Guided bone regeneration for critical bone defect using composite collagen scaffold and nacre

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Abstract

Critical bone defects are a major challenge for oral & maxillo-facial surgeons, & other clinical specialities. There are unmet surgical needs for bone repair biomaterials. To address this demand, in this study, the guided bone regeneration properties and bone healing properties of the CelGro™ and the newly developed nacre-derived hydroxyapatite are tested. The results indicate that CelGro™ collagen membrane can be used in GBR treatment to preserve or restore bone volume in cortical bone defects. The composite CelGro™/ may be a promising solution for the treatment of cortical bone defects.

Figure 1. Characterisation of nacre-derived hydroxyapatite(NDH)

Background and Aim

Background: Critical bone defects are a major challenge for oral & maxillo-facial surgeons, & other clinical specialities. There is a need for minimally-invasive treatments that deliver good therapeutic results, like biomaterials. However, the clinical outcomes of currently available bone biomaterials are compromised by their relatively slow resorption rate & minimal osteoinductivity. Nacre (mother-of-pearl) is a novel & readily available source material that demonstrates bio-mineralising activity.

Aim: To characterise the physico-chemical properties of a composite biomaterial for GBR consisting of a collagen membrane (CelGro™) and nacre-derived hydroxyapatite (NDH), and to evaluate its biological performance in a rabbit cortical bone defect model.

Methods and Materials

Characterisation of NDH was performed by imaging (SEM), chemical analysis (XRD), mechanical test (compressive strength) and in vivo degradation (subcutaneous implantation). GBR performance was tested in a rabbit cortical bone defect model. A cortical bone defect was created in the right femur of 24 male, skeletally mature NZ White Rabbits. Animals received 1) Autogenous bone graft + CelGro™; 2) Autogenous bone graft + comparator (Bio-Gide®); 3) Autogenous bone graft alone; or 4) no xa. Animals were sacrificed at 30- or 60-days (n=3 per group). Bone regeneration was assessed by μ -CT & histology. Composite CelGro™ & NDH was assessed in the same animal model. No treatment, & treatment with CelGro™+ commercially available hydroxyapatite were negative and positive controls (n=5 per group), respectively. After sample retrieval at 60 days, μ -CT analysis was used to assess healing of the cortical bone defect.

Figure 2. Surgery procedure for bone defect repair with CelGro™ and Autograft, NDH and HA composites

Results

Physico-chemical characterisation of NDH indicated that it consists of nacre and multiple calcium orthophosphates, with nacre crystal structures 'decorating' the

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calcium orthophosphate microparticle surface, which together could provide enough strength for clinical use. The NDH scaffolds showed a stable and relatively faster degradation rate than pure hydroxyapatite. In animals treated with collagen membrane & bone graft, μ -CT analysis of femur samples showed that bone defects were bridged by continuous & firm cortical bone. Without collagen membrane, new bone was of a porous, honeycomb-like structure, & the cortical surface could be observed in the defect region. Significantly lower % Po.V/TV ($p<0.05$) was seen in collagen membrane + bone graft compared to graft only or no treatment controls. CelGro™ & NDH composite scaffolds presented increased bone volume and cortical bone thickness, indicating significantly greater osteoinductivity compared to hydroxyapatite control.

Figure 3. Micro-CT result for bone defect repair with collagen membrane/Autograft composites

Figure 4. Micro-CT result for bone defect repair with CelGro™ and NDH and HA composites(60 days)

Conclusion

The results of this study indicate that CelGro™ collagen membrane can be used in GBR treatment to preserve or restore bone volume in cortical bone defects. The composite CelGro™ collagen membrane & nacre-derived hydroxyapatite may be a promising solution for the treatment of cortical bone defects.