Replacement by Bone." In: Bone Engineering, ed. JE Davies, Em^2 Inc., Toronto, Ont. Canada, Chapter 30, 332-344, 2000).

[0007] The many clinical situations that require extensive complex bone repair and regeneration continue to represent problems without acceptable solutions. The current clinical treatments are compromises that require elaborate and complex autogenous grafting procedures, or they represent imperfect allogeneic or alloplastic treatment options. In all cases these complex bone repair situations require that materials not made for a specific site are fit as well as possible into the defect. It would be desirable to provide new means for printing three dimensional scaffolds composed of osteoconductive biomaterials that have the potential to be custom-fabricated to repair complex defects.

SUMMARY ~~OF THE INVENTION~~

[0007a] In one aspect, there is provided a tissue repair device or scaffold having a porous bone ingrowth structure containing interconnected struts surrounded by a microporous shell.

[0008] ~~In a first aspect, the present invention provides~~Disclosed is a tissue repair device or scaffold having a porous bone ingrowth area containing interconnected struts surrounded by a microporous shell. The microporous shell may function to attach but limit soft tissue ingrowth. At the ends of the tissue repair device or scaffold, the shell may be extended as a guide flange to stabilize the tissue repair device or scaffold between ends of bone, across a bone defect, etc. or the tissue repair device or scaffold may be used to repair a defect of a flat bone. The center of the tissue repair device or scaffold may be empty and may serve as a potential marrow space. The porous ingrowth structure may be infiltrated with a soluble filler or carrier, such as, for example calcium sulfate. This soluble filler or carrier, such as, for example calcium sulfate, may be infiltrated with one or more of an antibiotic, a growth factor, a differentiation factor, a cytokine, a drug, or a combination of these agents. The tissue repair device or scaffold may fit between the cortical bone ends of long bone and conduct healing bone, which arises largely from the endosteal and periosteal surfaces or it may be used at or near a bone defect of, for instance, flat bone. The tissue repair device or scaffold may be stabilized using a modified bone plate or bone screws. The tissue repair device or scaffold may be produced by a three dimensional printing procedure and may be formed of, for instance, an osteoconductive ceramic.

[0011] The tissue repair device or scaffold may be effective for promoting bone growth and treating bone fracture, defect or deficiency across a distance of at least 5, 10, 11, 12, 13, 14, 15, 18, 20, 25, 30, 35, 40, 50, 60, 70, 80, 90 or 100 or more millimeters. Similarly, the tissue repair device or scaffold may be effective for promoting the growth of both cortical or cortical-like bone and trabecular or trabecular-like bone. The bone so grown may be in any suitable proportion, such as, for example 95%, 90%, 80%, 75%, 70%, 60%, 50%, 40%, 30%, 25%, 20%, 10% or so trabecular or trabecular-like bone, or just the opposite, i.e. 95%, 90%, 80%, 75%, 70%, 60%, 50%, 40%, 30%, 25%, 20%, 10% or so cortical or cortical-like bone. The tissue repair device or scaffold may be effective for reducing or shortening the normal repair time across a bone defect by 5, 10, 20, 25, 30, 40, 50, 75, 90% or more. In some instances, the bone defect may be repaired in about half, one third or one quarter of the normally required period of time. In many instances, the larger pore sizes are found near the outer portions of the scaffold and the smaller pore sizes are found near the inner portions of the scaffold. In some instances, the portion of the scaffold forming the inner half of the surface area may have a median pore diameter size or area that is 5, 10, 20, 25, 30, 40, 50, 75, 90% or more smaller than the median pore diameter size or area of the portion of the scaffold forming the outer half of the surface area. In some instances the pore sizes are arranged architecturally in any suitable or desirable configuration so as to customize the type of bone growth, for instance bone density, trabecular-like bone or cortical-like bone, desired. Similarly, in some instances, the tissue repair device or scaffold is formed and shaped to customize the shape of tissue or bone repair desired to optimally span a defect. Further, in some instances, a portion of the tissue repair device or scaffold may be substantially hollow, for instance, 10, 20, 25, 30, 40, 50, 75, 90% or more of the interior portion of the tissue repair device or scaffold may be substantially hollow.

