Evaluation Of Hydration Protocols for Human Cortical Mineralized Particulate Allografts

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Introduction

Bone grafting is widely used to regenerate deficient sites such as the sinus and alveolar ridge. Human allografts provide osteoconductive and osteoinductive properties through residual growth factors. Hydration improves their biological performance; however, standardized hydration protocols are lacking. Previous studies show that hydration affects graft behavior and osteogenesis, highlighting the need for material-specific hydration protocols to optimize bone regeneration and graft integration.

Aim of the Study

Evaluate physico-Chemical changes in particulate mineralized allografts through the use of infrared (IR) spectroscopy after hydration at different times in a saline solution.

Methodology

Three mineralized human cortical allografts (250–1000 µm) from Straumann (S), Geistlich (G), and Zimmer (Z) were evaluated. Granules were hydrated in saline to final concentrations of 100 mg/mL and 1 g/mL and incubated for 1, 10, and 30 minutes.

Surface morphology was analyzed using Scanning Electron Microscopy (SEM) (FEI Quanta 450 FEG). Chemical composition and crystallinity were assessed by Fourier Transform Infrared (FTIR) spectroscopy (Nicolet iS5, ATR accessory).

Spectral analysis focused on bands associated with amide I, amide II, phosphate, carbonate, amide III, and CH_2 to evaluate collagen integrity and mineral content.

Results

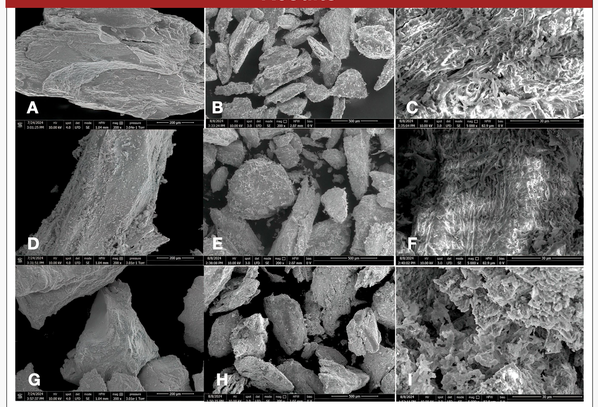

Figure 1. Scanning Electron Microscopy images of the groups GM (A, B, C), SM (D, E, F) and ZM (G, H, I). Dry biomaterials at 200x magnification (A, D, G), biomaterials hydrated for 30 minutes at 200X (B,E,H) and 5000X (C, F, I).

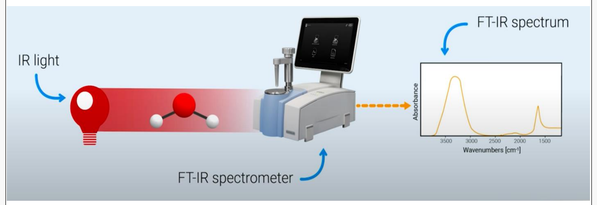

Figure 2. FT-IR Spectroscopy

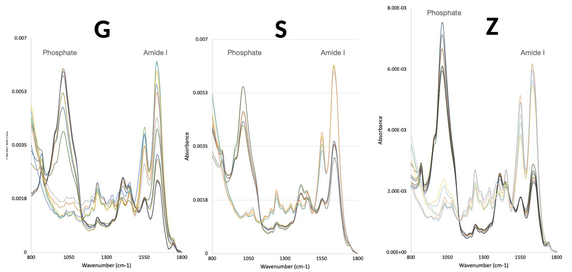

Figure 3. The FTIR spectra of groups G, S, and Z.

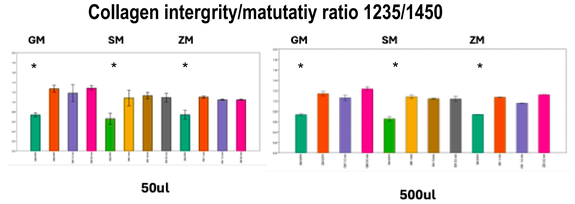

Figure 4. Collagen integrity/maturity analysis (1235 cm^{-1}/1450 cm^{-1}). The graph on the left shows data for 50uL concentration, while the graph on the right shows data for 500uL concentration.

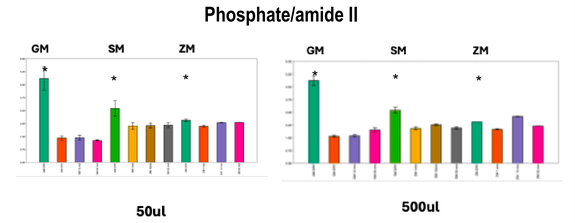

Figure 5. Mineral content (phosphate/amide II) for GM, SM, and ZM groups. The graph on the left shows data for 50uL concentration, while the graph on the right shows data for 500uL concentration.

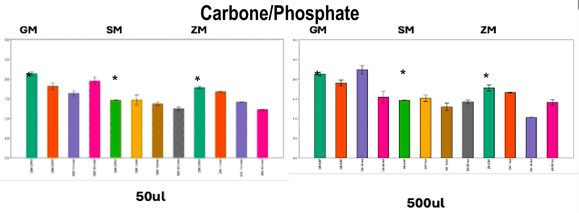

Figure 6. Mineral content (carbonate/phosphate) for GM, SM, and ZM groups. The graph on the left shows data for 50uL concentration, while the graph on the right shows data for 500uL concentration.

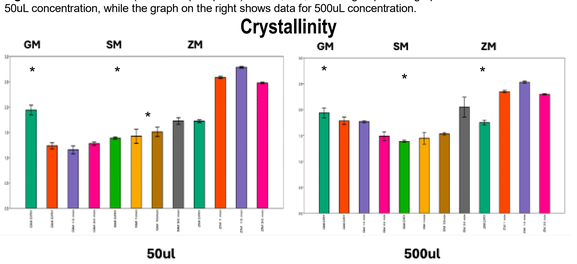

Figure 7. Crystallinity measurements for GM, SM and ZM groups. The graph in the left shows data for 50uL concentration, while the graph in the right shows data for 500uL concentration.

Across Geistlich (G), Zimmer (Z), and Straumann (S) groups, FTIR spectra showed consistent peak positions indicating chemical homogeneity, while variations in peak intensities reflected changes in mineral content and collagen integrity; SEM images demonstrated surface and morphological alterations after 30 minutes of hydration. Collagen integrity increased significantly within the first minute of hydration in all groups, with minimal additional changes thereafter. Mineral content (phosphate/amide II and carbonate/phosphate ratios) decreased over time, indicating gradual demineralization, while crystallinity remained largely stable with only minor hydration-related variations.

Conclusion

Biomaterial hydration results in increased graft collagen integrity/maturity and reduced mineral contents. Increasing hydration time past 1 minute did not result in significant changes in vibrational bands, suggesting that hydration times longer than 1 minute have minimal impact on the molecular structure of the particulate allografts evaluated.

Effects of hydration on crystallinity are biomaterial-specific. Biomaterial-specific hydration protocols may be needed.

Acknowladgments and References

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