

71

may be repaired include the ethmoid, frontal, nasal, occipital, parietal, temporal, mandible, maxilla, zygomatic, cervical vertebra, thoracic vertebra, lumbar vertebra, sacrum, rib, sternum, clavicle, scapula, humerus, radius, ulna, carpal bones, metacarpal bones, phalanges, ilium, ischium, pubis, femur, tibia, fibula, patella, calcaneus tarsal and metatarsal and condyle bones.

The invention can be used to make articles that restore a bone to its original contours, or it can be used to make pieces that extend bones beyond the original boundaries of the bones. The biostructure may be dimensioned and shaped uniquely for a particular patient's body, or it could have standardized shape and dimensions. The invention can be used to make spinal fusion devices, which act to fuse together vertebrae that originally were separate and distinct from each other. The invention could be used to make basic shapes that can be carved or modified by a surgeon intra-operatively. The word augmentation is used here to refer to any biostructure installed in a bone, whether or not the biostructure when installed extends beyond the original boundaries of the bone.

The method described herein for making a three-dimensional printing biostructure with mesostructures could also be used for making articles for non-medical purposes.

The above description of various illustrated embodiments of the invention is not intended to be exhaustive or to limit the invention to the precise form disclosed. While specific embodiments of, and examples for, the invention are described herein for illustrative purposes, various equivalent modifications are possible within the scope of the invention, as those skilled in the relevant art will recognize. The teachings provided herein of the invention can be applied to other purposes, other than the examples described above.

The various embodiments described above can be combined to provide further embodiments. Aspects of the invention can be modified, if necessary, to employ the process, apparatuses and concepts of the various patents, applications and publications described above to provide yet further embodiments of the invention. All patents, patent applications and publications cited herein are incorporated by reference in their entirety.

These and other changes can be made to the invention in light of the above detailed description. In general, in the following claims, the terms used should not be construed to limit the invention to the specific embodiments disclosed in the specification and the claims, but should be construed to include all devices that operate under the claims to provide a biostructure formed from powder and the associated method of manufacture. Accordingly, the invention is not limited by the disclosure, but instead the scope of the invention is to be determined entirely by the following claims.

We claim:

1. An osteoinductive or osteoconductive biostructure comprising a matrix of interconnected ceramic particles joined directly to each other and having at least one of a porous portion, wherein said porous portion comprises controlled particle packing providing controlled inter-particle pores, and further wherein said matrix of interconnected particles comprises multiple discrete regions having different compositions wherein the multiple discrete regions comprise a first region having a composition comprising hydroxyapatite and a second region having a composition comprising tricalcium phosphate, and wherein both the first region and the second region are porous, and further wherein said first and second porous regions have pore sizes that are approximately equal.

72

2. The biostructure of claim 1, wherein the biostructure further comprises macrochannels therethrough.

3. The biostructure of claim 1 produced by a process comprising heating a precursor biostructure, wherein the precursor biostructure comprises multiple discrete regions having different compositions, and wherein at least one of the multiple discrete regions comprises a different composition which converts to another substance by a chemical reaction initiated by said heating.

4. The biostructure produced by the process of claim 3, wherein said precursor biostructure further comprises a calcium-rich reactant that facilitates the chemical reaction.

5. The biostructure produced by the process of claim 4, wherein the calcium-rich reactant is selected from calcium carbonate, calcium oxide, calcium hydroxide, and combinations thereof.

6. The biostructure produced by the process of claim 3, wherein said precursor biostructure further comprises a phosphorus-rich reactant that facilitates the chemical reaction.

7. The biostructure produced by the process of claim 6, wherein the phosphorus-rich reactant is selected from dicalcium phosphate, monocalcium phosphate, phosphoric acid, ammonium phosphate, and combinations thereof.

8. An osteoinductive or osteoconductive biostructure comprising a matrix of interconnected ceramic particles joined directly to each other and having at least one of a porous portion, wherein said porous portion comprises controlled particle packing providing controlled inter-particle pores, and at least two intersecting macrochannels, and having an exterior surface wherein the exterior surface contains at least one groove.

9. The biostructure of claim 8, wherein said inter-particle pores have a pore size distribution having a peak in the range of 60 microns to 100 microns.

10. The biostructure of claim 8, wherein said biostructure comprises particles selected from calcium phosphates, hydroxyapatite, tricalcium phosphate, calcium salts, dental tooth enamel, aragonite, calcite, nacre, bioceramic and mixtures thereof.

11. The biostructure of claim 8, further comprising distinct regions of a first composition of hydroxyapatite and a second composition of tricalcium phosphate.

12. An osteoinductive or osteoconductive biostructure comprising a matrix of interconnected ceramic particles joined directly to each other and having at least one of a porous portion, wherein said porous portion comprises controlled particle packing providing controlled inter-particle pores, and macrochannels, wherein the biostructure further comprises, in space not otherwise occupied, a co-located polymer and bioactive substance.

13. The biostructure of claim 12, wherein said inter-particle pores have a pore size distribution having a peak in the range of 60 microns to 100 microns.

14. The biostructure of claim 12, wherein said biostructure comprises particles selected from calcium phosphates, hydroxyapatite, tricalcium phosphate, calcium salts, dental tooth enamel, aragonite, calcite, nacre, bioceramic and mixtures thereof.

15. The biostructure of claim 12, further comprising distinct regions of a first composition of hydroxyapatite and a second composition of tricalcium phosphate.

16. An osteoinductive or osteoconductive biostructure comprising a matrix of interconnected particles having at least one of a porous portion, wherein said porous portion comprises controlled particle packing providing controlled