

Mesenchymal Stromal Cells in Knee Osteoarthritis: A Review of Nomenclature, Criteria, and Therapeutic Mechanisms

Doo-Ho Lim^{1,*}, Chae-Chil Lee^{2,*}, Ki-Bong Park^{1,2}

¹Department of Internal Medicine, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Republic of Korea; ²Department of Orthopedic Surgery, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Republic of Korea

*These authors contributed equally to this work

Correspondence: Ki-Bong Park, Department of Orthopedic Surgery, Ulsan University Hospital, University of Ulsan College of Medicine, Dong-Gu, Ulsan, Republic of Korea, Tel +82 52 250 7129, Fax +82 52 235 2823, Email kbpark@uuh.ulsan.kr

Abstract: Cell-based therapies, particularly utilizing mesenchymal cells, have garnered significant global attention for treating knee osteoarthritis (OA). However, interpreting clinical outcomes remains challenging due to substantial heterogeneity in study designs, cell sources, and preparation methods. This narrative review aims to clarify the evolving nomenclature, outline defining criteria, and elucidate the fundamental mechanisms of these therapies. We highlight the critical scientific transition from “mesenchymal stem cells” to “mesenchymal stromal cells”, an adjustment strongly supported by recent clinical approvals emphasizing immune recalibration over direct tissue regeneration. Currently, robust evidence indicates that mesenchymal stromal cells exert their therapeutic effects primarily through paracrine signaling and immunomodulation, predominantly orchestrated by exosomes, rather than through lineage-driven direct structural repair. Furthermore, we address the practical implications of cell processing—differentiating between minimal manipulation (e.g. cell concentrates) and in vitro expansion—and the stringent regulatory frameworks governing them. Ultimately, standardizing the mechanism-accurate “stromal” terminology and optimizing cell preparation protocols are essential steps for advancing the efficacy and reliability of regenerative treatments in knee OA.

Keywords: osteoarthritis, knee, mesenchymal stem cells, exosomes, paracrine communication, regenerative medicine, cell- and tissue-based therapy

Introduction

Degenerative osteoarthritis (OA) of the knee is a prevalent musculoskeletal disorder that requires various therapeutic interventions depending on the severity of joint damage.^{1–3} While surgical options are effective for end-stage OA, non-surgical treatments for early to moderate stages often focus on symptom management without definitive regenerative outcomes.^{1–3} Consequently, regenerative medicine has garnered significant interest, with extensive research focused on joint cartilage repair using stem cells. Medical Subject Headings (MeSH) defines “regenerative medicine” as a field concerned with developing and utilizing strategies to repair or replace damaged, diseased, or metabolically deficient organs, tissues, and cells.⁴

A fundamental understanding of stem cell biology is essential for accurately implementing these treatments and effectively explaining their clinical course and efficacy to patients.^{1,5,6} MeSH defines “stem cells” as relatively undifferentiated cells that retain the capability to divide and proliferate throughout postnatal life, providing progenitor cells that can subsequently differentiate into specialized cell types.^{7,8} Historically, however, the terms “mesenchymal stem cells” and “mesenchymal stromal cells” have been used interchangeably or incorrectly in various studies.^{1,5,9} Therefore, a precise understanding of the distinct characteristics of these cells is required to ensure clinical safety and

Table 1 Definitions of Key Technical Terms

Terms	Definition
Plasticity	The inherent capacity of a cell to differentiate into multiple distinct cell lineages or phenotypes depending on the microenvironment.
Plastic Adherence	A fundamental characteristic of mesenchymal cells to attach and proliferate on tissue-culture treated plastic surfaces under standard in vitro conditions.
Mesenchymal Stem Cells	A population of progenitor cells defined by their functional ability for self-renewal and potential to differentiate into tissues of mesodermal origin (eg., bone, cartilage, and fat).
Mesenchymal Stromal Cells	A more heterogeneous cell population that meets specific in vitro criteria (adherence, markers) and primarily exerts therapeutic effects through secretory, immunomodulatory, and paracrine functions.

therapeutic efficacy.^{1,3,5} To clarify these conceptual and technical distinctions, key terms and their definitions are summarized in Table 1.

