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## **Regenerative and Conventional Intra-Articular Therapies in Osteoarthritis: A Narrative Review with a Focus on Sports Medicine**

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**Abstract**

**Background.** Osteoarthritis (OA) is one of the leading causes of chronic pain and functional limitation worldwide and represents a significant challenge not only in the general population but also in physically active individuals, where joint integrity is essential for maintaining mobility and performance.

**Aim.** The aim of this study was to present current evidence regarding the efficacy and safety of conventional and modern intra-articular injections in the treatment of osteoarthritis, with particular emphasis on their relevance in sports medicine and physically active populations.

**Materials and Methods.** This study was designed as a structured narrative review synthesizing available data on intra-articular therapies, including glucocorticosteroids, hyaluronic acid, platelet-rich plasma (PRP), collagen, mesenchymal stem cells (MSC), and bone marrow aspirate concentrate (BMAC), as well as injection techniques and combined therapeutic approaches.

**Results.** Available evidence indicates that corticosteroids provide primarily short-term pain relief, whereas hyaluronic acid may offer moderate symptomatic improvement. Platelet-rich plasma demonstrates promising results in terms of longer-term pain reduction and functional improvement, which may be particularly relevant for maintaining physical activity levels. Cell-based therapies and collagen injections represent emerging approaches, although they require further standardization and high-quality clinical trials.

**Conclusions.** Modern intra-articular injections may constitute an important component of integrated osteoarthritis management, particularly in individuals aiming to maintain mobility and physical performance. These therapies may play a key role within personalized treatment strategies in sports medicine and rehabilitation.

**Key words:** osteoarthritis; intra-articular injections; sports medicine; platelet-rich plasma; hyaluronic acid; mesenchymal stem cells; regenerative medicine; physical activity

## 1. Introduction

Osteoarthritis (OA) is one of the most common chronic diseases of the musculoskeletal system and represents a leading cause of pain and disability worldwide (Hunter & Bierma-Zeinstra, 2019; Kolasinski et al., 2020). Its prevalence continues to increase due to population aging and the growing incidence of obesity (Silverwood et al., 2015). Contemporary understanding of OA pathophysiology defines it as a complex disease of the entire joint, involving articular cartilage, synovial membrane, subchondral bone, and periarticular structures (Kolasinski et al., 2020; Martel-Pelletier et al., 2016).

Current therapeutic strategies for osteoarthritis are primarily based on non-pharmacological interventions, including exercise, weight reduction, and patient education, which are strongly

recommended in current clinical guidelines (Kolasinski et al., 2020; Arden et al., 2021). Pharmacological treatment is mainly focused on symptom control and pain reduction (Kolasinski et al., 2020). Osteoarthritis is also highly relevant in the field of sports medicine, as joint degeneration and chronic pain may significantly impair physical performance, limit training capacity, and delay return-to-activity in both professional athletes and physically active individuals. Intra-articular injections represent an important therapeutic option in patients with persistent symptoms despite first-line treatment, although their effectiveness varies depending on the administered agent (Arden et al., 2021). Glucocorticosteroids demonstrate well-documented efficacy in short-term pain reduction (McAlindon et al., 2017).

In contrast, hyaluronic acid may provide moderate improvement in symptoms and function, although its role in clinical guidelines remains controversial (Bannuru et al., 2015). In recent years, there has been increasing interest in biological therapies, particularly platelet-rich plasma (PRP), which may provide longer-lasting analgesic and functional effects compared with conventional injections (Filardo et al., 2011; Dai et al., 2017).

Despite the growing number of studies, most current clinical guidelines remain cautious regarding the routine use of biological therapies due to heterogeneity of preparations, lack of standardization, and variability in study quality (Arden et al., 2021).

At the same time, advances in regenerative medicine suggest that these methods may play an increasingly important role in the future, particularly in the context of personalized and combined therapeutic approaches (Freitag et al., 2016).

