Accelerated Mitigation of Infection Due to Spinal Implants or Wounds by Novel Photoactive Nanomats and Nanocoatings


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Introduction: Orthopaedic infections can be devastating. Disease-carrying bacteria, viruses, and parasites that get into the body can destroy healthy tissues, multiply and spread through blood. Depending upon severity and other factors, osteomyelitis can cause irreversible damage (necrosis) to bone cells. Infection of skin and other soft tissue can lead to infection of bones (osteomyelitis) and joints (septic arthritis). Without prompt treatment, orthopaedic infections can become chronic. Thus, the severity of the damages caused by infection cannot be overemphasized in the case of spine, just like any other joint in the body. Infection can be reduced and healing accelerated by using nano technology approach with photoactive antimicrobial attributes.

Methodology: In order to achieve this, we have taken a two-pronged approach: (i) the development of non-woven nanofibers of titanium dioxide (TiO$_2$) - possessing known photoactive antimicrobial attributes - either in pristine form or after impregnation with antibacterial agents, that can be used as disinfectant gauze for wound healing upon brief activation by a pocket UV/IR flashlight, and, (ii) the development of a procedure for treating the surface of the external fixator pins, bone replacement materials and implants (made of Ti or Ti-Al-V alloy, used for bone fractures healing) with nanoscale photoactive disinfectant in the form of a thin film or fibrillar structure. In the first case, technique of electrospinning was used for fabricating non-woven TiO$_2$ mesh, using titanyl nitrate as a benign and inexpensive precursor. In the second case, well-defined coating of nanoscale TiO$_2$ on Ti-implants was achieved via hydrothermal processing under very mild and benign experimental conditions.

Results and Discussion: Systematic and thorough structural and microstructural characterization was performed on the as-spun and the fired nanomats and, on the films grown on implants. Results pertaining to the biocidal activities of the self-standing nanofibers and the nanocoatings on Ti implants showed significant decrease in the density of the live E. coli cell colony upon exposure of the TiO$_2$ nanomats to IR radiation for 3 seconds. Thus, by interposing an effective procedure based on nanotechnology, the use of spinal implants can be made safer and bone healing will take place at an accelerated pace, eliminating or mitigating at the same time the probability of wound infection.