Currently, the existing clinical evidence regarding cell-based therapies for knee OA is often limited by substantial heterogeneity across studies. This includes significant variations in cell sources, preparation and manufacturing methods, administered doses, and delivery techniques, all of which complicate the standardization of expected outcomes.¹⁰ To address these complexities, this narrative review aims to provide a comprehensive overview of mesenchymal stromal cells in the context of knee OA, focusing on clarifying the evolving nomenclature, outlining defining criteria, and elucidating their fundamental clinical mechanisms — particularly paracrine-mediated actions and immunomodulation rather than definitive direct cartilage regeneration.

Classification and Biological Characteristics of Stem Cells

The defining characteristics of stem cells include self-renewal, the ability to generate multiple daughter cells with identical morphology and potential, and differentiation into various specialized cell types (Figure 1).⁸ Stem cells are broadly categorized into three types based on their potency:

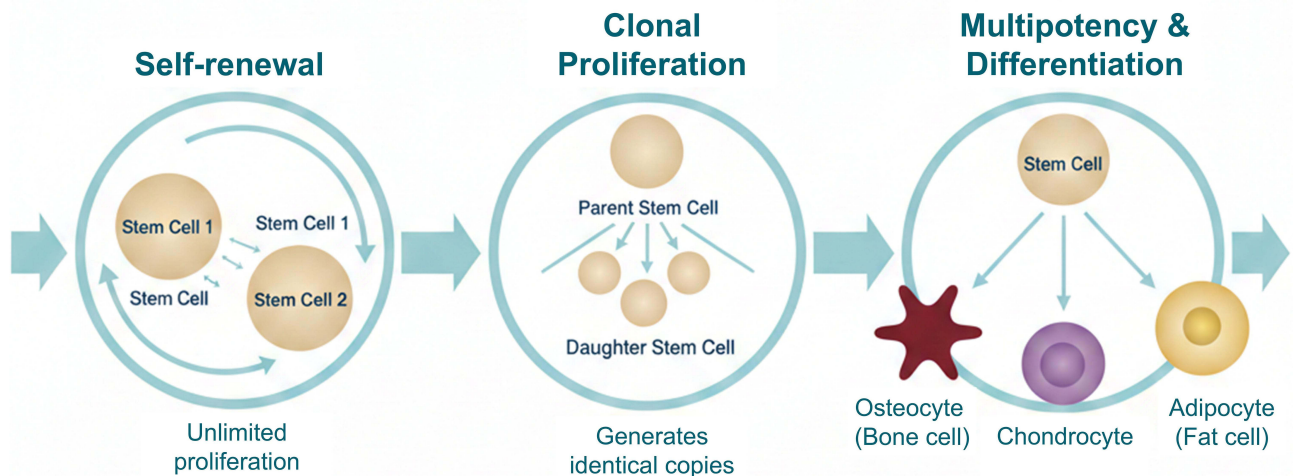


Figure 1 Core Biological Characteristics of Stem Cells. The defining properties of stem cells are characterized by three fundamental processes: 1. Self-renewal: The capacity of stem cells to undergo unlimited proliferation while maintaining their undifferentiated state through symmetric or asymmetric division. 2. Clonal Proliferation: The ability of a single parent stem cell to generate multiple identical daughter cells, ensuring the maintenance and expansion of the stem cell pool. 3. Multipotency and Differentiation: The potential of multipotent stem cells, such as mesenchymal stem cells (MSCs), to differentiate into various specialized mesodermal lineages, including osteocytes (bone cells), chondrocytes (cartilage cells), and adipocytes (fat cells), depending on specific microenvironmental signals.

- Totipotent stem cells: Embryonic cells existing immediately after fertilization that can differentiate into all embryonic and extra-embryonic cell types.
- Pluripotent stem cells: Cells capable of giving rise to all cell types of the body; embryonic stem cells are the representative example.
- Multipotent stem cells: Cells with a more restricted potential than pluripotent cells, capable of developing into multiple related cell types within a specific lineage; this group includes adult stem cells.