This review provides a comprehensive and integrative perspective on intra-articular therapies by evaluating both conventional pharmacological injections and emerging biological strategies within a unified clinical framework (Arden et al., 2021; Freitag et al., 2016). It emphasizes comparative effectiveness, mechanistic differences, and real-world clinical applicability of available treatments. The novelty of this review lies in its integrative and comparative approach, combining conventional and biological intra-articular therapies within a unified clinical decision-making framework.

## **2. Materials and methods**

This study was designed as a structured narrative review aimed at synthesizing current scientific evidence regarding intra-articular injection therapies in the management of osteoarthritis. The

review integrates data related to epidemiology, pathophysiology, risk factors, injection techniques, and both conventional and biological intra-articular therapies (Hunter & Bierma-Zeinstra, 2019; Kolasinski et al., 2020; Arden et al., 2021).

Particular emphasis was placed on glucocorticosteroids, hyaluronic acid, platelet-rich plasma (PRP), collagen, mesenchymal stem cells (MSC), and bone marrow aspirate concentrate (BMAC), as well as their clinical effectiveness, safety profiles, and applicability in contemporary therapeutic strategies (Filardo et al., 2011; Dai et al., 2017; McAlindon et al., 2017; Bannuru et al., 2015; Freitag et al., 2016; Furuzawa-Carballeda et al., 2012).

A targeted literature-based approach was adopted using key search concepts, including “osteoarthritis,” “intra-articular injections,” “platelet-rich plasma,” “hyaluronic acid,” “mesenchymal stem cells,” and “bone marrow aspirate concentrate,” in order to identify relevant peer-reviewed studies and clinical guidelines (Filardo et al., 2011; Dai et al., 2017; Bannuru et al., 2015; Freitag et al., 2016).

## **1. 3. Results**

### **3.1. Osteoarthritis: epidemiology, pathophysiology, and risk factors**

The analysis of available literature demonstrates that osteoarthritis is a highly prevalent and progressive musculoskeletal disorder affecting approximately 606–607 million individuals worldwide (Hunter & Bierma-Zeinstra, 2019). The burden of the disease increases significantly with age, with a higher prevalence observed in women, particularly in postmenopausal populations (Silverwood et al., 2015). Epidemiological data indicate that approximately 15% of adults over the age of 30 present with symptomatic osteoarthritis, with a continuously rising trend due to aging populations and increasing rates of obesity (Hunter & Bierma-Zeinstra, 2019; Silverwood et al., 2015).

The results of pathophysiological studies confirm that osteoarthritis is a multifactorial disease involving the entire joint rather than isolated cartilage degeneration (Kolasinski et al., 2020; Martel-Pelletier et al., 2016). The pathological process affects articular cartilage, subchondral bone, synovial membrane, ligaments, menisci, and periarticular muscles. Disruption of

homeostasis between anabolic and catabolic processes has been identified as a key mechanism underlying disease progression (Martel-Pelletier et al., 2016).

Chondrocyte dysfunction plays a central role, with phenotypic transformation toward pro-inflammatory and catabolic activity observed in osteoarthritic joints. This results in increased expression of matrix-degrading enzymes, including metalloproteinases and aggrecanases, accompanied by reduced synthesis of structural components such as type II collagen and aggrecan (Martel-Pelletier et al., 2016). Inflammatory processes within the synovium further contribute to disease progression, with elevated levels of cytokines such as IL-1 $\beta$ , TNF- $\alpha$ , and IL-6 promoting cartilage degradation and joint damage (Kolasinski et al., 2020).

Subchondral bone remodeling, sclerosis, and osteophyte formation have also been consistently reported as key structural changes associated with osteoarthritis progression (Kolasinski et al., 2020; Martel-Pelletier et al., 2016).

Risk factor analysis confirms that both modifiable and non-modifiable factors contribute significantly to disease development (Silverwood et al., 2015). Age remains the strongest non-modifiable risk factor, with prevalence increasing markedly after the age of 40. Female sex is associated with higher disease incidence, likely due to hormonal influences on cartilage metabolism and inflammatory processes. Genetic studies indicate heritability ranging from 40% to 65%, highlighting the importance of genetic predisposition in osteoarthritis development (Kolasinski et al., 2020).

