

From Concept to Clinical Relevance: 3D-Printed Hydroxyapatite Scaffolds Supporting Dental Implant Osteointegration in Alveolar Bone Augmentation

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Introduction

3D-printed biomaterials are increasingly investigated for bone regeneration; however, most preclinical studies focus solely on bone formation and rarely mimic their intended clinical use. For alveolar ridge augmentation, the clinical purpose is to place a dental implant into the 3D-printed biomaterial. This study aimed to assess, for the first time, the osteointegration of dental implants placed in combination with 3D-printed hydroxyapatite blocks featuring gyroid porosity (gyroid-3DHA) for large alveolar bone augmentation. Gyroid-3DHA is a 3D-printed scaffold with an optimized macroporosity for vascularisation and osteointegration [1].

Materials and Methods

In a minipig model, mandibula lateral bone augmentation was performed bilaterally using gyroid-3DHA blocks (Fig. 1). After 8 or 12 weeks of healing, dental implants were placed directly into the blocks using standard clinical procedures. Following an additional 12-week healing period, specimens were harvested for histological and histomorphometric analysis, assessing new bone formation, 3DHA integration, vertical bone gain, and bone-to-implant contact (BIC).

Results

Gyroid-3DHA blocks enabled stable fixation with screws and allowed for conventional dental implant placement with good primary stability. Histological analysis revealed 39.17% ($\pm$ 3.88) new bone formation and a vertical bone gain of 4.73 mm. The bone ingrowth within the gyroid-3DHA is on average 67.53% ($\pm$ 6.82). Bone growth is uninterrupted, starting from the native bone contact surface and uniformly distributed over the graft cross-section (Fig. 2). The dental implants achieved good and slightly higher bone-to-implant contact within the 3DHA (42.79% ($\pm$ 20.77)) compared to that observed in native bone (34.17% ($\pm$ 20.28)). But the difference is not statistically significant. Also, no significant difference was observed between the healing periods.