Biofunctionalization of porous Ti implants with chitosan composites with enhanced antimicrobial and osseointegrative properties

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The advancements in medicine and pharmacy over the past century have significantly increased life expectancy but have also led to health issues stemming from the gradual deterioration of human muscles, bones, skin, and joints [1]. Consequently, there is a pressing need for new materials and techniques in bone tissue engineering to enhance quality of life. Scientists are focused on developing more efficient strategies to treat osteochondral defects and regenerate articular sections by manufacturing prostheses with enhanced properties using biofunctional coatings. Key characteristics for prosthetic materials include appropriate mechanical properties, high porosity, corrosion resistance, biocompatibility, and inhibition of bacterial colonization [2].
While a wide variety of materials are used for prosthetic applications, metallic materials, particularly commercially pure titanium (cp Ti), are the most widely applied as bone substitutes due to their biological compatibility and mechanical properties [3]. However, cp Ti has limitations such as a higher Young's modulus compared to bone tissues, reduced osseointegration, or bacterial proliferation, leading to infections. Strategies like manufacturing porous Ti implants can mitigate these issues by reducing stress shielding and enhancing vascularization and cell growth, thereby reducing implant failure risk[4].

To further enhance prosthetic bioactivity, polymer coatings enriched with bioactive molecules, such as chitosan (CS), have been explored. CS, a natural polymer with optimal properties for biomedicine, exhibits antimicrobial properties by binding to bacterial cell walls and inhibiting DNA replication, leading to cell death [5]. The porosity and mechanical properties of these coatings can be controlled through cross-linking, with tripolyphosphate polyanion (TPP) being a commonly employed cross-linker for CS hydrogels.

Additionally, incorporating nanoparticles into hydrogel coatings can further improve bioactivity. Silver nanoparticles (AgNPs) and hydroxyapatite nanoparticles (nHA) have shown effectiveness in inhibiting bacterial activity and promoting bone growth around implants, respectively.

In this research work, the combination of porous Ti substrates with polymeric biocomposites loaded with AgNPs or nHA is presented, to enhance both the biofunctional and tribomechanical properties of Ti implants, thereby improving their overall performance and longevity.

References

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