World Journal of Orthopedics

Submit a Manuscript: https://www.f6publishing.com

World J Orthop 2025 December 18; 16(12): 110377

DOI: 10.5312/wjo.v16.i12.110377

ISSN 2218-5836 (online)

MINIREVIEWS

Platelet rich plasma applications in orthopedics: A review of recent advances

Arnav Pankaj Rathod, Yogesh Rathod, Rajendra Baitule, Ganesh Pundkar, Hrishikesh Saodekar

Specialty type: Orthopedics

Provenance and peer review: Invited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's classification

Scientific Quality: Grade B, Grade C

Novelty: Grade C, Grade C

Creativity or Innovation: Grade B, Grade B

Scientific Significance: Grade B, Grade C

P-Reviewer: Fan XC, MD, PharmD, PhD, Post Doctoral Researcher, Postdoc, Postdoctoral Fellow, Research Assistant Professor, China

Received: June 9, 2025

Revised: August 8, 2025

Accepted: October 22, 2025

Published online: December 18, 2025

Processing time: 192 Days and 21.3 Hours

Arnav Pankaj Rathod, Yogesh Rathod, Rajendra Baitule, Ganesh Pundkar, Hrishikesh Saodekar, Department of Orthopedics, Dr. Panjabrao Deshmukh Memorial Medical College and Hospital, Amravati 444602, Mahārāshtra, India

Co-corresponding authors: Arnav Pankaj Rathod and Yogesh Rathod.

Corresponding author: Arnav Pankaj Rathod, Academic Fellow, Department of Orthopedics, Dr. Panjabrao Deshmukh Memorial Medical College and Hospital, Flat No. 412, 4th Floor, Amravati 444601, Mahārāshtra, India. rarnav95@yahoo.in

Abstract

Platelet-rich plasma (PRP) therapy has gained prominence in orthopedics as a regenerative approach that utilizes autologous platelets enriched with growth factors to facilitate tissue healing. Innovations such as protein-enriched filtered PRP and the integration of PRP with biomaterials, including 3D-printed scaffolds and bioactive molecules like kartogenin, have been developed to enhance outcomes in cartilage and bone repair. Clinical studies have demonstrated the efficacy of PRP in managing conditions such as knee osteoarthritis, rotator cuff tendinopathy, and lateral epicondylitis, often showing superior long-term benefits compared with conventional treatments. Emerging therapies that combine PRP with mesenchymal stem cells and peptide-based treatments have shown synergistic effects, further enhancing tissue regeneration and functional recovery. Despite these promising developments, variability in PRP preparation methods and application protocols underscores the need for standardized guidelines and large-scale clinical trials to fully establish the role of PRP in orthopedic practice.

Key Words: Platelet-rich plasma; Regenerative medicine; Tendinopathy; Osteoarthritis; Cartilage repair

©The Author(s) 2025. Published by Baishideng Publishing Group Inc. All rights reserved.

Core Tip: Recent advancements have firmly established platelet-rich plasma (PRP) therapy as a valuable tool in orthopedic care. Innovations such as protein-enriched filtered PRP, integration with 3D-printed scaffolds, and combination therapies with mesenchymal stem cells and peptides have enhanced its regenerative potential. These developments have expanded PRP applications beyond sports medicine to include osteoarthritis, tendinopathies, and cartilage defects. While PRP offers promising outcomes, standardization of preparation methods and further large-scale clinical trials are essential to optimize its efficacy and establish comprehensive clinical guidelines.

Citation: Rathod AP, Rathod Y, Baitule R, Pundkar G, Saodekar H. Platelet rich plasma applications in orthopedics: A review of recent advances. *World J Orthop* 2025; 16(12): 110377
URL: https://www.wjgnet.com/2218-5836/full/v16/i12/110377.htm
DOI: https://dx.doi.org/10.5312/wjo.v16.i12.110377

INTRODUCTION

Orthopedic medicine has witnessed significant advancements in recent years, particularly with the introduction of regenerative therapies aimed at enhancing tissue repair and functional recovery. Among these, platelet-rich plasma (PRP) therapy has emerged as a prominent modality, gaining attention for its potential to accelerate healing in a variety of musculoskeletal conditions[1].