Obesity has been identified as a major modifiable risk factor, contributing both mechanical overload and systemic inflammation mediated by adipokines (Silverwood et al., 2015). Additionally, joint injuries, malalignment, and biomechanical abnormalities have been shown to significantly increase the risk of osteoarthritis onset and progression, which is particularly relevant in physically active individuals and athletes.

### **3.2. Accuracy and clinical relevance of intra-articular injection techniques**

The results of comparative studies indicate that the effectiveness of intra-articular injections is strongly dependent on the accuracy of needle placement within the joint cavity (Berkoff et al., 2012; Sibbitt et al., 2009). Incorrect, extra-articular administration has been shown to significantly reduce therapeutic efficacy and may increase the risk of adverse effects.

Landmark-guided injections demonstrate variable accuracy, which is influenced by both the anatomical location of the joint and operator experience. Higher accuracy has been reported for knee joint injections, whereas significantly lower precision has been observed in hip joint procedures due to anatomical complexity (Berkoff et al., 2012; Smith & Finnoff, 2009). Meta-analytic data demonstrate that ultrasound-guided injections are significantly more accurate compared with blind techniques (Berkoff et al., 2012). Improved accuracy has been associated with better clinical outcomes, including greater pain reduction and lower rates of unsuccessful procedures (Sibbitt et al., 2009).

Ultrasound guidance enables real-time visualization of anatomical structures, increasing procedural safety and reducing the risk of damage to surrounding tissues. Additionally, it eliminates exposure to ionizing radiation associated with fluoroscopy, which further supports its use in routine clinical practice (Finnoff et al., 2010; Smith & Finnoff, 2009).

Overall, the available evidence supports ultrasound guidance as the preferred method for intra-articular injections, particularly in technically demanding procedures and in joints with complex anatomy. This is especially relevant in physically active individuals, where precise treatment delivery may influence recovery time and return to activity.

### **3.3. Clinical effectiveness of conventional intra-articular therapies**

#### **3.3.1. Corticosteroids**

The results of randomized controlled trials consistently demonstrate that intra-articular corticosteroids provide significant short-term pain relief in patients with osteoarthritis (McAlindon et al., 2017). The analgesic effect is typically observed within days after injection and lasts approximately 4–6 weeks. However, the therapeutic effect decreases over time and is generally not sustained beyond 8–12 weeks.

Evidence indicates that corticosteroids primarily provide symptomatic relief and do not influence structural disease progression. Long-term studies have suggested that repeated corticosteroid injections may be associated with increased cartilage loss compared with placebo and may contribute to adverse structural changes, including subchondral bone damage (Wernecke et al., 2015; McAlindon et al., 2017).

### **3.3.2. Hyaluronic acid**

The results of clinical studies indicate that hyaluronic acid provides moderate improvement in pain and joint function in patients with osteoarthritis (Bannuru et al., 2015). Its mechanism of action includes restoration of synovial fluid viscoelasticity and modulation of inflammatory processes.

However, meta-analyses have demonstrated that the magnitude of clinical benefit is relatively small and may not reach clinically significant thresholds. Substantial variability in outcomes has been reported, which is likely related to differences in molecular weight, formulation, and injection protocols (Bannuru et al., 2015; Bowman et al., 2018).

Overall, the effectiveness of hyaluronic acid remains inconsistent, and its routine use continues to be debated in clinical guidelines.

