



Antibacterial effect of incorporating silver ions in electrochemically deposited hydroxyapatite coating: An experimental study

Yaser Ghani¹ • Melanie J Coathup¹ • Karin A Hing²
• Gordon W Blunn¹

¹The John Scales Centre for Biomedical Engineering, Institute of Orthopaedics and Musculoskeletal Science, Division of Surgery and Interventional Science, University College London, The Royal National Orthopaedic Hospital Trust, Brockley Hill, Stanmore, Middlesex, HA7 4LP, UK; ²Department of Materials and IRC in Biomedical Materials, School of Engineering and Materials, Queen Mary University of London, Mile End Road, London E1 4NS, UK

Correspondence to: Yaser Ghani. Email: y.ghani@doctors.org.uk

DECLARATIONS

Competing interests

None declared

Funding

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Ethical approval

In line with institutional policy, ethical approval was not required

Guarantor

YG

Contributorship

YG conducted literature review, carried out experiments, collected and analysed data and drafted and revised article.

Objectives

Infections relating to orthopaedic procedures are difficult to treat with systemic antibiotics due to encapsulation of the implant by fibrous tissue and formation of biofilm.^{1,2}

The aim of the study was to develop electrochemically deposited hydroxyapatite (EHA) coating and incorporate silver (Ag) to provide a controlled and sustained release of Ag ions at a bactericidal concentration.

Design

We investigated six groups: electrochemical co-precipitation of HA and Ag (EHA/Ag); EHA pre-coated discs treated in AgNO₃ (EHA/AgNO₃); plasma-sprayed HA (PHA) pre-coated discs treated in AgNO₃ (PHA/AgNO₃); EHA with 2 'layers' of Ag (EHA/Ag/2-layers); EHA coating only and PHA coating only.

Setting

The tests were carried out in a laboratory.

Main outcome measures

Bacterial inhibition tests were carried out by placing coated discs on agar plates of *Staphylococcus*

aureus and zones of inhibition were quantified in each group. Scanning electron microscopy and energy dispersive X-ray (EDX) and X-ray diffraction (XRD) analyses quantified coating thickness, calcium/phosphorous ratio and % atomic silver content, respectively.

Results

XRD and EDX analyses confirmed the presence of Ag in all coatings deposited using electrochemical method and silver.

The mean thickness coating was noted to be highest in EHA/AG group (102.20 ± 4.20 µm) followed by PHA (76.40 ± 2.20 µm). Mean coating thicknesses in other groups were: PHA/AgNO₃ (76.20 ± 1.29 µm); EHA (32.98 ± 2.50 µm); EHA/Ag/2-layers (30.70 ± 2.40 µm); EHA/AgNO₃ (8.60 ± 0.60 µm).

The average silver content measured was highest with 6.55% in EHA/Ag/2-layer followed by 3.92% in EHA/AgNO₃, 0.38% in EHA/Ag and 0.10% in PHA/AgNO₃.

The electrochemical technique deposited a uniform coating onto the disc surface with clearly defined microcrystals as compared to the PHA-coated discs where the surface appeared smoother. The EHA coating, however, appeared less dense when compared with the PHA coating.

MC carried out experiments, analysed data and helped with writing up the article. GB conceived and designed the study and revised the article. Each of the authors has been an active contributor to the article and has seen, approved and is fully conversant with its contents

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None

Provenance

Submitted; peer reviewed by RSM Orthopaedic section

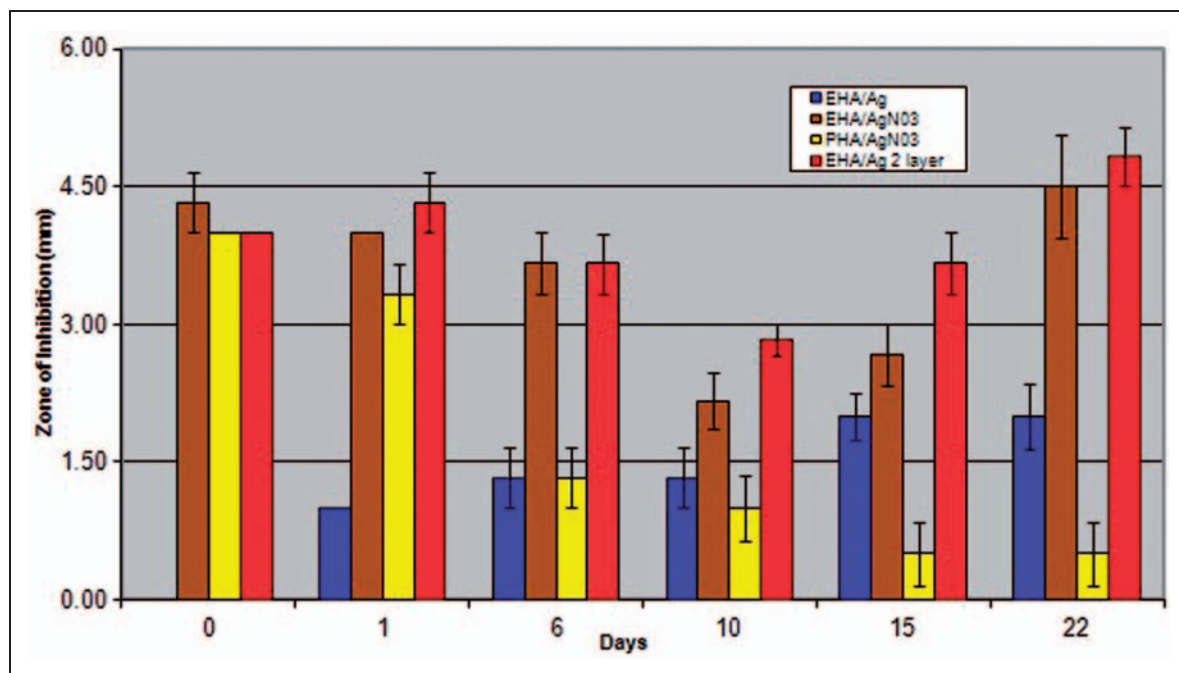


Figure 1. A graph comparing bacterial inhibition zones in all groups at all time points.

In the bacterial inhibition test no zone of inhibition was seen in the EHA and PHA groups.

No-inhibition zones were seen in the EHA/Ag group on day 0, but appeared on day 1 and gradually increased by day 22. In the PHA/AgNO₃ large zones of inhibition were present initially on days 0 and 1 but decreased significantly from day 6 to 22.

Zones of inhibition in EHA/AgNO₃ and EHA/Ag/2-layers showed significantly larger zones of inhibition than PHA/AgNO₃ at days 6,10,15 and 22 and also significantly larger zones than EHA/Ag at most days (Figure 1).

Conclusions

We have developed a method of electrochemically depositing HA coating and incorporating silver ions within it resulting in a crystal appearance as compared with the plasma-coated HA which has molten appearance.

The bacterial inhibition test signifies that when the smooth PHA-coated discs were dipped in silver nitrate only the surface is coated showing burst release initially and rapidly depleting over days.

Our different methods of incorporating silver within the crystalline EHA entrapped the silver ions within the coating, resulting in sustained release of silver ions at bactericidal concentrations when the coating dissolves.

This study demonstrated that Ag ions can be incorporated into an HA coating using an electrochemical technique to provide an antibacterial implant coating.

References

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