PRP is an autologous concentration of platelets suspended in a small volume of plasma. It is rich in growth factors and cytokines that play pivotal roles in tissue regeneration. These bioactive molecules, including platelet-derived growth factor, transforming growth factor-beta, vascular endothelial growth factor, and insulin-like growth factor, contribute to cellular proliferation, angiogenesis, and extracellular matrix synthesis, thereby facilitating tissue repair[2].

The application of PRP in orthopedics has expanded beyond its initial role in sports medicine to include osteoarthritis (OA), tendinopathies, ligament injuries, and cartilage defects. Clinical studies have demonstrated its efficacy in reducing pain, improving joint function, and enhancing the quality of life for patients with these conditions[3].

Recent research has focused on optimizing PRP preparation methods, standardizing protocols, and clarifying the mechanisms underlying its therapeutic effects. Innovations such as leukocyte-rich *vs* leukocyte-poor PRP formulations, different activation techniques, and combination therapies with stem cells or biomaterials are being investigated to maximize clinical benefits[4].

Despite its potential, heterogeneity in PRP preparation and application protocols creates challenges in comparing study outcomes and establishing definitive clinical guidelines. Ongoing research and well-designed randomized controlled trials are therefore essential to determine the optimal use of PRP in orthopedic practice[5].

This review provides a comprehensive overview of recent advances in PRP therapy in orthopedics, highlighting current evidence, emerging techniques, and future directions to inform clinical practice. The preparation and mechanism of action of PRP are summarized in Figure 1.

APPLICATIONS IN ORTHOPEDICS

Knee OA

A study titled investigated the effects of intra-articular PRP injections in patients with knee OA[6]. Twenty-four participants with Kellgren-Lawrence grade II or III OA received three 2 mL PRP injections at 1-month intervals. Clinical assessments using the Oxford Knee Score (OKS) and Visual Analogue Scale (VAS) were performed on days 0, 90, and 180. Ultrasound measurements of femoral and trochlear cartilage thickness were taken at baseline and on days 90 and 180. Results demonstrated a reduction in mean pain scores from 7.2 at baseline to 4.5 by day 180, alongside an improvement in OKS from 33.5 to 38.5. Cartilage thickness increased from 0.92 mm at baseline to 1.01 mm by Day 180, indicating significant cartilage regeneration following PRP treatment. The study concluded that PRP effectively alleviates symptoms, improves joint function, and promotes articular cartilage repair in patients with knee OA[6].

A randomized controlled trial involving 50 participants with knee OA further confirmed the efficacy of intra-articular PRP injections. Two injections administered four weeks apart resulted in significant improvements at 3 months in pain, stiffness, and physical function, as assessed by the Western Ontario and McMaster Universities Arthritis Index (WOMAC). Mean pain scores decreased from 7.44 to 4.8 on the VAS, while WOMAC subscores for pain, stiffness, and physical function improved by 75.5%, 84.5%, and 46.2%, respectively. No adverse effects were reported, supporting PRP as a safe and effective treatment for knee OA[7].

Rotator cuff disease

Rotator cuff tendinopathy, a common shoulder disorder, has been effectively managed using PRP injections.

Comparative efficacy: A systematic review and meta-analysis of 12 randomized controlled trials involving 639 patients compared PRP injections with corticosteroid (CS) injections in treating rotator cuff disease. CS injections showed superior

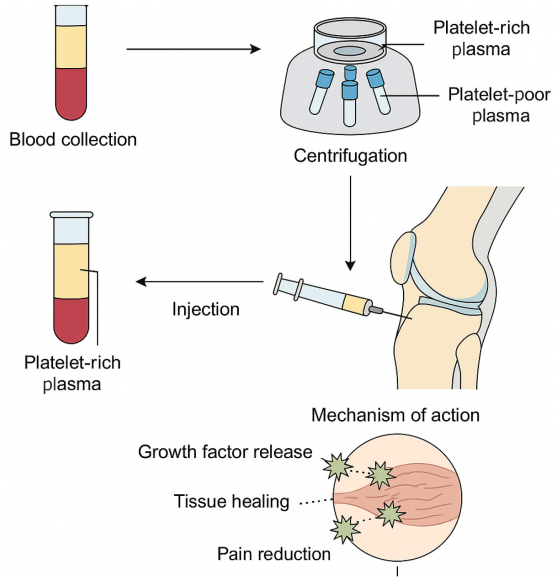


Figure 1 Preparation and mechanism of action of platelet-rich plasma. Whole blood is collected and centrifuged to separate platelet-rich plasma from platelet-poor plasma. The platelet-rich plasma is injected into the affected site, where it promotes healing through growth factor release, tissue regeneration, and pain reduction.

