

Abstract

To investigate the osteogenic response of sinusoidal loading frequencies in vitro, a mechanical load with deformation in the physiological range was applied to a bone-like construct and the change in the degree of calcification was monitored for 42 consecutive days. Tissue-engineered bone was made by seeding pre-osteoblastic cells (MC3T3-E1) into a type I collagen sponge scaffold in osteogenic medium. Sinusoidal mechanical loads with a peak of 0.3% deformation with vibration (Gaussian quasi-white noise with a standard deviation of 0.03% deformation) was applied to the constructs at 0.5, 1.0, 1.5, 2.0 and 2.5 Hz for 3 minutes per day for 42 consecutive days using a piezoelectric mechanical stimulator. A non-destructive optical monitoring device using near-infrared light was used for the detection of the calcification response of the tissue-engineered bone once a day. The degree of calcification was evaluated as calcium content (mg/cm^3) based on the initial calcium calibration curve.

Mechanical loading promoted higher calcification of the osteoblasts cultured in the scaffolds when compared with the calcification of the scaffolds without loading. The degree of calcification started to increase in the stimulated constructs after day 8. On day 42, the calcium content of the control constructs was 1.19-fold higher than its initial measurement (day 0). The calcium content in the stimulated constructs at 0.5, 1.0, 1.5, 2.0 and 2.5 Hz was 1.32, 1.52, 1.90, 2.00 and 1.32-fold, respectively, higher than that of the control construct on day 42. From the results, it was concluded that the sinusoidal loading frequency could function as a potent enhancer of osteogenesis in vitro, suggesting the usefulness of mechanical loading in bone tissue engineering.

Keywords : Bone / Calcification / Infrared / Mechanical Stimuli / Piezoelectric / Tissue Engineering