Mesenchymal stem cells (MSCs) are multipotent cells with diverse differentiation lineages that can develop into various musculoskeletal tissues, including bone and soft tissues.¹¹ Due to their ability to differentiate into osteogenic and chondrogenic lineages, they are widely utilized in regenerative medicine to address cartilage damage. To formally identify true MSCs, it is necessary to confirm their microscopic differentiation potential into specific lineages, such as osteocytes, chondrocytes, or adipocytes.¹²

Evolution of MSC Nomenclature: from “Stem” to “Stromal” Historical Context and Terminological Confusion

The terminological confusion between “mesenchymal stem cells” and “mesenchymal stromal cells” originated in the early 1990s and emerged as a prominent academic issue by the mid-2000s. In his 1991 paper, published in the *Journal of Orthopaedic Research*, Professor Arnold Caplan coined the term “mesengenic process” to describe the in vitro differentiation of specific cell populations into bone, cartilage, and other lineages. He designated these cells as “mesenchymal stem cells”, a milestone that catalyzed the global research and commercialization.¹³

Over time, however, it became evident that when administered in vivo, MSCs do not actually survive by directly differentiating into bone or cartilage tissues. The scientific dilemmas of this period are detailed in a later paper, “Mesenchymal stem cells: time to change the name!”, in which Professor Caplan explicitly advocated for a change in nomenclature.¹⁴ Repudiating the very name he established, Caplan clarified that these cells do not function as multipotent stem cells in vivo; rather, they serve to secrete immunomodulatory and trophic factors at the site of injury. Consequently, he proposed retaining the acronym “MSC” while redefining it as “medicinal signaling cells”.

Mechanism-Aligned Terminology and Recent Regulatory Approvals

The rationale for transitioning the MSC nomenclature from “mesenchymal stem cells” to “mesenchymal stromal cells” is to accurately reflect their true biological mechanisms of action and to mitigate public misconceptions associated with the legacy term “stem cell”.¹⁵ Historically, the “stem cell” designation was adopted based on the clonogenicity and multipotency observed during in vitro culture. However, accumulating clinical data have revealed that, in vivo, MSCs exert their therapeutic effects primarily through the secretion of paracrine factors and immunoregulatory mechanisms, rather than through direct, lineage-driven tissue regeneration.

Consequently, both the International Society for Cell & Gene Therapy (ISCT) and the Japanese Society for Regenerative Medicine (JSRM) are spearheading the movement to replace “stem cells” with “stromal cells” to better align with these biological functions. Through its 2019 official recommendation, the ISCT advised retaining the acronym “MSC” while adopting “mesenchymal stromal cells” as the full designation.¹⁶ Echoing this international convergence, the JSRM has also officially recommended the use of this mechanism-accurate terminology.¹⁷

Furthermore, the generic term “stem cells” can instill regeneration-centric expectations in patients, creating the misconception that damaged tissues will unconditionally regenerate. Transitioning the nomenclature clarifies that the primary objective is immune recalibration and inflammation control. Globally, the clinical application of mesenchymal stromal cells has been extensively evaluated in trials spanning the last two decades for the management of steroid-refractory acute graft-versus-host disease (aGVHD).¹⁸ Notably, in December 2024, the first MSC product approved by the United States Food and Drug Administration (U.S. FDA) was indicated for steroid-refractory pediatric aGVHD.¹⁵ Similarly, in January 2025, a product conditionally approved by China’s National Medical Products Administration was also targeted at aGVHD.¹⁵ The approval of these therapies primarily for immune-mediated diseases corroborates that the

predominant mechanism of MSCs is immunomodulation, strongly reinforcing the argument for unifying the nomenclature as “stromal cells”.

Minimal Criteria for Defining Mesenchymal Stromal Cells

To standardize scientific investigations and preclinical studies, the ISCT’s Mesenchymal and Tissue Stem Cell Committee proposed a set of minimal criteria to define human mesenchymal stromal cells.⁶ First, these cells must exhibit adherence to plastic surfaces when maintained under standard culture conditions. Second, the cell population must demonstrate a specific phenotypic profile, characterized by the expression of positive surface antigens such as CD105, CD73, and CD90 ($\geq 95\%$), while remaining negative ($\leq 2\%$) for hematopoietic markers including CD45, CD34, CD14 or CD11b, CD79 α or CD19, and HLA-DR molecules.⁹ Finally, *in vitro* assays must demonstrate the capacity of the cells to achieve trilineage differentiation into osteoblasts, chondroblasts, and adipocytes under standard differentiating conditions.

