Effects of Surface Potential Induced by Cyclic Deformation of $BaTiO_3$ on Osteogenic Differentiation of Rat Bone Marrow Cells

Y. Kato, Y. Morita, E. Nakamachi

Faculty of Life and Medical Sciences, Doshisha University, 1-3 Tatara-Miyakodani, Kyotanabe, Kyoto, Japan

ymorita@mail.doshisha.ac.jp

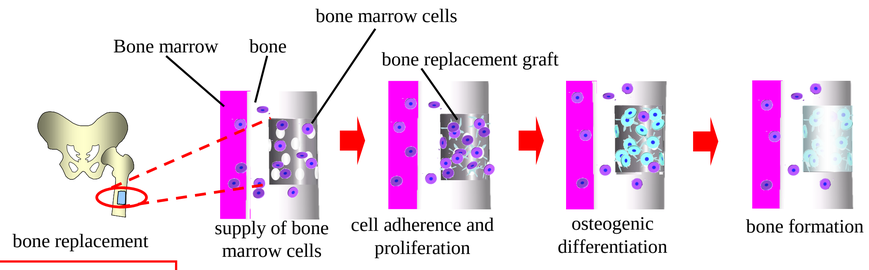
Introduction

Repair of bone defects using artificial bone grafts

It is necessary to accelerate osteogenic differentiation of bone marrow cells which adhere on artificial bone grafts for early fixation between host bone and bone graft.

Previous studies:

Development of surface roughness, wettability and morphology of bone grafts

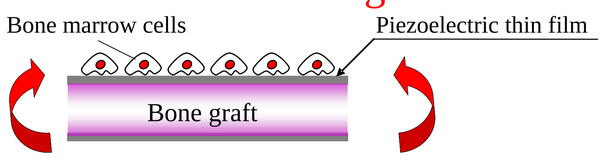


Novel treatment is required to improve fixation between host bone and artificial bone graft.

We focused on piezoelectric thin film coat on bone graft

It is expected that stress-generated potential on piezoelectric thin film can enhance osteogenic differentiation of bone marrow cells *in vivo*.

Barium titanate ($BaTiO_3$) { Biocompatible lead-free material; High piezoelectric property



Surface potential is generated on piezoelectric thin film by its deformation.

Previous studies

There is no report about the effects of potential of piezoelectric ceramics on bone marrow cells under dynamic loading *in vitro*.

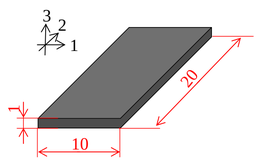
Objective

To investigate the effects of cyclic surface potential of BTO ceramics with deformation on osteogenic differentiation of rat bone marrow cells *in vitro*.

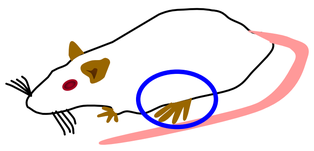
Materials and Methods

BTO ceramics

- Polarized BTO
- Non-polarized BTO

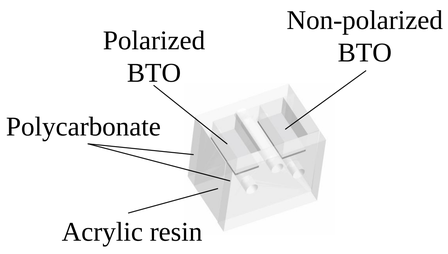


Cell preparation



Bone marrow cells were isolated from femoral bone shaft of 7-week-old male Fischer 344 rats.

Cell seeding

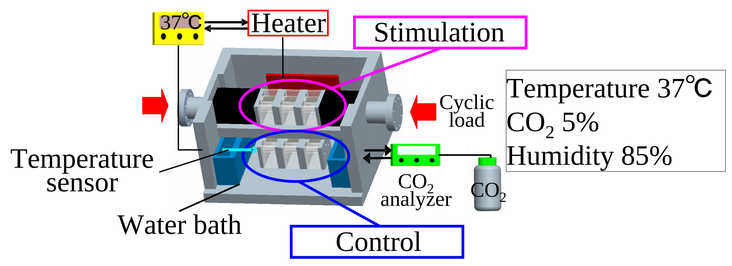


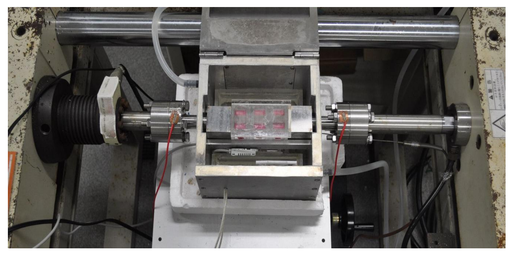
Seeded at 3.0×10^4 cells/cm^2 on polarized BTO and non-polarized BTO.

