUS, musculoskeletal ultrasound; NGF, nerve growth factor; NSAID, non-steroidal anti-inflammatory drug; PIP, proximal interphalangeal; PRP, platelet-rich plasma; QoL, quality of life; RCT, randomized controlled trial; TKA, total knee arthroplasty; TNF-α, tumor necrosis factor-alpha; YLD, years lived with disability.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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