[0012] ~~In a second aspect, the present invention provides~~Disclosed is a method for promoting bone growth or treating bone fracture, defect or deficiency by providing a tissue repair device or scaffold having a porous bone ingrowth area containing interconnected struts surrounded by a microporous shell. The promoting bone growth or treating bone fracture, defect or deficiency may feature controlling or affecting the density of bone or may feature remodeling bone, for instance, cancellar or cortical bone. In most instances the tissue repair device or scaffold is provided *in vivo* to a region featuring a bone deficiency, fracture or void. The microporous shell may function to

[0015a] In one aspect, there is provided a method for producing a tissue repair device or scaffold useful for promoting bone growth or treating bone fracture, defect or deficiency having a porous bone ingrowth region containing interconnected struts surrounded by a microporous shell, comprising:

(a) providing microporous shell that may function to attach but limit soft tissue ingrowth, and

(b) infiltrating the porous ingrowth structure with a soluble filler or carrier.

[0016] ~~In a third aspect, the present invention provides~~Disclosed is a method for producing a tissue repair device or scaffold useful for promoting bone growth or treating bone fracture, defect or deficiency having a porous bone ingrowth area containing interconnected struts surrounded by a microporous shell. The method features (a) providing a microporous shell that may function to attach but limit soft tissue ingrowth, (b) infiltrating a porous ingrowth structure with a soluble filler or carrier, and optionally (c) infiltrating the porous ingrowth structure with one or more of an antibiotic, a growth factor, a differentiation factor, a cytokine, a drug, or a combination of these agents. The soluble filler or carrier may be a filler that attracts osteoclasts, such as, for example calcium phosphate mineral and type I collagen protein. tissue repair device or scaffold useful for promoting bone growth or treating bone fracture, defect or deficiency having a porous bone ingrowth area containing interconnected struts surrounded by a microporous shell may have the features described herein with respect to the ~~first and second~~ aspects and embodiments of the ~~invention~~disclosure.

BRIEF DESCRIPTION OF THE FIGURES

[0017] Figure 1 is a schematic drawing of a tissue repair device or scaffold design that may be used to regenerate a long bone defect, showing its placement and fixation in the defect. The scaffold has a porous bone ingrowth area (A) containing interconnected 250μm cylindrical struts surrounded by a microporous shell (B) to attach but limit soft tissue ingrowth. At the ends of the scaffold, the shell may be extended as a guide flange (C) to stabilize the construct between the bone ends. The center of the scaffold (D) may be left empty as a potential marrow space. The porous ingrowth structure (outlined with dashed line in upper left drawing) may be infiltrated with a soluble filler/carrier (such as calcium sulfate as an example) that may be infiltrated with one or more of antibiotic, growth factors, differentiation factors, cytokines, drugs, or a combination of these agents. The scaffold may fit between the cortical bone ends (E) of the long bone and conduct healing bone, which arises largely from the endosteal and periosteal surfaces (F). The construct may be stabilized using a modified bone plate (G) and bone screws (H).

9. The tissue repair device or scaffold according to claim 1 wherein one or more struts are separated longitudinally by a space of at least 500 μm.

10. The tissue repair device or scaffold according to claim 1 being porous and comprising mesopores present in a size generally more than about 20 μm diameter.

11. The tissue repair device or scaffold according to claim 1 wherein the struts are arranged in a substantially linear arrangement.

12. The tissue repair device or scaffold according to claim 1 being resorbable so that after about 8 weeks presence *in vivo*, at least about 25% of the tissue repair device or scaffold is resorbed.

13. The tissue repair device or scaffold according to claim 1 being at least about 50% porous.

14. The tissue repair device or scaffold according to claim 1 being operable to encourage and provide bone growth such that after about 8 weeks presence *in vivo*, at least about 25% of the tissue repair device or scaffold is replaced by bone.

15. The tissue repair device or scaffold according to claim 1 comprising micropores or nanopores having a diameter of about 0.1-1 μm.

16. The tissue repair device or scaffold according to claim 15 wherein one or more micropores or nanopores are infiltrated with solubilized collagen.

17. The tissue repair device or scaffold according to claim 1 produced by a three dimensional printing method.

~~18. A method for promoting bone growth or treating bone fracture, defect or deficiency comprising providing a tissue repair device or scaffold having a porous bone ingrowth structure containing~~

~~interconnected struts surrounded by a microporous shell according to claim 1 *in vivo* to a region featuring a bone deficiency, fracture or void.~~

~~19~~18. A method for producing a tissue repair device or scaffold useful for promoting bone growth or treating bone fracture, defect or deficiency having a porous bone ingrowth region containing interconnected struts surrounded by a microporous shell, comprising:

(a) providing microporous shell that may function to attach but limit soft tissue ingrowth, and

(b) infiltrating the porous ingrowth structure with a soluble filler or carrier.

~~20~~19. A method according to claim 18~~19~~ further comprising (c) infiltrating the porous ingrowth structure with one or more of an antibiotic, a growth factor, a differentiation factors, a cytokine, a drug, or a combination of these agents.