Culture medium

DMEM + { 10%FBS; Antibiotics; 10 nM Dexamethasone; 10 mM β-Glycerophosphate; 82 μg/ml Ascorbic acid

Dynamic cultivation for 6 and 9 days





- Cyclic compressive load was applied three culture dishes set on the upper stage by a fatigue testing machine.
- Another three culture dishes were set on the lower stage without cyclic compressive strain.

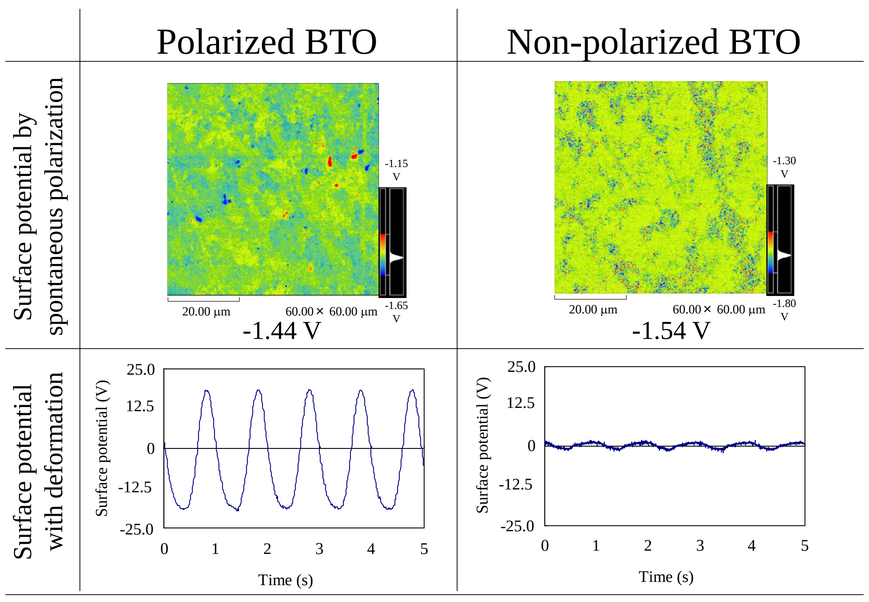
Stimulation condition

Compressive waveform	Sinusoidal wave
Compressive frequency (Hz)	1
Maximum strain of BTO (με)	65

- DNA amount
- Alkaline phosphate activity (ALP activity)

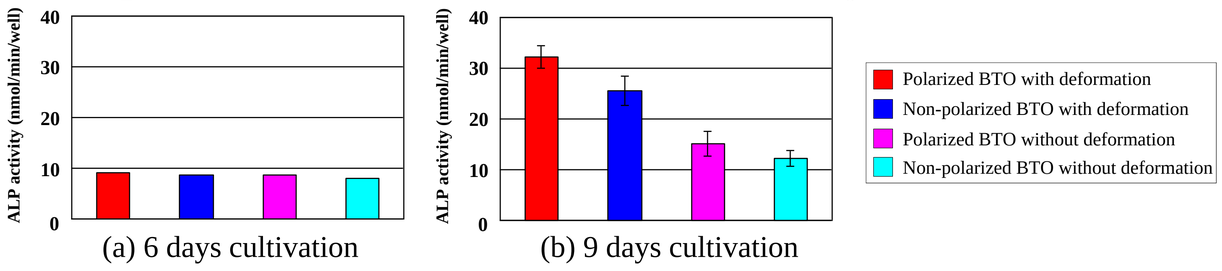
Results and Discussion

Surface potential of BTO ceramics



- Surface potential of non-polarized BTO by spontaneous polarization was almost same as that of polarized BTO.
- Surface potential of non-polarized BTO with compressive deformation was much smaller than that of polarized BTO.

Effects of piezoelectric stimulation on ALP activity



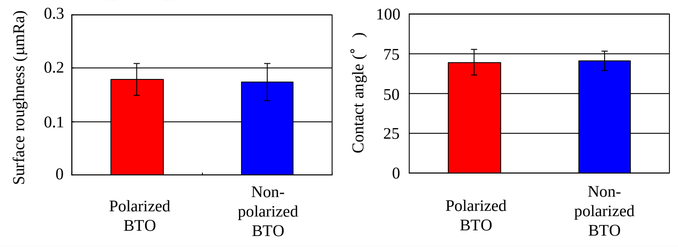
6 days cultivation

- There was no difference in ALP activity in all conditions.

9 days cultivation

- ALP activity was not affected by spontaneous polarization.
- ALP activity was affected by strain of BTO ceramics with deformation.
- ALP activity was much affected by synergistic effects of surface potential and strain of BTO ceramics compared with only strain.

Surface properties



Difference in ALP activity was not affected by surface properties of BTO ceramics.

Surface potential of polarized BTO enhances osteogenic differentiation of bone marrow cells

Conclusions

It is suggested that surface potential of polarized BTO enhances osteogenic differentiation of rat bone marrow cells under dynamic loading *in vitro*.