short-term improvements in Disabilities of the Arm, Shoulder, and Hand (DASH) scores and the Simple Shoulder Test. However, PRP injections provided greater benefits at intermediate and medium-term follow-ups, particularly in American Shoulder and Elbow Surgeons scores. Both treatments achieved the minimal clinically important difference, suggesting clinical effectiveness for both. Despite statistical differences across follow-ups, no significant clinical difference was identified overall, indicating that both PRP and CS injections remain viable management options[8].

Functional improvements: A randomized controlled trial with 58 patients compared PRP with CS injections for rotator cuff tendinopathy. Over 3 months, PRP resulted in significantly greater improvements in pain reduction and range of motion (ROM) in shoulder adduction and external rotation. Pain scores decreased from 6.66 to 3.08 on the VAS in the PRP group, compared with a decrease from 5.53 to 3.88 in the CS group. ROM improvements were also greater in the PRP group, with adduction increasing from 20.5° to 28° and external rotation from 59.66° to 76.66°, compared with improvements from 23.21° to 28.46° and from 57.14° to 65.57° in the CS group. These findings suggest PRP injections may offer superior short-term benefits in pain relief and functional recovery than CS injections in patients with rotator cuff tendinopathy[9].

Lateral epicondylitis (tennis elbow)

PRP therapy has also been investigated for the treatment of lateral epicondylitis, commonly known as tennis elbow.

Short-term *vs* long-term outcomes: A systematic review and meta-analysis of 13 randomized controlled trials compared PRP with CS injections for treating lateral epicondylitis (tennis elbow). CS injections provided superior pain relief at 1 month, while PRP produced more significant improvements in pain at 3 and 6 months. Pooled estimates of VAS scores favored CS at 1 month (P = 0.75) but shifted in favor of PRP at 3 months (P = 0.003) and 6 months (P < 0.0001). Similarly, DASH scores favored CS at 1 month (P = 0.028) but favored PRP at 3 months (P = 0.01), with no significant difference at 6 months (P = 0.107). These findings indicate that although CS injections may provide superior short-term relief, PRP offers sustained improvements in pain and function over the medium term[10-15]. An overview of clinical applications of PRP across various orthopedic conditions is provided in Table 1[1,3,6-10,15-19].

RECENT ADVANCES IN PRP

Recent innovations in PRP formulations have significantly advanced orthopedic regenerative therapies. The development of protein-enriched filtered PRP (PEF PRP) and the integration of PRP with biomaterials such as 3D-printed scaffolds and kartogenin (KGN) have shown considerable promise in enhancing tissue repair and regeneration.

PEF PRP

PEF PRP is an advanced formulation achieved through ultrafiltration techniques that concentrate beneficial proteins and growth factors while removing unwanted components. This process produces a PRP product with enhanced regenerative potential.

Table 1 Clinical applications of platelet-rich plasma in orthopedic conditions

Orthopedic condition	Type of PRP used	Level of evidence	Key findings	Ref.
Knee osteoarthritis	LR-PRP/LP-PRP	RCTs, meta-analyses	Significant pain and function improvement in early to moderate OA; superior to HA and corticosteroids in mid-term follow-up	[6,7,18]
Rotator cuff tears	LR-PRP	RCTs, cohort studies	Mixed results; some studies report reduced retear rate and improved healing post-repair	[8,9]
Lateral epicondylitis	LP-PRP	RCTs, systematic reviews	Faster and sustained pain relief compared to corticosteroids; functional gains observed	[10]
Achilles tendinopathy	LP-PRP	Systematic reviews	Limited clinical benefit; high variability in outcomes	[1,3]
Meniscal repair	LR-PRP	Cohort studies	Enhanced healing rates in arthroscopic repairs; evidence still low	[15,16]
ACL reconstruction	LR-PRP	RCTs	Accelerates graft maturation and tunnel healing; no significant long-term functional benefit	[17,19]

LR-PRP: Leukocyte-rich platelet-rich plasma; LP-PRP: Leukocyte-poor platelet-rich plasma; RCT: Randomized controlled trial; HA: Hyaluronic acid; ACL: Anterior cruciate ligament.