## **3.4. Clinical effectiveness of biological intra-articular therapies**

### **3.4.1. Platelet-rich plasma (PRP)**

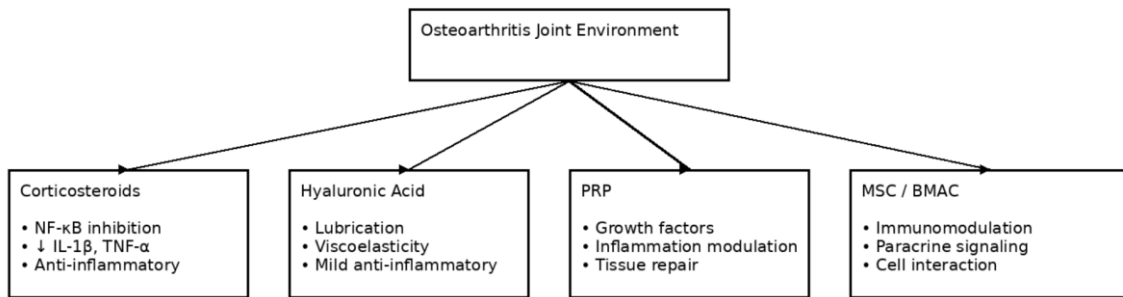
The results of multiple randomized controlled trials and meta-analyses indicate that platelet-rich plasma provides clinically meaningful improvement in pain and function in patients with osteoarthritis (Filardo et al., 2011; Dai et al., 2017). The therapeutic effect of PRP is typically sustained for up to 6–12 months, exceeding that of conventional intra-articular therapies. Comparative studies have demonstrated that PRP is more effective than hyaluronic acid in improving clinical outcomes (Dai et al., 2017). The mechanism of action involves the delivery of growth factors that modulate inflammation and promote tissue repair processes (Andia & Maffulli, 2013).

However, substantial heterogeneity in PRP preparation protocols has been identified, including differences in platelet concentration, leukocyte content, and activation methods (Dohan Ehrenfest et al., 2014). This variability limits comparability between studies and complicates the development of standardized treatment recommendations.

From a clinical perspective, PRP may be particularly relevant in physically active individuals, as its longer-lasting effects may support maintenance of joint function, facilitate return to physical activity, and contribute to improved functional performance.

The key mechanisms of action of major intra-articular therapies are summarized in Figure 1.

## Mechanisms of Intra-Articular Therapies in Osteoarthritis



**Figure 1. Mechanisms of action of intra-articular therapies in osteoarthritis.**

This illustrates the biological mechanisms underlying commonly used intra-articular therapies, including anti-inflammatory effects of corticosteroids, viscoelastic properties of hyaluronic acid, growth factor-mediated activity of platelet-rich plasma, and immunomodulatory and paracrine effects of mesenchymal stem cells and bone marrow aspirate concentrate.

### 3.4.2. Collagen

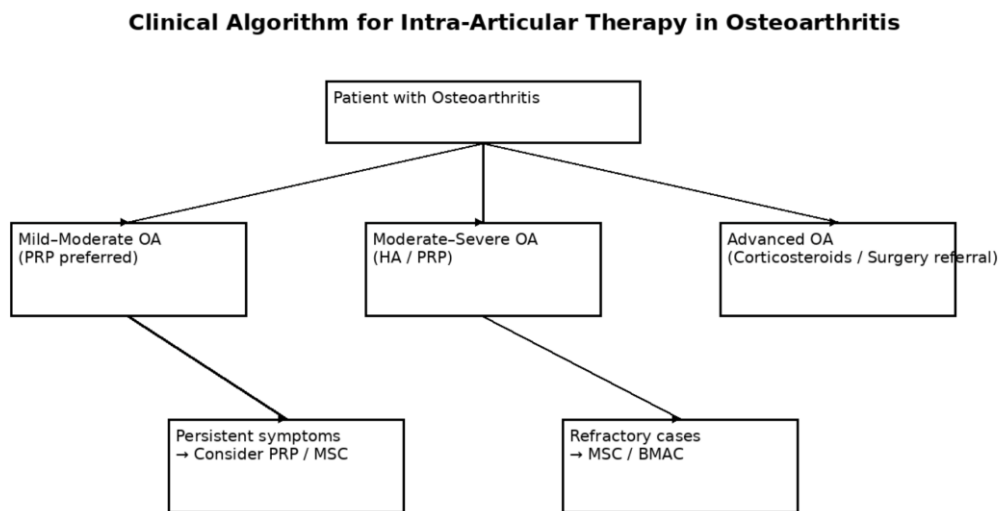
Available studies indicate that intra-articular collagen injections may provide improvement in pain and joint function (Furuzawa-Carballeda et al., 2012). The proposed mechanism includes support of extracellular matrix structure and modulation of chondrocyte activity. However, the current body of evidence remains limited, and further high-quality studies are required to confirm clinical effectiveness.

