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BASIC RESEARCH

Novel bioactive titanium membrane for bone regeneration; effect of alkali treatment

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Background and Aim

Background

Guided bone regeneration (GBR) with barrier membrane technique is popular method of implant treatment for bone regeneration at bone defect site. Titanium is often used for barrier membrane, but titanium has no osteoinductive ability. Therefore, various modification methods have been applied to modify titanium [1]. Our previous study demonstrated that alkali treatment creates nanoscale pore and titania layer on titanium thin membrane without mechanical strength reduction.

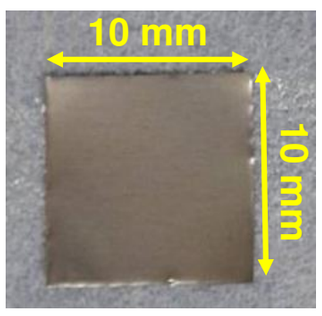
Aim

The aim of this study was to evaluate the ability of titanium membrane with alkali treatment to stimulate apatite-forming in simulated body fluid (SBF) and to promote bone regeneration *in vivo*.

Methods and Materials

Materials

- Titanium thin membrane
  (pure titanium, thickness: 20 μm)
- SBF: Hanks' Balanced Salt Solution
  (HBSS, Lonza)



Methods

Membranes were washed in an ultrasonic cleaner with acetone and distilled water for 1 hour each.

- Control group: no alkali treated titanium membrane
- Alkali group: the titanium membranes were soaked in 5 N NaOH solution at 60 ℃ for 24 h

In vitro

The samples were soaked in SBF for 7, 14 and 21 days.

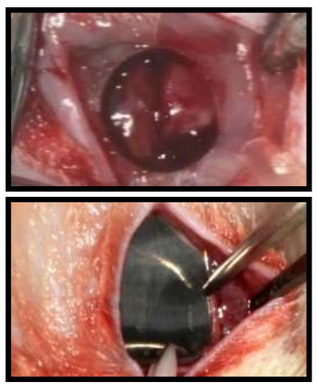
- Surface structure: Scanning electron microscopy
- Surface composition: Electron probe microanalysis

In vivo

The critical-sized bone defect (diameter: 6 mm) was trephined in the center of rat calvaria. The defect area was covered with the control membrane, alkali-treated membrane, or no membrane.

4 weeks

Four weeks later, tissue blocks were harvested.



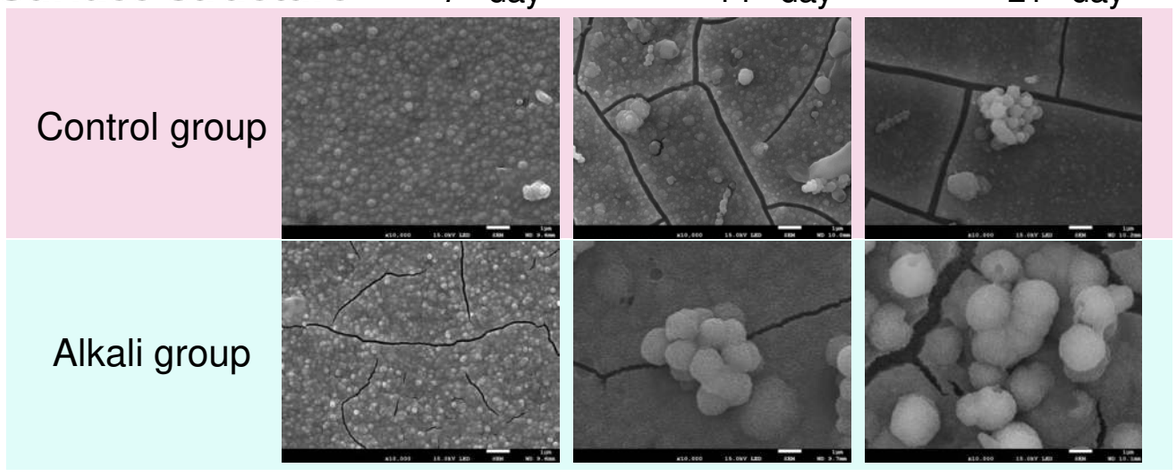
- Bone tissue area (BTA)

  The area surrounding by a line connecting the upper end section and the lower end section of the original defect area
- Bone membrane contact ratio (BMC)

  The length of the bone contact portion divided by the entire length of the membrane

Results

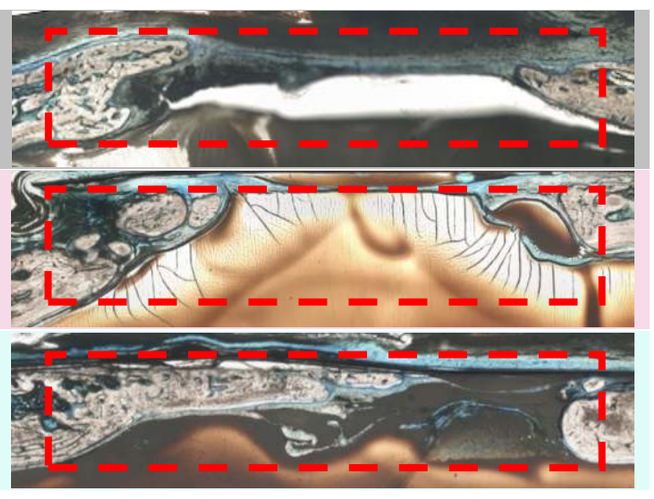
Surface structure



Surface composition

	Control group					Alkali group				
	C	O	Ti	Ca	P	C	O	Ti	Ca	P
0th day	0.26	5.91	93.8	-	-	2.58	23.7	73.7	0.08	-
7th day	0.64	35	54.3	4.52	4.36	0.54	42.2	36.1	9.46	8.24
14th day	0.65	42.8	40.4	7.52	7.09	0.71	43.9	32.8	10.3	8.83
21th day	0.44	43.1	32.4	11	10.3	1.41	38.6	38.8	9.37	8.01

Histological observation



Histomorphometric analysis

	BTA (%)		BMC (%)	
	total area	central area	total area	central area
Control group	35.1±20.6*	21.4±21.4	21.6±12.1	8.0±13.7
Alkali group	37.9±13.0**	33.1±17.1**	42.5±28.8	41.1±29.3*
Without membrane	11.7±4.6	1.5± 2.6		

* compared to without membrane (p<0.05)
** compared to without membrane (p<0.01)
* compared to control(p<0.05)

Alkali-treated titanium membrane induces forming a layer of Ca-P composites on its surface rather than no alkali treated titanium surface. Alkali-treated titanium membranes exhibited a high apatite-forming ability in a body-simulating environment, and high bone forming ability.

Conclusion

Titanium membrane with alkali treatment stimulate apatite-forming in SBF and promote bone regeneration *in vivo*.

Reference

1) Umehara, H. Kobatake, R. Doi, K. Oki, Y. Makihara, Y. Kubo, T. Tsuga, K. Histological and Bone Morphometric Evaluation of Osseointegration Aspects by Alkali Hydrothermally-Treated. Implants. Appl Sci. 8, 635, 2017.

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