Mechanisms of Action: The Shift to Paracrine Signaling From Direct Regeneration to Paracrine Action

The therapeutic effects of mesenchymal stromal cells are understood through two primary mechanisms. The “old school” theory previously suggested direct cell differentiation, positing that mesenchymal stromal cells participate in the repair process by structurally differentiating into tissue-specific chondrocytes. However, contemporary understanding has shifted away from expectations of definitive, direct cartilage regeneration.

Instead, current evidence emphasizes paracrine action. In this model, mesenchymal stromal cells migrate from their perivascular niches to the site of injury in response to inflammatory signals, where they secrete bioactive molecules to re-establish tissue homeostasis. This paracrine secretion reduces inflammation, oxidative stress, and apoptosis while promoting the recruitment of endogenous regenerative cells. Due to this dominant functional role, the term “medicinal signaling cells” has been proposed as a more accurate alternative.¹⁴ Therefore, the efficacy of these therapies should primarily be evaluated based on their immunomodulatory capacities and symptom management, rather than structural cartilage regeneration.

Biogenesis of Exosomes and Macrophage Polarization

Exosomes are cell-secreted nanovesicles, ranging from 30 to 150 nm in diameter, that encapsulate a diverse array of bioactive substances, including proteins, deoxyribonucleic acid, messenger ribonucleic acid (mRNA), and microRNA (miRNA). The biogenesis of exosomes follows an intracellular endosomal pathway. This process is initiated by a double invagination process to form an “early endosome”, which subsequently matures into multi-vesicular bodies. These multi-vesicular bodies then fuse with the plasma membrane, discharging their internal vesicles into the extracellular space. It is only upon this release into the extracellular environment that these vesicles are formally designated as “exosomes”.¹⁹

Historically, it was believed that administered mesenchymal stromal cells directly differentiated into new cartilage. However, it is now widely accepted that exosomes secreted by mesenchymal stromal cells orchestrate the regeneration of surrounding endogenous cells. In regions of OA or tissue injury, pro-inflammatory M1 macrophages are highly active, driving destructive inflammation. When mesenchymal stromal cell-derived exosomes are internalized by these macrophages, their bioactive cargo induces macrophage polarization, shifting them toward an anti-inflammatory and tissue-regenerating M2 phenotype.²⁰ Furthermore, the secreted exosomes fuse with target cells — such as mechanically degraded and senescent chondrocytes — to deliver their payload, which inhibits apoptosis, stimulates cell proliferation, and promotes the synthesis of extracellular matrix, ultimately establishing a microenvironment conducive to endogenous tissue repair.

Clinical Applications, Efficacy, and Regulatory Frameworks Cell Sources and Processing Methods

For successful treatment using mesenchymal stromal cells, the initial step involves selecting an appropriate source for adult cell collection.⁹ Cells can be harvested from diverse tissues, including bone marrow, adipose tissue, synovial fluid,

and umbilical cord. The clinical pathway for mesenchymal stromal cells-based treatment in knee OA can be categorized based on the cell source and processing method.²¹ Clinicians must decide whether to utilize cell concentrates obtained via centrifugation or cells expanded through in vitro culture. To provide a clear overview of the current clinical landscape, address the heterogeneity of available products, and clarify their regulatory classification based on processing methods, we have summarized the clinical approaches and main outcomes associated with different MSC product types in Table 2.

Clinical Efficacy and Managing Heterogeneity

While regenerative medicine has garnered significant interest, evaluating the true clinical efficacy of these therapies is challenged by substantial heterogeneity across clinical studies.^{2,3,24–26} This heterogeneity stems from diverse cell sources, processing methods, and patient indications, making direct comparisons difficult. Despite this, several systematic reviews have reported positive symptomatic outcomes. Ha et al²⁵ reported that intra-articular injections provide notable improvements in pain and function during short-term follow-up, though definitive evidence of macroscopic cartilage regeneration remains inconclusive. Additionally, Zhang et al²⁴ highlighted that human umbilical cord-derived MSCs offer advantages in terms of abundant supply and convenient extraction processes, while promoting a chondroprotective microenvironment.