### 3.4.3. Mesenchymal stem cells (MSC) and BMAC

The results of clinical studies indicate that mesenchymal stem cells and bone marrow aspirate concentrate therapies may lead to significant improvements in pain, function, and quality of life in patients with osteoarthritis (Freitag et al., 2016). The therapeutic effect is primarily attributed to immunomodulatory and paracrine mechanisms rather than direct cartilage regeneration (Caplan & Correa, 2011). Comparative studies suggest that outcomes are similar across different cell sources, although variability in results has been reported (Freitag et al., 2016). Studies comparing PRP, BMAC, and hyaluronic acid demonstrate improvements in all groups without clear superiority of a single therapy (Anz et al., 2020). Despite promising results, the use of

MSC and BMAC is limited by high costs, lack of standardization, and insufficient long-term evidence. In the context of sports medicine, these regenerative therapies may play an important role in supporting functional recovery, optimizing joint performance, and potentially delaying the need for surgical intervention in physically active individuals.

A proposed clinical decision-making algorithm for intra-articular therapies in osteoarthritis is presented in Figure 2.



**Figure 2.** Clinical algorithm for intra-articular injection therapy in osteoarthritis.

This figure presents a structured, phenotype-based approach to treatment selection, integrating disease severity, clinical presentation, and response to therapy. It highlights the role of platelet-rich plasma as a preferred option in early to moderate osteoarthritis and emphasizes personalized decision-making.

#### 4. Discussion

The results of this review confirm that intra-articular injections constitute an important component of non-surgical management of osteoarthritis, particularly in patients who do not achieve adequate symptom control with conservative therapy (Arden et al., 2021). The comparative analysis of available evidence demonstrates substantial variability in clinical effectiveness depending on the type of administered agent and patient characteristics (Arden et al., 2021; Freitag et al., 2016).

Corticosteroids remain widely used due to their rapid onset of action and effectiveness in short-term pain reduction (McAlindon et al., 2017). However, their therapeutic effect is transient and primarily symptomatic, without evidence of disease-modifying properties. Furthermore, repeated administration has been associated with potential adverse structural effects, including cartilage degeneration and subchondral bone changes (Wernecke et al., 2015).

Hyaluronic acid represents an alternative approach aimed at restoring joint lubrication and modulating inflammation (Bowman et al., 2018). Nevertheless, the results of meta-analyses indicate that its clinical benefit is modest and often does not reach clinically meaningful thresholds (Bannuru et al., 2015). Additionally, substantial variability in formulations and molecular weight contributes to inconsistent therapeutic outcomes across studies.

In contrast, platelet-rich plasma has emerged as one of the most promising intra-articular therapies in recent years (Filardo et al., 2011; Dai et al., 2017). The results of randomized controlled trials and meta-analyses consistently demonstrate clinically meaningful improvements in pain and function compared with both placebo and hyaluronic acid. The biological rationale underlying PRP therapy, including growth factor release and modulation of inflammatory pathways, supports its use in the context of osteoarthritis as a whole-joint disease (Andia & Maffulli, 2013).

Despite these favorable findings, the interpretation of PRP efficacy is limited by significant heterogeneity in preparation protocols, including differences in platelet concentration, leukocyte content, and activation methods (Dohan Ehrenfest et al., 2014). This lack of standardization remains a major limitation in the development of clear clinical recommendations.

Cell-based therapies, including mesenchymal stem cells and bone marrow aspirate concentrate, represent an advanced stage of regenerative medicine approaches in osteoarthritis (Freitag et al., 2016). Their mechanism of action is primarily based on immunomodulatory and paracrine effects rather than direct cartilage regeneration (Caplan & Correa, 2011). Clinical studies indicate improvements in pain, function, and quality of life; however, the strength of evidence remains limited by small sample sizes, methodological variability, and short follow-up periods.

An important finding of this review is the critical role of procedural factors, particularly injection accuracy, in determining treatment outcomes (Berkoff et al., 2012; Sibbitt et al., 2009). Ultrasound-guided injections have been shown to significantly improve precision and clinical effectiveness compared with landmark-based techniques.

