

Fabrication and histological evaluation of a self-setting granular cement using calcium sulfate hemihydrate granules with different pore distribution

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論 文 名 : Fabrication and histological evaluation of a self-setting granular cement using calcium sulfate hemihydrate granules with different pore distribution.
(異なる細孔分布を有する硫酸カルシウム半水和物顆粒を用いた自己硬化型粒状セメントの製造および組織学的評価)

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論 文 内 容 の 要 旨

Granular bone substitutes are widely used in dentistry for alveolar bone defect treatment due to their adaptability to irregularly shaped defects. However, granule migration from the defect site remains a significant clinical challenge, often resulting in insufficient bone formation. Calcium sulfate hemihydrate (CSH; $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$) is a self-setting material that converts into calcium sulfate dihydrate (CSD; $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) through hydration. This transformation involves dissolution, ion saturation, and precipitation of interlocking needle-like CSD crystals. While CSD supports bioresorption and calcium release, its rapid resorption limits clinical utility. This study aims to optimize the porosity of CSH granules to improve their stability and osteogenic potential.

CSH granules were fabricated by pressing CSH powder at 0, 50, 100, and 150 MPa, followed by heat treatment at 120° C for six hours to ensure complete conversion from CSD to CSH. The pressed blocks were crushed and sieved into granules sized 300-600 μm and designated as CSH(0), CSH(50), CSH(100), and CSH(150). MIP revealed a significant reduction in micropores ($<1.0 \mu\text{m}$) and cumulative pore volumes with increasing pressing pressure, especially in CSH(100) and CSH(150). These granules formed porous blocks upon setting in 0.25 mol/L K_2SO_4 solution. SEM analysis confirmed needle-like interlocking crystals, with larger crystal lengths in CSH(100) and CSH(150). XRD confirmed the complete conversion to CSD, unaffected by applied pressure.

Mechanical strength increased with higher pressing forces due to reduced porosity, though no direct correlation between pressure and strength was observed. Degradation test in distilled water showed that CSH(0) dissolved completely within five days, while CSH(100) and CSH(150) maintained their structure after seven days due to lower micropore volumes.

In a rabbit femoral defect model, $\mu\text{-CT}$ and histological analysis demonstrated new bone

formation across all groups. CSH(150) granules retained structural integrity with minimal migration, supporting osteogenesis and angiogenesis. Although no significant differences in bone formation were observed among groups, CSH(150) showed slightly enhanced osteogenic potential.

In conclusion, the study successfully developed self-setting CSH granules with reduced micropores and improved degradation resistance. These granules hardened effectively in bone defects, minimizing dispersion and promoting new bone formation, even though the rate of increase was modest. The findings highlight the potential of CSH granules as promising materials for bone reconstruction in dental applications.

Keywords: Calcium sulfate, bone substitute, self-setting granules.