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Shield to Integrate

Strontium–Graphene Nanocomposite Coating Enhance Osseointegration via Antibacterial and Osteogenic Activity

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Academy of Osseointegration

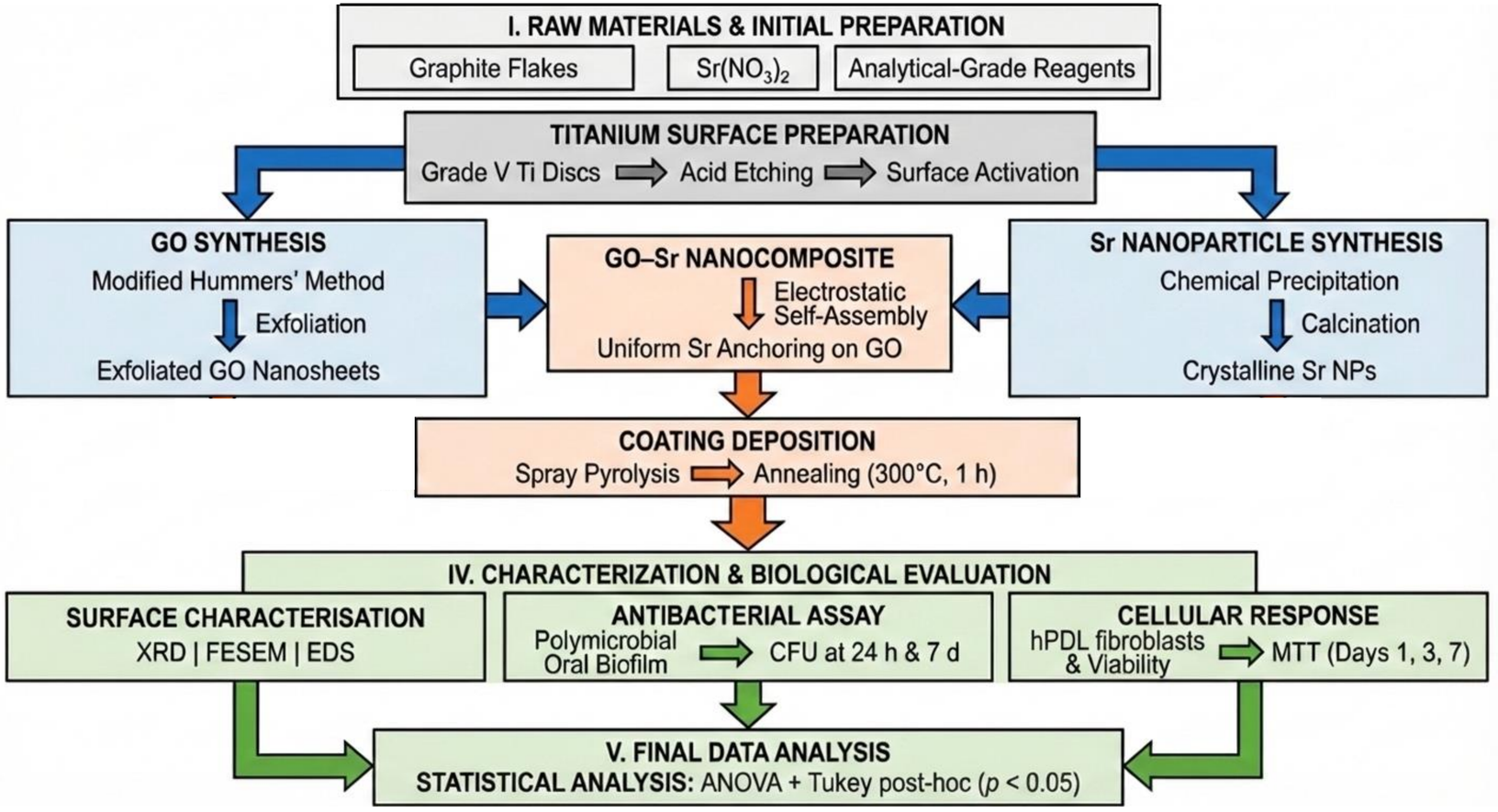
INTRODUCTION

Titanium remains the gold standard for dental implants; however, susceptibility to bacterial colonisation and suboptimal early bone integration continue to compromise long-term clinical outcomes, while existing surface modification strategies suffer from limited durability and safety concerns. Emerging nanomaterials such as graphene oxide and strontium offer antibacterial and osteogenic potential. Hence, this study was directed to investigate the potential synergistic effects of graphene oxide and strontium combined coating on titanium surfaces which can enable simultaneous infection resistance and accelerate osseointegration.