Regulatory Frameworks for Cell Culture Expansion

The regulatory classification of mesenchymal stem/stromal cells hinges critically on the manufacturing process, specifically in vitro culture expansion. Across major global jurisdictions, cell expansion is universally recognized as exceeding “minimal manipulation”. Consequently, cultured MSCs are regulated under stringent biological drug frameworks rather than as simple tissue grafts.

For instance, the U.S. FDA classifies expanded cells as Section 351 biological products requiring a Biologics License Application due to exceeding minimal manipulation criteria, while non-expanded tissues may be regulated under Section 361 as simple tissue grafts.²⁷ The European Medicines Agency designates expanded cells as Advanced Therapy Medicinal Products based on Regulation (EC) No 1394/2007.²⁸ Similarly, South Korea regulates expanded cells under a specific advanced biopharmaceutical framework, the Advanced Regenerative Medicine and Advanced Biopharmaceuticals Safety and Support Act.²⁹ Notably, Japan possesses one of the most flexible regulatory frameworks globally. Commercial cell therapy products fall under the Pharmaceuticals and Medical Devices Act,³⁰ which utilizes a “conditional and time-limited approval” system to enable early commercialization based solely on Phase II clinical trial results. Conversely, physician-led cultured cell procedures are governed by the Act on the Safety of Regenerative Medicine³¹ and are strictly managed according to their respective risk classifications.

Table 2 Summary of MSC-Based Treatments: Classification, Processing Methods, and Clinical Outcomes

Product Type	Cell/Tissue Source	Processing Method & Clinical Approach	Main Clinical Efficacy and Results	References
Progenitor Cell Concentrate (eg., Bone Marrow Aspirate Concentrate)	Autologous	Minimal manipulation (eg., Centrifugation); One-step procedure	Clinically feasible procedure; effective in providing symptomatic relief and functional recovery	Kim et al ²²
In Vitro Expanded Autologous MSCs (eg., Bone Marrow MSCs)	Autologous	Extraction followed by cell expansion (exceeds minimal manipulation); Two-step procedure	Demonstrated safety in moderate to severe OA; provided short-term pain relief and functional improvement via paracrine effects	Al-Najar et al; ¹² Doyle et al ²³
In Vitro Expanded Allogeneic MSCs (eg., Umbilical Cord MSCs)	Allogeneic	Pre-cultured and cryopreserved; Ready-to-use one-step procedure	Abundant allogeneic supply; provides symptomatic relief and helps establish a chondroprotective environment.	Zhang et al ²⁴

Abbreviations: MSC, Mesenchymal Stromal Cells; OA, Osteoarthritis.

Conclusion

Nonsurgical treatments utilizing cell-based therapies for knee OA are garnering significant global attention. However, while the biological concepts underlying these therapies—particularly paracrine-mediated signaling and immunomodulation—are highly promising, their therapeutic efficacy and capacity for true cartilage regeneration remain areas of ongoing investigation rather than definitively established clinical outcomes. To define the real clinical role of these therapies, future efforts must prioritize better standardization, clearer product characterization, and higher-quality clinical studies. Ultimately, to accurately reflect these paracrine-driven mechanisms and to ensure precise communication in both clinical and academic settings, we strongly recommend the adoption of the term “Mesenchymal Stromal Cells” over “Mesenchymal Stem Cells”.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

There is no funding to report.

Disclosure

Doo-Ho Lim and Chae-Chil Lee are co-first authors for this study. The authors report no conflicts of interest in this work.