These findings are particularly relevant in the context of sports medicine, where preservation of joint function, reduction of pain, and rapid return to physical activity are critical therapeutic goals. In this setting, intra-articular therapies—especially biological approaches such as platelet-rich plasma—may play a significant role in supporting functional recovery and maintaining long-term joint performance.

Taken together, these results support the concept of a personalized and phenotype-based approach to osteoarthritis management (Arden et al., 2021). Different intra-articular therapies may be more suitable for specific patient groups depending on disease stage, inflammatory activity, and functional demands.

Future research should focus on standardization of biological therapies, identification of predictors of treatment response, and development of combined therapeutic strategies integrating pharmacological, regenerative, and biomechanical interventions.

#### **4.1. Limitations of the study**

This study has several limitations related to its narrative design, including the absence of quantitative meta-analysis and the potential for selection bias in the reviewed literature (Arden et al., 2021). Additionally, heterogeneity in study methodologies, particularly in biological therapies such as platelet-rich plasma and mesenchymal stem cells, limits the direct comparability of results (Dohan Ehrenfest et al., 2014; Freitag et al., 2016).

### **5. Conclusions**

Modern intra-articular injection therapies play a significant role in the contemporary management of osteoarthritis, particularly within multimodal and individualized treatment strategies (Arden et al., 2021). Corticosteroids provide effective short-term pain relief but do not influence disease progression and should be used with caution, especially in repeated applications (McAlindon et al., 2017; Wernecke et al., 2015).

Hyaluronic acid demonstrates moderate and inconsistent clinical benefit, which limits its role in evidence-based therapeutic algorithms (Bannuru et al., 2015). Among currently available options, platelet-rich plasma provides the most consistent and clinically meaningful improvements in pain and function, supported by an increasing body of high-quality evidence (Filardo et al., 2011; Dai et al., 2017).

Mesenchymal stem cells and bone marrow aspirate concentrate represent promising regenerative therapies; however, their routine clinical use requires further standardization, cost optimization, and validation in large-scale clinical trials (Freitag et al., 2016).

From a sports medicine perspective, intra-articular therapies may play a key role in maintaining joint function, supporting physical performance, and facilitating return to activity in physically active individuals.

The future of osteoarthritis treatment is likely to be based on biologically driven, patient-specific approaches that integrate multiple therapeutic modalities in order to optimize clinical outcomes.

### **Disclosure**

The authors declare no competing interests regarding the publication of this paper.

### **Supplementary Materials**

Not applicable.

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**Writing - review and editing:** all authors.

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## **Conflicts of Interest**

The authors declare no conflict of interest.

## **References**

- Altman, R.D. & Bedi, A. (2015). Hyaluronic acid injections in osteoarthritis. *Cartilage*. <https://doi.org/10.1177/1947603515588578>
- Andia, I. & Maffulli, N. (2013). Platelet-rich plasma for managing pain and inflammation. *Expert Opinion on Biological Therapy*, 13(5), 573–585. <https://doi.org/10.1517/14712598.2013.774457>
- Anz, A.W. et al. (2020). PRP vs BMAC. *Orthopaedic Journal of Sports Medicine*.
- Arden, N.K. et al. (2021). Non-surgical management of knee osteoarthritis: comparison of ESCEO and OARSI 2019 guidelines. *Nature Reviews Rheumatology*, 17, 59–66. <https://doi.org/10.1038/s41584-020-00523-9>
- Bannuru, R.R. et al. (2015). Comparative effectiveness of pharmacologic interventions for knee osteoarthritis. *Annals of Internal Medicine*, 162(1), 46–54. <https://doi.org/10.7326/M14-1231>
- Bannuru, R.R. et al. (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>
- Berkoff, D.J., Miller, L.E. & Block, J.E. (2012). Ultrasound-guided knee injections are more accurate. *The American Journal of Sports Medicine*, 40(9), 2005–2008. <https://doi.org/10.1177/0363546512453299>
- Bowman, S. et al. (2018). Hyaluronic acid mechanisms. *Clinical Medicine Insights: Arthritis*.
- Campbell, K.A. et al. (2015). Platelet-rich plasma in meniscus repair. *Orthopaedic Journal of Sports Medicine*. <https://doi.org/10.1177/2325967115573298>
- Caplan, A.I. & Correa, D. (2011). MSC immunomodulatory mechanisms. *Cell Stem Cell*, 9(1), 11–15. <https://doi.org/10.1016/j.stem.2011.06.012>
- Centeno, C.J. et al. (2015). BMAC therapy outcomes. *Pain Physician*.

