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SockGEL/PLUG: Injectable Nano-Scaled Hydrogel Platforms for Oral and Maxillofacial Interventional Application

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Abstract : Millions of teeth are removed annually, and dental extraction is one of the most commonly performed surgical procedures globally. Whether due to caries, periodontal disease, or trauma, exodontia and the ensuing wound healing and bone remodeling processes of the resultant socket (hole in the jaw bone) usually result in serious deformities of the residual alveolar osseous ridge and surrounding soft tissues (reduced height/width). Such voluminous changes render the placement of a proper conventional bridge, denture, or even an implant-supported prosthesis extremely challenging. Further, most extractions continue to be performed with no regard for preventing the onset of alveolar osteitis (also known as dry socket, a painful and difficult-to-treat/-manage condition post-exodontia). Hence, such serious resorptive morphological changes often result in significant facial deformities and a negative impact on the overall Quality of Life (QoL) of patients (and oral health-related QoL); alarming, particularly for the geriatric with compromised healing and in light of the thriving longevity statistics. Despite advances in tissue/wound grafting, serious limitations continue to exist, including efficacy and clinical outcome predictability, cost, treatment time, expertise, and risk of immune reactions. For cases of dry socket, specifically, the commercially available and often-prescribed home remedies are highly-lacking. Indeed, most are not recommended for use anymore. Alveogyl is a fine example. Hence, there is a great market demand and need for alternative solutions. Herein, SockGEL/PLUG (patent pending), an innovative, all-natural, drug-free, and injectable thermo-responsive hydrogel, was designed, formulated, characterized, and evaluated as an osteogenic, angiogenic, anti-microbial, and pain-soothing suture-free intra-alveolar dressing, safe and efficacious for use in fresh extraction sockets, immediately post-exodontia. It is composed of FDA-approved, biocompatible and biodegradable polymers, self-assembled electro-statically to formulate a scaffolding matrix to (1) prevent the on-set of alveolar osteitis via securing the fibrin-clot in situ and protecting/sealing the socket from contamination/infection; and (2) endogenously promote/accelerate wound healing and bone remodeling to preserve the volume of the alveolus. The intrinsic properties of the SockGEL/PLUG hydrogel were evaluated physical-chemical-mechanically for safety (cell viability), viscosity, rheology, bio-distribution, and essentially, capacity to induce wound healing and osteogenesis (small defect, in vivo) without any signaling cues from exogenous cells, growth factors or drugs. The proposed animal model of cranial critical-sized and non-vascularized bone defects shall provide new and critical insights into the role and mechanism of the employed natural bio-polymer blend and gel product in endogenous reparative regeneration of soft tissues and bone morphogenesis. Alongside, the fine-tuning of our modified formulation method will further tackle appropriateness, reproducibility, scalability, ease, and speed in producing stable, biodegradable, and sterilizable thermo-sensitive matrices (3-dimensional interpenetrating yet porous polymeric network) suitable for the intra-socket application. Findings are anticipated to provide sufficient evidence to translate into pilot clinical trials and validate the innovation before engaging the market for feasibility, acceptance, and cost-effectiveness studies.

Keywords : hydrogel, nanotechnology, bioengineering, bone regeneration, nanogel, drug delivery
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