References

1. Park YB, Ha CW, Rhim JH, Lee HJ. Stem cell therapy for articular cartilage repair: review of the entity of cell populations used and the result of the clinical application of each entity. *Am J Sports Med.* 2018;46(10):2540–2552. doi:10.1177/0363546517729152
2. Zhao L, Kaye AD, Abd-Elseyed A. Stem cells for the treatment of knee osteoarthritis: a comprehensive review. *Pain Physician.* 2018;21(3):229–242.
3. Cong B, Sun T, Zhao Y, Chen M. Current and novel therapeutics for articular cartilage repair and regeneration. *Ther Clin Risk Manag.* 2023;19:485–502. doi:10.2147/TCRM.S410277
4. National Library of Medicine. Medical Subject Headings (MeSH): regenerative medicine. Available from: <https://www.ncbi.nlm.nih.gov/mesh/?term=regenerative+medicine>. Accessed January 8, 2026.
5. Horwitz EM, Le Blanc K, Dominici M, et al. Clarification of the nomenclature for MSC: the International Society for Cellular Therapy position statement. *Cytotherapy.* 2005;7(5):393–395. doi:10.1080/14653240500319234
6. Dominici M, Le Blanc K, Mueller I, et al. Minimal criteria for defining multipotent mesenchymal stromal cells. The International Society for Cellular Therapy position statement. *Cytotherapy.* 2006;8(4):315–317. doi:10.1080/14653240600855905
7. National Library of Medicine. Medical Subject Headings (MeSH): stem cells. Available from: <https://www.ncbi.nlm.nih.gov/mesh/68013234>. Accessed January 8, 2026.
8. UpToDate. Overview of stem cells. Available from: <https://www.uptodate.com/contents/overview-of-stem-cells>. Accessed January 8, 2026.
9. Xiang XN, Zhu SY, He HC, et al. Mesenchymal stromal cell-based therapy for cartilage regeneration in knee osteoarthritis. *Stem Cell Res Ther.* 2022;13(1):14. doi:10.1186/s13287-021-02689-9
10. Giordano R, Albano D, Fusco S, Peretti GM, Mangiavini L, Messina C. Knee osteoarthritis: epidemiology, pathogenesis, and mesenchymal stem cells: what else is new? An update. *Int J Mol Sci.* 2023;24(7):6405. doi:10.3390/ijms24076405
11. Shariatzadeh M, Song J, Wilson SL. The efficacy of different sources of mesenchymal stem cells for the treatment of knee osteoarthritis. *Cell Tissue Res.* 2019;378(3):399–410. doi:10.1007/s00441-019-03069-9
12. Al-Najar M, Khalil H, Al-Ajlouni J, et al. Intra-articular injection of expanded autologous bone marrow mesenchymal cells in moderate and severe knee osteoarthritis is safe: a phase I/II study. *J Orthop Surg Res.* 2017;12(1):190. doi:10.1186/s13018-017-0689-6
13. Wakitani S, Mera H, Nakamura N, Gobbi A. Review of Caplan (1991) on cell-based therapeutic technology using mesenchymal stem cells. *J ISAKOS.* 2024;9(3):426–430. doi:10.1016/j.jisako.2023.08.010
14. Caplan AI. Mesenchymal stem cells: time to change the name! *Stem Cells Transl Med.* 2017;6(6):1445–1451. doi:10.1002/sctm.17-0051
15. Long Q. From “stem” to “stromal”: reframing the nomenclature of mesenchymal stromal cell therapy. *Cell Transplant.* 2025;34:9636897251385288. doi:10.1177/09636897251385288