Enhanced healing: A preclinical study demonstrated that PEF PRP significantly improved cell proliferation and tissue regeneration compared with standard PRP, highlighting its superior therapeutic efficacy[11].

Clinical application: In clinical practice, PEF PRP was successfully used to treat patients with large surface-area pressure ulcers who were not candidates for surgery, underscoring its potential as a non-surgical treatment option[12].

INTEGRATION WITH BIOMATERIALS

The combination of PRP with advanced biomaterials has created new opportunities for managing complex musculoskeletal injuries, particularly in bone and cartilage repair.

3D-PRINTED SCAFFOLDS

3D printing enables the fabrication of scaffolds that closely replicate the natural extracellular matrix, providing structural support and enhancing tissue regeneration when combined with PRP.

Cartilage regeneration: Studies have shown that 3D-printed scaffolds infused with PRP promote chondrogenesis, leading to improved cartilage repair outcomes[13].

Osteochondral repair: Multiphasic scaffolds incorporating PRP have been designed to simultaneously regenerate cartilage and subchondral bone, addressing the challenges in osteochondral tissue engineering[14].

KGN INTEGRATION

KGN is a small molecule that induces chondrogenic differentiation of mesenchymal stem cells (MSCs), making it a valuable addition to PRP-based therapies[15].

Hydrogel scaffolds

Incorporating KGN into hydrogel-based scaffolds with PRP has been shown to enhance cartilage regeneration, offering a synergistic approach to treating cartilage defects[16].

Bilayered constructs

Advanced bilayered scaffolds combining KGN-loaded hydrogels with PRP have been developed to mimic the osteochondral interface, supporting simultaneous regeneration of cartilage and underlying bone[17].

EMERGING THERAPIES

Current trends in orthopedics increasingly focus on combining PRP with MSCs and peptide-based treatments to maximize tissue regeneration and functional recovery.

PRP and MSCs

The combination of PRP with MSCs has demonstrated synergistic effects in tissue regeneration. PRP provides a concentrated source of growth factors, while MSCs contribute to repair through differentiation and paracrine signaling. This strategy has been applied successfully in conditions such as OA and tendon injuries.

Clinical efficacy: A meta-analysis by Zhao *et al*[18] assessed the efficacy and safety of MSCs combined with PRP in treating knee OA. The study concluded that the combination significantly improved pain relief and functional outcomes compared with either treatment alone[18].

Preclinical evidence: A study by Wang *et al*[19] investigated the effects of PRP and adipose-derived MSCs, individually and in combination, in a rat model of OA. The combination therapy showed superior cartilage preservation and reduced inflammation compared with monotherapies[19].

PRP and peptide-based therapies

Integrating PRP with peptide-based treatments has the potential to further enhance healing and recovery. Peptides can modulate inflammation and stimulate cellular activities essential for regeneration, complementing the effects of PRP.

Clinical insights: A comprehensive review by Goulian *et al*[1] evaluated the clinical efficacy of PRP, MSCs, peptide-based therapies, and biomimetic materials in orthopedic care. The review concluded that peptide-based therapies, when combined with PRP, show strong potential for improving tissue regeneration and functional outcomes.

These emerging therapies emphasize the potential of combining PRP with MSCs and peptide-based treatments to improve orthopedic regenerative outcomes. Nevertheless, large-scale clinical trials are needed to establish standardized protocols and confirm long-term efficacy.

CONCLUSION

Recent advancements have firmly established PRP therapy as a valuable tool in orthopedic care. Innovations such as PEF PRP, integration with 3D-printed scaffolds, and combination therapies with MSCs and peptides have enhanced its regenerative potential. These developments have extended the applications of PRP beyond sports medicine to include OA, tendinopathies, and cartilage defects. Although PRP demonstrates promising outcomes, standardization of preparation methods and additional large-scale clinical trials are essential to optimize its efficacy and establish comprehensive clinical guidelines.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support of the Department of Orthopedics, Dr. Panjabrao Deshmukh Memorial Medical College and Hospital, Amaravati, Maharashtra, India, for providing access to library resources and literature necessary for the preparation of this manuscript.

