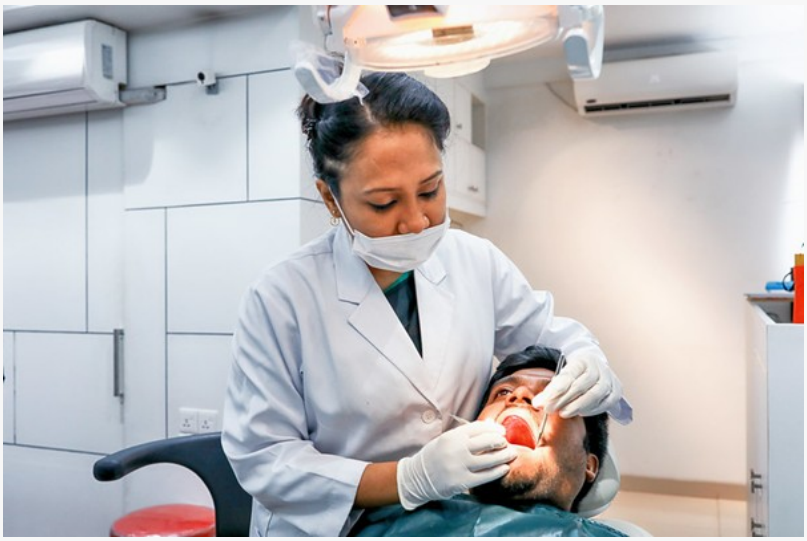
New Composite Hydrogel Shows Promise for Treating Dental Pulp Infection

The injectable bioceramics-containing composite hydrogel could enable pulp-dentin complex repair by facilitating innervation and odontogenic differentiation.



Traditional treatment strategies involved in pulp-dentin complex repair do not promote innervation or odontogenesis. A newly developed injectable composite hydrogel now shows promising results on this front, promoting neural differentiation and odontogene

CHENGDU, SICHUAN, CHINA, December 16, 2025 / EINPresswire.com/ -- The dental pulp is susceptible to microbial infection, which often results in inflammation, necrosis, and defects in the pulp-dentin complex. Traditional treatment strategies suffer from multiple limitations and do not promote neural regeneration. In a new International Journal of Oral Science study, researchers have now developed an injectable composite hydrogel containing bioceramics and gelatin methacrylate matrix with photo-crosslinking properties that promote neural differentiation and odontogenesis, opening doors to a new strategy for pulp-dentin complex repair.

The dental pulp is a soft tissue of the teeth involved in sensory information transmission, immunoprotection, and dentin formation. Odontoblast cells in the pulp differentiate and lead to the formation of dentin that helps in maintaining the structure and function of the teeth. The pulp-dentin complex is also densely innervated by a variety of nerve fibers that are crucial for tooth sensation and pain perception.

The dental pulp is sensitive and susceptible to microbial infection that can damage not only the pulp but also the dentin-oral complex structure. Moreover, the process of odontogenesis (tooth development) and nerve differentiation in the pulp-dentin complex are affected by the defects caused by microbial infection. Unfortunately, traditional treatment strategies, including root canal therapy and vital pulp therapy, which target the pulp instead of the complex do not

promote neural regeneration, and thus cannot completely repair this damage.

Modern treatment plans, involving biomaterials such as hydrogels, aim to overcome these limitations. Biomaterials find applications in drug delivery, remineralization, and tissue regeneration. Silicate-based bioceramics are often used in oral therapies owing to their biocompatibility and biodegradable properties. Involvement of lithium (Li) ions, known for neuroprotective properties, and calcium (Ca) ions, which is primarily involved in dentin formation, can further improve the effectiveness of the biomaterials.

A team of researchers from China, led by Professor Chengtie Wu from Shanghai Institute of Ceramics, Chinese Academy of Sciences, set out to explore the efficiency of Li-Ca-Si (LCS) bioceramics in promoting innervated pulp-dentin complex regeneration. “Most biomaterials that are currently used are focused on antibacterial properties, immune regulation, and mineral deposition. As nerves play a very important role in the dentin-pulp complex, the re-innervation property of the biomaterial used in the treatment is equally important,” explains Prof. Chengtie Wu, speaking about the motivation underlying the study, which was published in International Journal of Oral science on October 01, 2025.

The researchers developed a composite hydrogel composed of LCS bioceramics particles and gelatin methacryloyl (GelMA) matrix for the treatment of pulp-dentin complex defects. Both in vivo and in vitro experiments were conducted to check the innervation properties of the hydrogel.

Property analysis of the LCS bioceramics hydrogel showed good injectability, shape fidelity, and photo-crosslinking ability, along with enhanced mechanical strength and mineralization ability. This resulted in convenient dental filling along with a rapid curing as observed by the team. “The composite hydrogel maintained stable structure once filled in even under the erosion of flush water and maintained its stability when immersed in a simulated oral fluid,” highlights Prof. Zhiguang Huan, the Co-corresponding author of the study.

Schwann cells (SCs), which form a prominent glial network in the dentin-pulp complex, play a crucial role in nerve and dental tissue repair and regeneration. The hydrogel promoted SC regeneration and migration. Moreover, the hydrogel showed cytocompalitibility for both SC cells and dental pulp stem cells (DPSCs), along with promoting the proliferation, migration, and odontogenic differentiation of DPSCs.

“DPSC differentiation is usually regulated by the nerve cells in the dentin-pulp complex. We also wanted to see if the odontogenic differentiation of DPSCs was modulated by neural cells under the treatment of bioceramics-containing composite hydrogels,” explains Ms. Xingyu Tao, the first author of this study. The team’s findings suggested that the composite hydrogel helped create a suitable neuro-modulatory microenvironment for odontogenesis, facilitating an integrated dentin-pulp repair via the coupling of neuro-odontogenesis.

Studies in rat model also showed promising results. There was an increase in bone volume and bone mineral density following a hydrogel-based treatment. Innervation and pulp-dentin regeneration was achieved in the in vivo model and pulp tissue morphology also indicated the repairing property of the hydrogel.

Further research on these composite hydrogels could aid our understanding of the biological mechanism of innervation and regeneration process influenced by the treatment. “While the immunomodulatory and antibacterial properties of the hydrogel remain to be fully understood, our study offers a promising approach for functional pulp-dentin integrated repair,” concludes Prof. Chengtie Wu.

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Reference
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