International Journal of Research in Medical Sciences
Rastogi A et al. Int J Res Med Sci. 2025 Oct;13(10):4559-4560
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20253220

Editorial

Knee deep in innovation: advancing osteoarthritis therapy through regenerative medicine and precision interventions

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Received: 28 July 2025
Accepted: 10 September 2025

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Knee osteoarthritis (KOA) is a complex, heterogeneous illness that includes abnormal joint remodelling, chronic inflammation, mechanical strain, and metabolic dysregulation. It is not just a disease of cartilage loss. Its increasing prevalence highlights the critical need for disease-modifying approaches beyond palliation, particularly in older and obese individuals.[1]

Non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroid injections, physical therapy, and ultimately total knee arthroplasty (TKA) have been the mainstays of the treatment strategy for KOA for decades. These modalities do not address the fundamental biological processes that drive the progression of disease, despite the fact that they offer alleviation.

There is a new perspective regarding regenerative medicine, especially regarding intra-articular drugs like platelet-rich plasma (PRP) and mesenchymal stem cells (MSCs). These treatments work by modulating angiogenesis, matrix breakdown, and synovial inflammation in addition to tissue regeneration.[2,3] Early trials show improvements in imaging-based indicators and patient-reported outcomes in early-to-moderate KOA.[4,5] However, the lack of long-term data, varying regulatory standards, and procedure heterogeneity must temper enthusiasm. Before these treatments are generally accepted, rigorous randomized controlled studies and the standardization of biologic products are necessary.[6]

Simultaneously, precision medicine is changing our understanding of and approach to treating KOA. KOA is rapidly being classified into phenotypes, each with unique therapeutic implications, and is no longer considered a single disease. Clinicians are now able to investigate tailored therapies, such as bracing for varus malalignment, neuromuscular reconditioning for proprioceptive deficits, and gait retraining for aberrant loading, thanks to the convergence of gait biomechanics, wearable technology, digital imaging, and genetic profiling.[7]

Furthermore, inventive possibilities have been made possible by the use of machine learning (ML) and artificial intelligence (AI) into KOA care. Clinical, radiological, and biomechanical data can be used to create predictive models that can predict treatment response and progression, guiding the choice of intervention type and timing. Even though these technologies are still developing, they have the potential to change joint preservation from a reactive to a proactive strategy.[8,9]

With advanced disease, precise surgical execution catered to each patient's unique joint morphology and biomechanics is now possible thanks to patient-specific equipment and robot-assisted total knee arthroscopy (TKA), which may improve long-term results and lower revision rates. In the pursuit of individualized KOA care, these technologies are prime examples of how digital innovation enhances biological techniques.[10,11]

However, there are still significant challenges to overcome. The lack of standardized care routes, payment restrictions, and regulatory ambiguity all impede the adoption of regenerative and precision techniques from the bench to the bedside. Ensuring equitable access is also crucial; advances must help all patients, not just those who are privileged financially or logistically.

The management of KOA is at a turning point. Care could be redefined by the combination of precision technology and regenerative biology, moving from symptomatic

management to patient-specific, mechanistically informed therapy. However, innovation alone won't be enough. In order to bridge the gap between potential and practice, interdisciplinary cooperation, practical testing, and unambiguous instructions will prove essential.

REFERENCES

1. Hunter DJ, Bierma-Zeinstra S. Osteoarthritis. Lancet. 2019;393(10182):1745-59.
2. Murphy MB, Moncivais K, Caplan AI. Mesenchymal stem cells: environmentally responsive therapeutics for regenerative medicine. Exp Mol Med. 2013;45(11):e54.
3. Filardo G, Kon E, Di Matteo B, Di Martino A, Merli G, Marcacci M. Platelet-rich plasma for the treatment of knee osteoarthritis: an updated systematic review and meta-analysis. Am J Sports Med. 2021;49(1):195-203.
4. Gupta PK, Das AK, Chullikana A, Majumdar AS. Efficacy and safety of adult human bone marrow-derived, cultured, pooled, allogeneic MSCs (Stempeucel®): preclinical and clinical trial in osteoarthritis of the knee joint. Arthritis Res Ther. 2016;18(1):301.
5. Mautner K, Malanga GA, Smith J, Shiple B, Sampson S, Bowen JE, et al. A call for a standard classification system for future biologic research: the rationale for new PRP nomenclature. PM R. 2015;7(4 Suppl):S53-9.
6. McIntyre JA, Jones IA, Han B, Vangsness CT Jr. Intra-articular mesenchymal stem cell therapy for the human joint: a systematic review of clinical trials on intra-articular MSC injections. Am J Sports Med. 2018;46(14):3550-63.
7. Dell'Isola A, Allan R, Smith SL, Marreiros SS, Steultjens M. Identification of clinical phenotypes in knee osteoarthritis: a systematic review of the literature. BMC Musculoskelet Disord. 2016;17(1):425.
8. Saxby DJ, Killen BA, Fiedler B, Besier TF, Palanisamy R, Diamond LE. Wearable technology in osteoarthritis: a scoping review. Phys Ther. 2021;101(4):pzab010.
9. Tiulpin A, Klein S, Bierma-Zeinstra SMA, Thevenot J, Rahtu E, Lehenkari P, et al. Multimodal machine learning-based knee osteoarthritis progression prediction from plain radiographs and clinical data. Sci Rep. 2019;9(1):20038.
10. Kayani B, Konan S, Tahmassebi J, Pietrzak JRT, Haddad FS. Robotic technology in total knee arthroplasty: a review of the literature and future directions. Bone Joint J. 2019;101-B(7):852-60.
11. Conditt MA, Roche MW. Minimally invasive robotic-arm-guided unicompartmental knee arthroplasty. J Bone Joint Surg Am. 2009;91:63-8.

Cite this article as: Rastogi A, Kalia RB, Meena PK. Knee deep in innovation: advancing osteoarthritis therapy through regenerative medicine and precision interventions. Int J Res Med Sci 2025;13:4559-60.