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Regeneration of Bone using Piezoelectric Dental Implants

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Delayed or insufficient bone regeneration remains a major challenge in dental implantology, particularly in patients with osteoporosis, diabetes, or compromised healing capacity. Conventional titanium implants are passive devices that rely entirely on natural osseointegration, often resulting in prolonged recovery and increased risk of implant failure. To address this limitation, the present study proposes a titanium dental implant coated with the piezoelectric ceramic barium titanate ($BaTiO_3$). The coating is designed to convert masticatory forces into localized bioelectric signals that mimic the natural electrical potentials of bone, thereby stimulating osteoblast activity, accelerating extracellular matrix deposition, and promoting mineralized tissue formation. The system is self-powered, requiring no external energy source, and offers improved healing kinetics compared to conventional implants. Material selection emphasizes the mechanical strength and biocompatibility of titanium, the strong piezoelectric response of barium titanate ($BaTiO_3$), and the optional use of hydroxyapatite as a bioactive interface. *In vitro* studies and computational models suggest enhanced osteoblast adhesion, proliferation, and faster osseointegration on the coated surfaces. This approach demonstrates the potential of piezoelectric-based dental implants to significantly reduce healing time, improve implant stability, and broaden applications to geriatric dentistry, post-trauma reconstruction, and patients with compromised bone regeneration.

Keywords: Bioelectric signals, Osteoporosis, Osseointegration, Piezoelectric

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