AIM

To develop and biologically validate a strontium–graphene nanocomposite titanium coating that simultaneously enhances antibacterial activity and cellular response to optimise implant osseointegration.

MATERIALS AND METHODS



ABBREVIATIONS: $Sr(NO_3)_2$: Strontium nitrate; Ti: Titanium; GO: Graphene Oxide; NPs: Nanoparticles; XRD: X-ray Diffraction; FESEM: Field Emission Scanning Electron Microscope; EDS: Energy Dispersive Spectroscopy; CFU: Colony Forming Unit; hPDL: Human Periodontal Ligament.

RESULTS

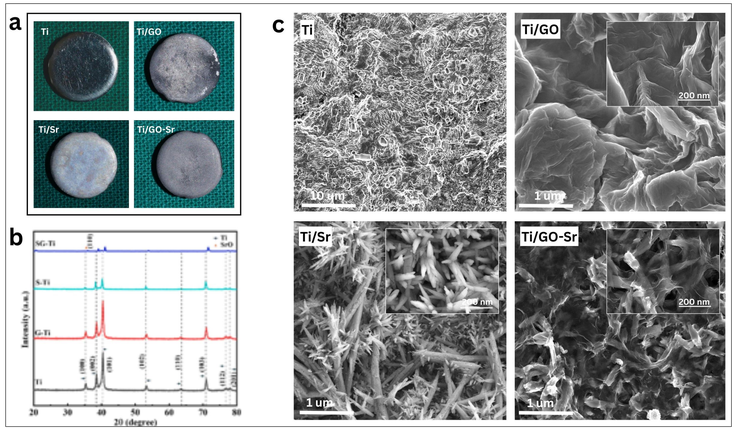


Fig1: Surface characteristics of the coatings. (a): Visual observation. (b): XRD analysis revealing peaks corresponding to hcp α-Ti. (c): FESEM analysis showing GO nanosheets and knife-like Sr.

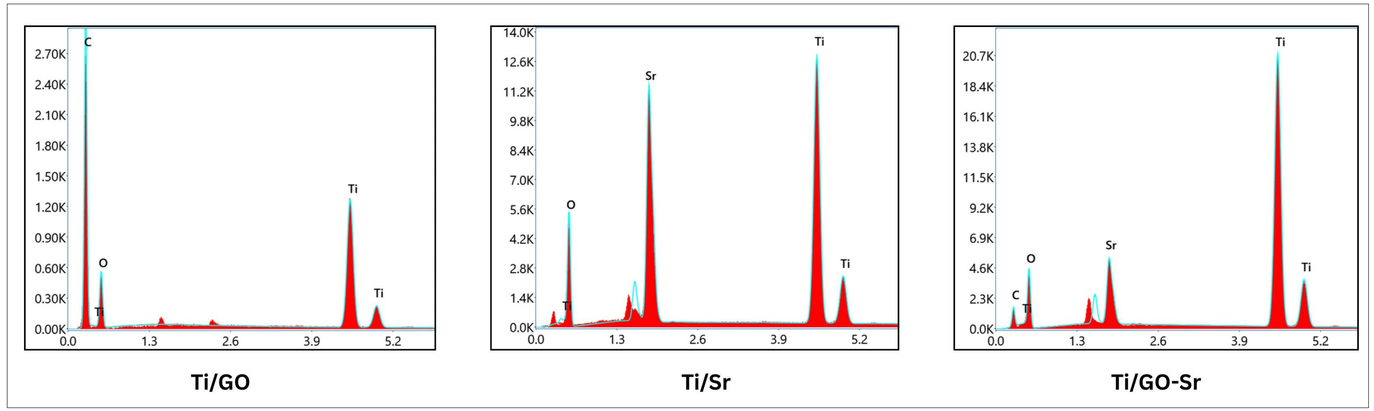


Fig2: EDS analysis confirming elemental composition across all samples.

