Fabrication of self-setting β-TCP granular cement using β-TCP granules and sodium hydrogen sulfate solution

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（溶解析出反応を利用した β-TCP 顆粒セメントの創製）

区　　分 ：甲

論 文 内 容 の 要 旨

Beta tricalcium phosphate (β-TCP; $Ca_3(PO_4)_2$) has been widely used as a bone substitute due to its bioresorbability and osteoconductivity. Several forms of β-TCP such as granules, porous blocks, cements, sponges or strips are available for bone graft substitutes. Granular type is by far the most frequently used as bone graft substitutes due to their relatively low cost, broad availability and good biological properties. However, if granular type of β-TCP is implanted in a large defect, granules tend to flow out from implantation site.

Previously, we have proposed beta tricalcium phosphate granular cement (β-TCPGC) that is useful to prevent flowing out of the β-TCP granules from the bone defect. When the β-TCP granules were mixed with acidic calcium phosphate solution, it set to form interconnected porous structure. Bridging beta-tricalcium phosphate (β-TCP) granules with dicalcium phosphate dihydrate (DCPD) creates a porous, interconnected β-TCP granular cement (GC) that is useful for reconstructing bone defects. The interconnected pores can accelerate new bone ingrowth and the set cement prevents the loss of granules from the bone defect area. However, the setting time of β-TCP GC in an acidic calcium phosphate solution is too short (<1 min) for handling in clinical applications, such as in orthopedic surgery.

In this study, β-TCP GC consisting of β-TCP granules and $NaHSO_4$ solution was tested, as SO_4^{2-} is an inhibitor of DCPD formation. When 2 mol/L $NaHSO_4$ solution was used as the liquid phase, setting time became 5.3 ± 0.2 min, which is suitable for clinical applications. Both DCPD and calcium sulfate dihydrate (CSD) were precipitated on the β-TCP granular surface and bridged β-TCP granules to one another. The amount of precipitate and mechanical strength of the set β-TCP GC increased with increasing $NaHSO_4$ concentrations. The diametral tensile strength value was approximately 2.0 MPa when 5 mol/L $NaHSO_4$ solution was used.

In conclusion, self-setting β-TCP granules cement that has suitable setting time for clinical applications upon mixing the β-TCP granules with $NaHSO_4$ solution was successfully fabricated in this study. Partial dissolution of the β-TCP granules and precipitation of newly formed CSD and DCPD crystals, and resulting β-TCP granules' bridge by the precipitates was the key for the setting reaction. Since the self-setting granules addressed the issue of setting time and flowing out the granules from implantation site, β-TCP GC using $NaHSO_4$ solution as the liquid phase has good potential value as bone augmentation cement and could be useful for dental and medical application.