

PR572 - Effect of sintering on physicochemical characteristics and biological performance of bovine hydroxyapatite.

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INTRODUCTION

The influence of the manufacturing process on physicochemical properties of biomaterials and on their biological performance in terms of bone regeneration remains incompletely understood. Calcium-phosphate-based (CaP) materials have received a lot of attention due to their chemical similarity to bone, but also due to their excellent biocompatibility (1,2). Natural HA from bovine origin (BHA) remains the most popular, compared to synthetic HA, exhibiting physico-chemical properties close to natural bone such as surface topography and microporosities (1-50 μm) (3,4). According to some authors, these characteristics may influence the osteoconductivity of the materials and therefore their clinical performance. Additionally, their slowly resorbable feature is of great interest in the field of dentistry and maxillofacial surgery as the goal of the bone regenerative treatment is to maintain the volume overtime. For safety reasons, xenogenic materials from bovine origin need to be completely deproteinized through thermal or chemical strategies, to eliminate the risk of transmission of bacteria, virus or prion particles. One easy and cheap process to deproteinize BHA is sintering at temperatures higher than 1000°C, ensuring the complete removal of the organic compounds and improving mechanical properties (density, grain size, compressive, flexural and torsional strength). However, sintering HA also has a significant impact on the surface properties, including surface roughness and on microstructure including the crystallinity and microporosity and may therefore influence the biological performance of the biomaterial. The primary objective of this study was to **analyze the effect of heat treatment on the physicochemical characteristics of a newly developed bovine hydroxyapatite (BHA)**. The secondary objective was to **evaluate the consequences on its *in vivo* biological performance (new bone formation and osteoconductivity), and to correlate the results with the physical and topographical characteristics of the studied biomaterials.**

MATERIALS & METHODS

Protein-free hydroxyapatite from bovine origin was produced under sub-critical conditions and then either briefly hardened at mid-range temperature (820°C), or sintered at 1200°C. Non-sintered samples were also produced. The physicochemical properties were assessed by scanning electronic microscopy (SEM), measurement of specific surface area (BET) and X-ray diffractometry (XRD). The materials were then implanted in standardized alveolar bone defects in minipigs. 3 months after implantation, histological and histomorphometric evaluations (%age of newly formed bone and %age of bone-to-material contact) were performed using non-decalcified sections. The Scheffé test was used to compare temperatures two by two.

SOURCES:

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RESULTS

Marked topographical differences were observed by SEM analysis, showing highly structured surfaces on the unheated and hardened BHAs, while the highly sintered one was characterized by a much smoother surface and very few remaining porosities.

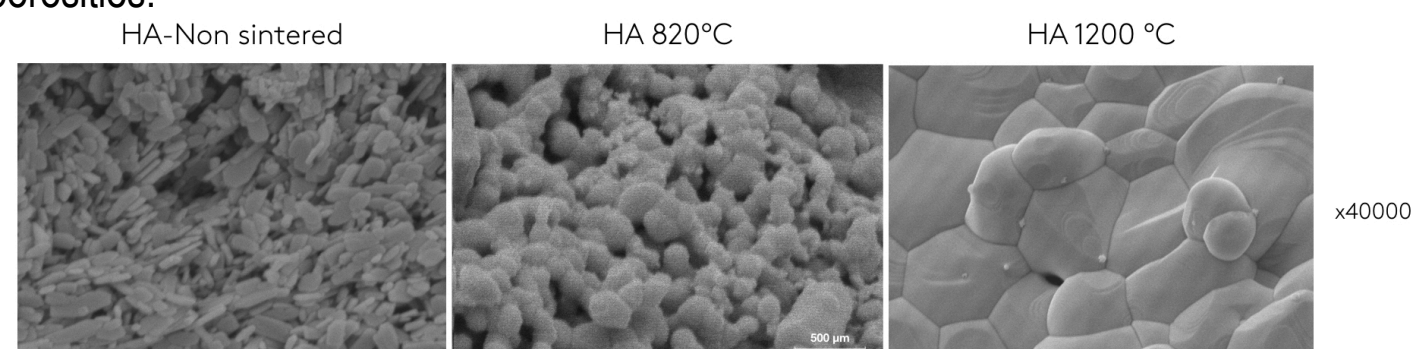


Fig. 1. Scanning electronic microscopy of the studied biomaterials

As the sintering temperature increased, the specific surface area (BET) significantly decreased while crystals size (XRD) increased. *In vivo* samples showed a similar regenerated area observed in the 3 groups, while the highly sintered BHA presented a significantly lower %age of newly formed bone than the unheated one ($p=0,009$). In addition, the %age of bone-to-material contact (osteoconductivity) was significantly lowered by sintering when compared to the unheated ($p=0,01$;) and to the hardened ($p=0,02$) groups. Both %age of newly formed bone and BMC positively correlated with BET values and negatively correlated to the increase of HA crystal size.