Table 1: - Comparison of Log_{10} CFU between 24 hr and 7 days in each study group

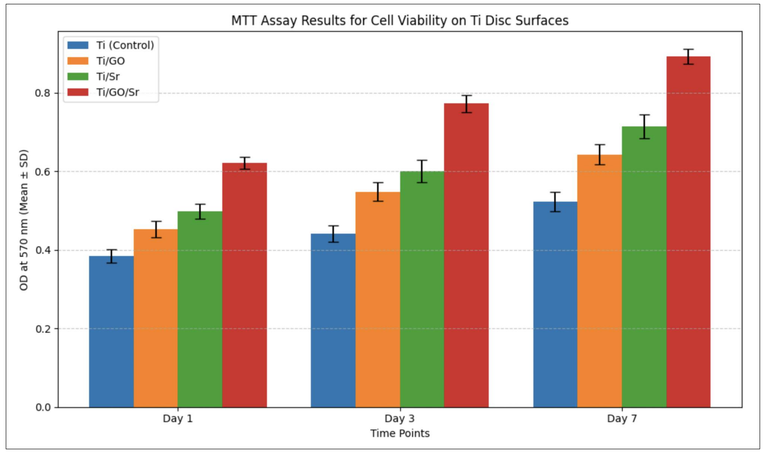
Study Group	Time	CFU/mL	Mean Difference	p-value
Ti/GO	24h	4.276 ± 0.004	1.16	<0.001*
	7d	3.116 ± 0.012		
Ti/Sr	24h	5.375 ± 0.014	2.34	<0.001*
	7d	3.037 ± 0.018		
Ti/GO-Sr	24h	4.235 ± 0.010	1.46	<0.001*
	7d	2.778 ± 0.141		
Ti	24h	3.146 ± 0.005	-2.27	<0.001*
	7d	5.416 ± 0.006		

Independent sample t test
*p<0.05 Statistically Significant.

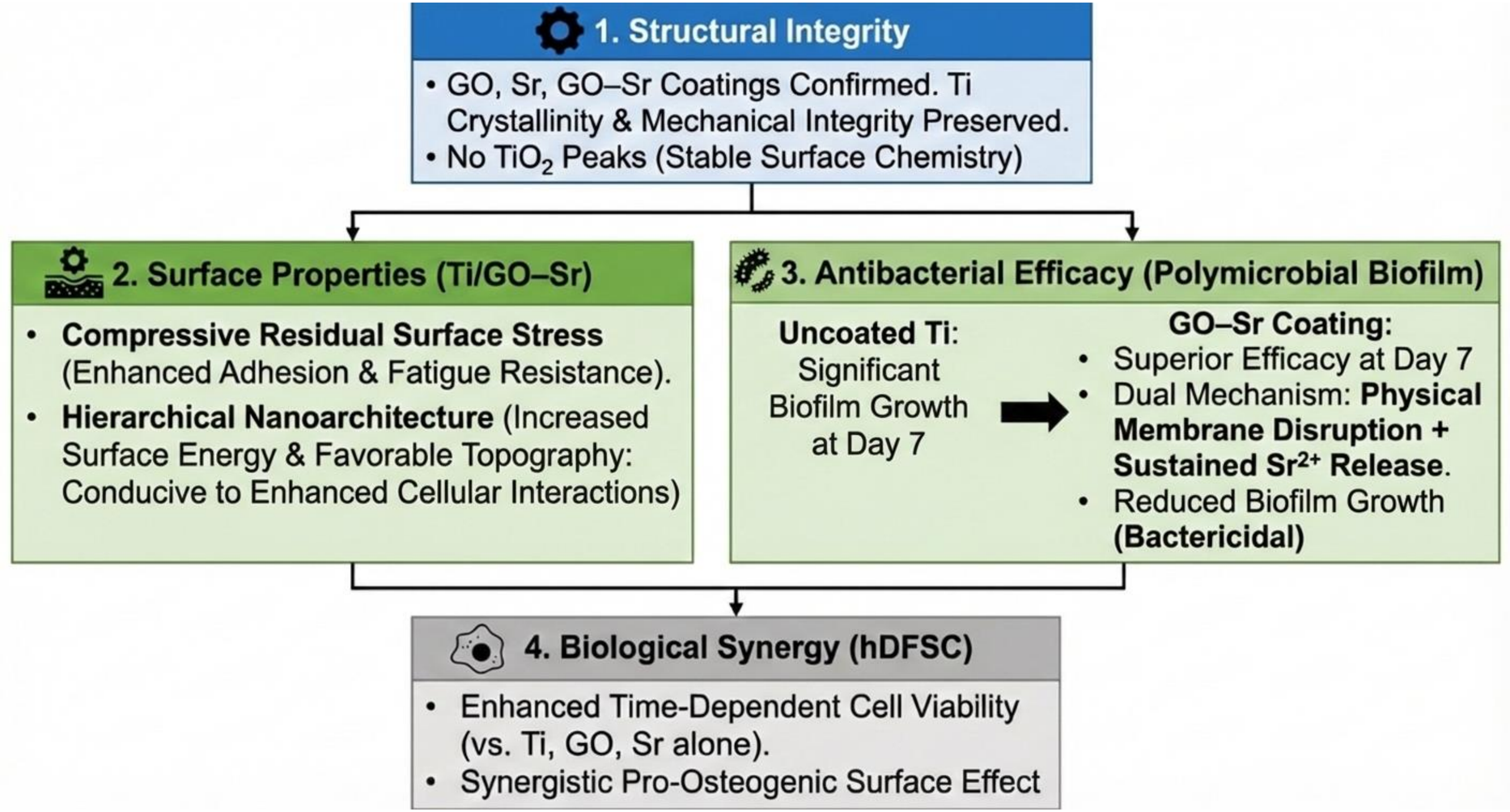
Table 2: - Comparison of Log_{10} CFU between study groups at 24 hr and 7 days.