16. Viswanathan S, Shi Y, Galipeau J, et al. Mesenchymal stem versus stromal cells: international Society for Cell & Gene Therapy (ISCT®) Mesenchymal Stromal Cell committee position statement on nomenclature. *Cytotherapy*. 2019;21(10):1019–1024. doi:10.1016/j.jcyt.2019.08.002
17. Terai S, Ezoe S, Mano K, et al. Recommendations for the safe implementation of intravenous administration of mesenchymal stromal cells. *Regen Ther*. 2025;29:171–176. doi:10.1016/j.reth.2025.01.024
18. Alsultan A, Farge D, Kili S, et al. International Society for Cell and Gene Therapy Clinical Translation Committee recommendations on mesenchymal stromal cells in graft-versus-host disease: easy manufacturing is faced with standardizing and commercialization challenges. *Cytotherapy*. 2024;26(10):1132–1140. doi:10.1016/j.jcyt.2024.05.007
19. Yuan YG, Wang JL, Zhang YX, Li L, Reza AMMT, Biogenesis GS. Composition and potential therapeutic applications of mesenchymal stem cells derived exosomes in various diseases. *Int J Nanomed*. 2023;18:3177–3210. doi:10.2147/IJN.S407029
20. Zhang J, Rong Y, Luo C, Cui W. Bone marrow mesenchymal stem cell-derived exosomes prevent osteoarthritis by regulating synovial macrophage polarization. *Aging*. 2020;12(24):25138–25152. doi:10.18632/aging.104110
21. Lopa S, Colombini A, Moretti M, de Girolamo L. Injective mesenchymal stem cell-based treatments for knee osteoarthritis: from mechanisms of action to current clinical evidences. *Knee Surg Sports Traumatol Arthrosc*. 2019;27(6):2003–2020. doi:10.1007/s00167-018-5118-9
22. Kim JD, Lee GW, Jung GH, et al. Clinical outcome of autologous bone marrow aspirates concentrate (BMAC) injection in degenerative arthritis of the knee. *Eur J Orthop Surg Traumatol*. 2014;24(8):1505–1511. doi:10.1007/s00590-013-1393-9
23. Doyle EC, Wragg NM, Wilson SL. Intraarticular injection of bone marrow-derived mesenchymal stem cells enhances regeneration in knee osteoarthritis. *Knee Surg Sports Traumatol Arthrosc*. 2020;28(12):3827–3842. doi:10.1007/s00167-020-05859-z
24. Zhang P, Dong B, Yuan P, Li X. Human umbilical cord mesenchymal stem cells promoting knee joint chondrogenesis for the treatment of knee osteoarthritis: a systematic review. *J Orthop Surg Res*. 2023;18(1):639. doi:10.1186/s13018-023-04131-7
25. Ha CW, Park YB, Kim SH, Lee HJ. Intra-articular mesenchymal stem cells in osteoarthritis of the knee: a systematic review of clinical outcomes and evidence of cartilage repair. *Arthroscopy*. 2019;35(1):277–288.e2. doi:10.1016/j.arthro.2018.07.028
26. Getelman MH. Editorial commentary: stem cell treatment for knee osteoarthritis: holy grail or tin cup? *Arthroscopy*. 2019;35(1):289–290. doi:10.1016/j.arthro.2018.08.027
27. US Food and Drug Administration. *Regulatory Considerations for Human Cells, Tissues, and Cellular and Tissue-Based Products: Minimal Manipulation and Homologous Use; Guidance for Industry and Food and Drug Administration Staff*. Silver Spring, MD: US Food and Drug Administration; 2020.
28. European Parliament, Council of the European Union. Regulation (EC) No 1394/2007 of the European Parliament and of the Council of 13 November 2007 on advanced therapy medicinal products and amending Directive 2001/83/EC and Regulation (EC) No 726/2004. Official Journal of the European Union. 2007;L324:121–137.
29. National Assembly of the Republic of Korea. Advanced Regenerative Medicine and Advanced Biopharmaceuticals Safety and Support Act. Act No. 16556. Enacted August 27, 2019.
30. National Diet of Japan. Act on Securing Quality, Efficacy and Safety of Products Including Pharmaceuticals and Medical Devices (PMD Act). Act No. 84 of 2013.
31. National Diet of Japan. Act on the Safety of Regenerative Medicine (ASRM). Act No. 85 of 2013.

Therapeutics and Clinical Risk Management

Publish your work in this journal

Therapeutics and Clinical Risk Management is an international, peer-reviewed journal of clinical therapeutics and risk management, focusing on concise rapid reporting of clinical studies in all therapeutic areas, outcomes, safety, and programs for the effective, safe, and sustained use of medicines. This journal is indexed on PubMed Central, CAS, EMBase, Scopus and the Elsevier Bibliographic databases. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/therapeutics-and-clinical-risk-management-journal>

Dovepress
Taylor & Francis Group