- Dai, W.L. et al. (2017). Efficacy of platelet-rich plasma in the treatment of knee osteoarthritis: a meta-analysis. *Arthroscopy*, 33(3), 659–670. <https://doi.org/10.1016/j.arthro.2016.09.024>
- Dohan Ehrenfest, D.M. et al. (2014). Classification of platelet concentrates. *Trends in Biotechnology*, 32(9), 469–478. <https://doi.org/10.1016/j.tibtech.2014.04.006>
- Filardo, G. et al. (2011). Platelet-rich plasma intra-articular injections for cartilage degeneration and osteoarthritis. *Knee Surgery, Sports Traumatology, Arthroscopy*, 19(4), 528–535. <https://doi.org/10.1007/s00167-010-1238-6>
- Finnoff, J.T. et al. (2010). Accuracy of ultrasound-guided injections. *PM&R*, 2(10), 957–963. <https://doi.org/10.1016/j.pmrj.2010.06.014>
- Freitag, J. et al. (2016). Mesenchymal stem cell therapy. *Regenerative Medicine*. <https://doi.org/10.2217/rme-2016-0046>
- Furuzawa-Carballeda, J. et al. (2012). Collagen therapy in osteoarthritis. *Journal of Inflammation*.
- Hochberg, M.C. et al. (2012). American College of Rheumatology recommendations. *Arthritis Care & Research*.
- 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)
- Jevsevar, D.S. et al. (2013). AAOS guideline update. *The Journal of Bone and Joint Surgery*.
- Kolasinski, S.L. et al. (2020). 2019 American College of Rheumatology/Arthritis Foundation guideline. *Arthritis Care & Research*, 72(2), 149–162. <https://doi.org/10.1002/acr.2413>
- Kon, E. et al. (2013). Biological treatments for cartilage regeneration. *The Journal of Knee Surgery*.
- Martel-Pelletier, J. et al. (2016). Osteoarthritis. *Nature Reviews Disease Primers*, 2, 16072. <https://doi.org/10.1038/nrdp.2016.72>
- McAlindon, T.E. et al. (2017). Effect of intra-articular triamcinolone vs saline on knee cartilage volume and pain. *JAMA*, 317(19), 1967–1975. <https://doi.org/10.1001/jama.2017.5283>
- Shen, L. et al. (2017). The temporal effect of PRP on pain. *Arthroscopy*. <https://doi.org/10.1016/j.arthro.2016.12.019>
- Sibbitt, W.L. et al. (2009). Does ultrasound guidance improve outcomes. *The Journal of Rheumatology*, 36(9), 1892–1902. <https://doi.org/10.3899/jrheum.090013>
- Silverwood, V. et al. (2015). Current evidence on risk factors for knee osteoarthritis. *Osteoarthritis and Cartilage*, 23(4), 507–515. <https://doi.org/10.1016/j.joca.2014.11.019>
- Smith, J. & Finnoff, J.T. (2009). Sonographically guided intra-articular injections. *Journal of Ultrasound in Medicine*, 28(10), 1393–1401. <https://doi.org/10.7863/jum.2009.28.10.1393>

Wernecke, C., Braun, H.J. & Dragoo, J.L. (2015). The effect of intra-articular corticosteroids on articular cartilage. *Orthopaedic Journal of Sports Medicine*.  
<https://doi.org/10.1177/2325967115581163>

Xie, X. et al. (2014). Platelet-rich plasma for knee osteoarthritis. *Arthroscopy*.  
<https://doi.org/10.1016/j.arthro.2014.05.007>