FOOTNOTES

Author contributions: Rathod AP, Rathod Y contributed to conception and design of the study, acquisition of data, analysis and interpretation of data, drafting or revising the manuscript, final approval of the version to be published; Baitule R, Pundkar G, Saodekar H contributed to analysis and interpretation of data, drafting or revising the manuscript, final approval of the version to be published.

Conflict-of-interest statement: All the authors report no relevant conflicts of interest for this article.

Open Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: https://creativecommons.org/Licenses/by-nc/4.0/

Country of origin: India

ORCID number: Arnav Pankaj Rathod 0009-0001-8445-4004.

S-Editor: Liu H

L-Editor: A
P-Editor: Zheng XM

REFERENCES

1 **Goulian AJ**, Goldstein B, Saad MA. Advancements in Regenerative Therapies for Orthopedics: A Comprehensive Review of Platelet-Rich Plasma, Mesenchymal Stem Cells, Peptide Therapies, and Biomimetic Applications. *J Clin Med* 2025; **14**: 2061 [*RCA*] [PMID: 40142869 DOI: 10.3390/jcm14062061] [FullText] [Full Text(PDF)]
2 **Stokes DJ**, Frank RM, Platelet-Rich Plasma for Osteoarthritis in 2024–More Hype-AOSSM. [cited 22 September 2025]. Available from: https://www.sportsmed.org/membership/sports-medicine-update/spring-2024/platelet-rich-plasma-for-osteoarthritis-in-2024
3 **Liang W**, Zhou C, Bai J, Zhang H, Jiang B, Wang J, Fu L, Long H, Huang X, Zhao J, Zhu H. Current advancements in therapeutic approaches in orthopedic surgery: a review of recent trends. *Front Bioeng Biotechnol* 2024; **12**: 1328997 [*RCA*] [PMID: 38405378 DOI: 10.3389/fbioe.2024.1328997] [FullText]
4 **Kawase T**, Mourão CF, Fujioka-Kobayashi M, Mastrogiacomo M. Editorial: Recent advances in platelet-concentrate therapy in regenerative medicine. *Front Bioeng Biotechnol* 2024; **12**: 1518095 [*RCA*] [PMID: 39659986 DOI: 10.3389/fbioe.2024.1518095] [FullText]
5 Orthobiologics 2024: Cutting-Edge Advances for Sports Medicine and Beyond. SportsSmithMD. [cited 10 October 2025]. Available from: https://www.sportssmithmd.com/post/orthobiologics-2024-cutting-edge-advances-for-sports-medicine-and-beyond
6 **Pundkar AG**, Shrivastava S, Chandanwale R, Jaiswal A, Patel H. Exploring the Efficacy of Biologics in Knee Osteoarthritis: Ultrasound Evaluation of Cartilage Regeneration Effects. *Indian J Orthop* 2024; **58**: 1009-1015 [*RCA*] [PMID: 39087051 DOI: 10.1007/s43465-024-01199-z] [FullText] [Full Text(PDF)]
7 **Johnson DS**, Dhiman N, Badhal S, Wadhwa R. Effects of Intra-articular Platelet Rich Plasma on Cartilage Thickness, Clinical and Functional Outcomes in Knee Osteoarthritis. *Cureus* 2022; **14**: e32256 [*RCA*] [PMID: 36620792 DOI: 10.7759/cureus.32256] [FullText]
8 **Jiang X**, Zhang H, Wu Q, Chen Y, Jiang T. Comparison of three common shoulder injections for rotator cuff tears: a systematic review and network meta-analysis. *J Orthop Surg Res* 2023; **18**: 272 [*RCA*] [PMID: 37013620 DOI: 10.1186/s13018-023-03747-z] [FullText]
9 **Dadgostar H**, Fahimipour F, Pahlevan Sabagh A, Arasteh P, Razi M. Corticosteroids or platelet-rich plasma injections for rotator cuff tendinopathy: a randomized clinical trial study. *J Orthop Surg Res* 2021; **16**: 333 [*RCA*] [PMID: 34020672 DOI: 10.1186/s13018-021-02470-x] [FullText] [Full Text(PDF)]