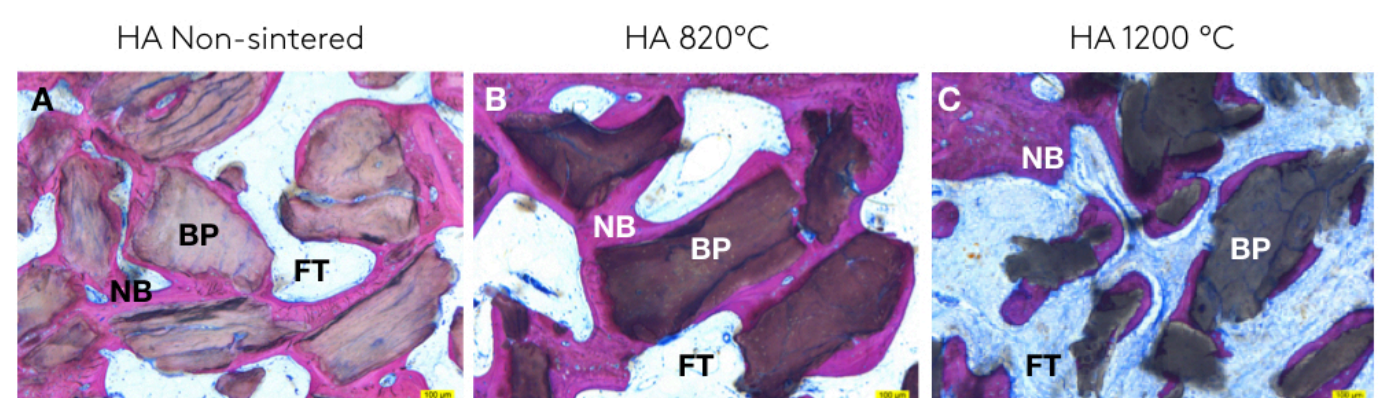


Fig. 2. Descriptive histology at 3 months. BP, bone particle; NB, newly formed bone; FT, fibrous connective tissue

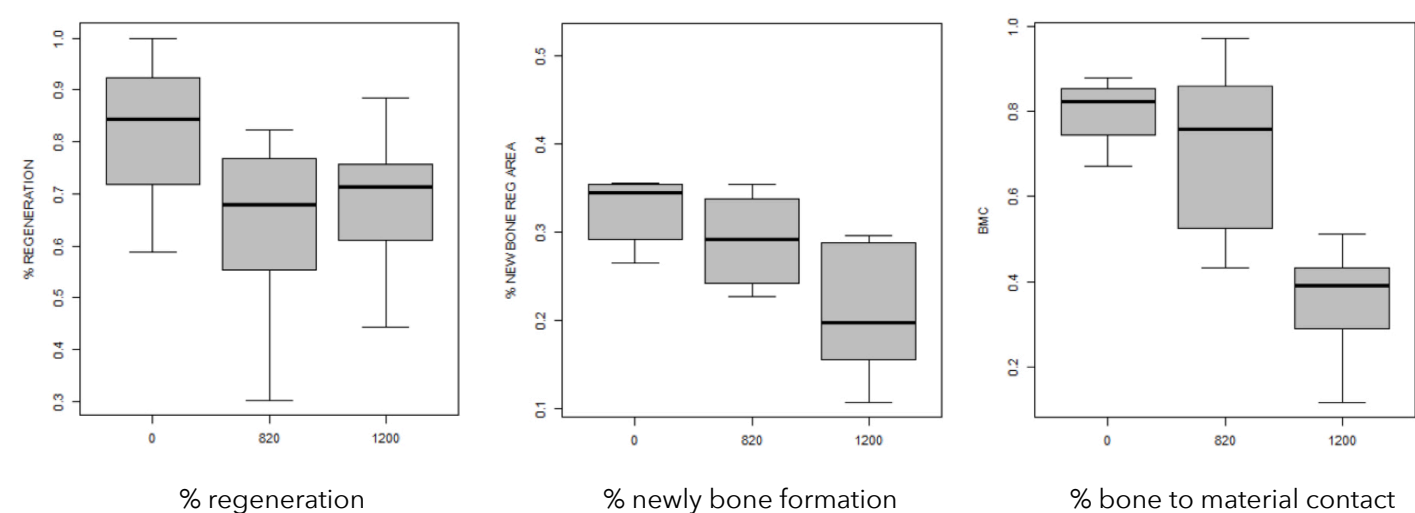


Fig. 3. Evaluation of the biological performance of the different samples in terms of % of regeneration, % of newly formed bone and % of bone to material contact

DISCUSSION/CONCLUSION

Within the limits of this study, sintering temperature affects the surface properties of HA biomaterials and those parameters influence the *in vivo* performance in terms of new bone formation and bone to material contact. Sintering process of BHA at 1200°C has a marked effect on its physicochemical characteristics and significantly lowers its biological performance while lower sintering temperature seems to preserve the topographical characteristics (surface roughness) of bovine hydroxyapatite and allows good bone regeneration and osteoconductivity (bone to material contact).