

SECTION 6. Other translational studies

<https://doi.org/10.7124/bc.000B9F>

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DEVELOPMENT OF THE CONCEPT AND RATIONALE OF THE COMPOSITION OF AN INNOVATIVE TWO-COMPONENT BIOTECHNOLOGICAL SYSTEM «EXOMENIS-GEL» FOR MENISCUS REGENERATION

Background/Aim. Meniscal injuries in the avascular zone exhibit almost no spontaneous regeneration due to the absence of blood supply. Surgical meniscectomy triggers osteoarthritis, whereas non-surgical approaches – such as hyaluronic acid injections and PRP therapy – possess significant limitations regarding efficacy and safety. **Methods.** A theoretical analysis of the literature from the PubMed, Scopus, and Web of Science databases regarding knee joint regeneration was conducted. AI (Perplexity) with subsequent critical verification was employed for data retrieval and systematization. **Results.** The composition of the innovative two-component «ExoMenis-Gel» system for minimally invasive treatment of meniscal injuries was theoretically rationalized. Umbilical cord MSC-derived nanoscale exosomes (30–150 nm) were selected as the active component to deliver microRNAs and proteins to fibrochondrocytes, mitigating inflammation and stimulating matrix restoration without immune rejection. To prevent synovial fluid washout, a photopolymerizable HAMA-Dopa hydrogel (methacrylated hyaluronic acid with dopamine) was justified. Methacrylic groups ensure three-dimensional scaffold formation via in situ radical photopolymerization under light exposure with the water-soluble photoinitiator LAP (absorption at 365/405 nm). The hydrogel mimics the natural tissue environment, providing mechanical support. The incorporation of marine mussel-inspired dopamine groups ensures stable covalent and non-covalent adhesion to wet biological surfaces via hydrogen bonds, coordination complexes, and o-quinones reacting with amino and thiol groups of tissue proteins. This guarantees system integration into the defect without dislocation under physiological loads. Phosphate-buffered saline and trehalose, protecting exosomes from degradation during lyophilization, were selected for stabilization. The quality target product profile (QTPP) was established, analytical approaches for control were determined, and implementation risks were assessed. **Conclusions.** The theoretical model of «ExoMenis-Gel» provides a sound basis for further in vitro and in vivo studies. The synergy between MSC-derived exosomes and the hydrogel drives a transition from simple defect filling to the true biological restoration of the avascular zone of the meniscus. This approach holds potential as a minimally invasive strategy that may, upon further in vivo validation, offer an alternative to surgical meniscectomy.

Keywords: meniscus regeneration, MSC-derived exosomes, HAMA-Dopa hydrogel, photopolymerization, tissue engineering.

Received: 28.05.2026; Accepted: 08.09.2026; Published: 29.09.2026

Citation: Aleksandrova O.G., Dvinskykh N.V. (2026) Development of the concept and rationale of the composition of an innovative two-component biotechnological system «ExoMenis-Gel» for meniscus regeneration. *Biopolymers & Cell*, Special issue(42), 101. <https://doi.org/10.7124/bc.000B9F>

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