10 **Maroun R**, Daher M, Boufadel P, Lopez R, Khan AZ, Abboud JA. Platelet rich plasma versus corticosteroids for lateral epicondylitis: a meta-analysis of randomized clinical trials. *Clin Shoulder Elb* 2025; **28**: 40-48 [*RCA*] [PMID: 40077872 DOI: 10.5397/cise.2024.00801] [FullText]
11 **Mazzucco L**, Balbo V, Martinotti S, Ranzato E, Patrone M, Manfredi M, Guaschino R. Protein-enriched Platelet-Rich Plasma (PEF PRP): A new product for tissue regeneration developed through the ultrafiltration of PRP – Preclinical study. *Frontiers* 2021; **1**: 1-6
12 **Mazzucco L**, Balbo V, Zingarelli EM, Desilvestri M, Marchioni M, Perrero L, Pollis F, Varvello I. Treatment of severe pressure ulcers with protein-enriched filtered platelet-rich plasma (PEF(PRP)): a possible management. *Front Bioeng Biotechnol* 2023; **11**: 1279149 [*RCA*] [PMID: 38288245 DOI: 10.3389/fbioe.2023.1279149] [FullText]
13 **Yang X**, Li S, Ren Y, Qiang L, Liu YH, Wang JW, Dai KR. 3D printed hydrogel for articular cartilage regeneration. *Compos Part B Eng* 2022; **237**: 109863 [DOI: 10.1016/j.compositesb.2022.109863] [FullText]
14 **Ghobadi F**, Mohammadi M, Kalantarzadeh R, Lotfi E, Borhan S, Chauhan NPS, Salehi G, Simorgh S. Advanced 3D-printed multiphasic scaffold with optimal PRP dosage for chondrogenesis of BM-MSCs in osteochondral tissue engineering. Available from: arXiv:2502.11130 [DOI: 10.48550/arXiv.2502.11130] [FullText]
15 **Li H**, Liao Z, Yang Z, Gao C, Fu L, Li P, Zhao T, Cao F, Chen W, Yuan Z, Sui X, Liu S, Guo Q. 3D Printed Poly(ε-Caprolactone)/Meniscus Extracellular Matrix Composite Scaffold Functionalized With Kartogenin-Releasing PLGA Microspheres for Meniscus Tissue Engineering. *Front Bioeng Biotechnol* 2021; **9**: 662381 [*RCA*] [DOI: 10.3389/fbioe.2021.662381] [FullText] [Full Text(PDF)]
16 **Huang C**, Zhang X, Luo H, Pan J, Cui W, Cheng B, Zhao S, Chen G. Effect of kartogenin-loaded gelatin methacryloyl hydrogel scaffold with bone marrow stimulation for enthesis healing in rotator cuff repair. *J Shoulder Elbow Surg* 2021; **30**: 544-553 [*RCA*] [PMID: 32650072 DOI: 10.1016/j.jse.2020.06.013] [FullText]
17 **Zhang W**, Tang GK, Zhu BY, Yan MJ, Yu FY, Wang X. Fabrication of an injectable hydrogel scaffold embedding kartogenin-encapsulated PLGA microsphere with long-term drug release to promote chondrogenesis. *Redox Exp Med* 2024; 196: 105821 [DOI: 10.1016/j.reactfunctpolym.2023.105821] [FullText]
18 **Zhao J**, Liang G, Han Y, Yang W, Xu N, Luo M, Pan J, Liu J, Zeng LF. Combination of mesenchymal stem cells (MSCs) and platelet-rich plasma (PRP) in the treatment of knee osteoarthritis: a meta-analysis of randomised controlled trials. *BMJ Open* 2022; **12**: e061008 [*RCA*] [PMID: 36385022 DOI: 10.1136/bmjopen-2022-061008] [FullText] [Full Text(PDF)]
19 **He W**, Zhao J, Liu J, Wang F, Xu Z. Adipose-derived mesenchymal stem cells combined with platelet-rich plasma are superior options for the treatment of osteoarthritis. *J Orthop Surg Res* 2025; **20**: 2 [*RCA*] [PMID: 39748384 DOI: 10.1186/s13018-024-05396-2] [FullText]

Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: office@baishideng.com
Help Desk: https://www.f6publishing.com/helpdesk
https://www.wjgnet.com

© 2025 Baishideng Publishing Group Inc. All rights reserved.