Time	Study Groups	CFU/mL	p-value
24h	Ti/GO	4.276 ± 0.004	<0.001*
	Ti/Sr	5.375 ± 0.014	
	Ti/GO-Sr	4.235 ± 0.010	
	Ti	3.146 ± 0.005	
7d	Ti/GO	3.116 ± 0.012	<0.001*
	Ti/Sr	3.037 ± 0.018	
	Ti/GO-Sr	2.778 ± 0.141	
	Ti	5.416 ± 0.006	

One-way ANOVA
*p<0.05 Statistically Significant



DISCUSSION


1. Structural Integrity
• GO, Sr, GO–Sr Coatings Confirmed. Ti Crystallinity & Mechanical Integrity Preserved.
• No TiO_2 Peaks (Stable Surface Chemistry)
2. Surface Properties (Ti/GO–Sr)
• Compressive Residual Surface Stress (Enhanced Adhesion & Fatigue Resistance).
• Hierarchical Nanoarchitecture (Increased Surface Energy & Favorable Topography: Conducive to Enhanced Cellular Interactions)
3. Antibacterial Efficacy (Polymicrobial Biofilm)
Uncoated Ti: Significant Biofilm Growth at Day 7
GO–Sr Coating:
• Superior Efficacy at Day 7
• Dual Mechanism: Physical Membrane Disruption + Sustained Sr^{2+} Release.
• Reduced Biofilm Growth (Bactericidal)
4. Biological Synergy (hDFSC)
• Enhanced Time-Dependent Cell Viability (vs. Ti, GO, Sr alone).
• Synergistic Pro-Osteogenic Surface Effect

CONCLUSION

The strontium–graphene nanocomposite coating successfully integrates antibacterial functionality with enhanced osteogenic cellular response, without compromising titanium surface integrity or stability. The synergistic physicochemical architecture enables sustained biofilm suppression while promoting early cell adhesion and proliferation, positioning this coating as a next-generation bioactive implant surface. These findings establish Sr-GO nanocomposites as a translational platform for simultaneously addressing infection control and accelerated osseointegration in implant dentistry.

CLINICAL IMPACT STATEMENT

This nanocomposite surface technology has the potential to reduce peri-implantitis risk while accelerating implant integration, enabling safer, faster, and more predictable implant therapy in high-risk clinical scenarios.

ACKNOWLEDGEMENT

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