Element Solubility from Dental Implants

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Six kinds of dental implants: Apaceram, Bioceram, Free design blade implant, Shape memory blade implant, Hydroxyapatite-coating blade implant and Vitallium were immersed in three kinds of solutions: Ringer's solution, 1.0 % lactic acid solution, and 0.05 % HCl solution, for seven days at 37°C. Using an inductively coupled plasma emission spectroscope, the solutions were analyzed. The element solubilities were observed in five kinds of dental implants, except Bioceram.

Key words: Dental implant, Element solubility, Emission spectroscope

INTRODUCTION

Recently, the dental implant materials made of single, poly-crystal alumina, hydroxyapatite, tricalcium phosphate, titanium and shape memorial alloy (Nitinol) have been improving rapidly, and these dental implants are often used in clinical care. The biocompatibility of these dental implant materials was investigated in *in vivo* and *in vitro* studies¹⁻¹⁰⁾, but the behavior of the solubility of elements in dental implants in the oral cavity has not been investigated.

In this study, we examined the solubility of elements in one experimental implant and five commercial implants that were immersed in three kinds of solutions.

MATERIALS AND METHODS

1. MATERIALS

As shown in Table 1, the four commercial endosseous implants used in this experiment were Apaceram, Bioceram, Free design blade implant and Shape memory blade implant. Hydroxyapatite-coating blade implant was manufactured in our laboratory. For the osseointegrated implant, Vitallium was used.

In making up a resin pattern (20 mm × 15 mm × 1.5 mm, Photo 1), the specimen of Vitallium was invested with a phosphate-bonded investment* in a vacuum. After 24 hours, the temperature was increased to 800°C and was kept there for 30 min. The specimen was cast by the autocentrifugal casting machine with high-frequency induction furnace**. The cast specimen was treated by a sandblaster and polished with sandpaper (No. 100, No. 400, No. 800). After it was washed in pure water, grease was removed from the specimen surface by an ultrasonic cleaner using acetone.

* CROWNVEST : Sankin Industry Co., Ltd., Osaka, Japan

** DENKO AUTOSENSOR MD-201, Tokyo, Japan

Table 1 Dental implant materials

CODE	IMPLANT	TYPE	LOT NO.	MANUFACTURER
APA	Apaceram	ART 1555	IDD1815	Pentax
BIO	Bioceram	16T1L	—	Kyocera
FDI	Free design blade implant	TYPE 11	—	Mitsutomo
SMI	Shape memory blade implant	—	—	Nitto Kogyo
HCI	Hydroxyapatite-coating blade implant	STS-15D	DP5004	Trial production
VIT	Vitallium	—	—	Howmedica

Photo 1 Resin pattern for Vitallium.

Photo 2 Specimen immersed in the experimental solution.

2. METHODS

The three types of solutions used in this study were Ringer's solution, 1.0 % lactate acid and 0.05 % HCl. The specimen was hung by a hook and totally immersed in 50 ml of each

Table 2 Measurement conditions

Frequency	27.12MHz
Power	1.2 kW
Ar coolant gas flow rate	15 l/min
Ar plasma gas flow rate	1.2 l/min
Ar carrier gas flow rate	1.0 l/min
Observation Height	15mm above the RF coil
Grating	2160 rulings/mm

Table 3 Surface area of dental implant

IMPLANT	SURFACE AREA (mm ²)
Apaceram	265.4
Bioceram	346.6
Free design blade implant	291.5
Shape memory blade implant	298.2
Hydroxyapatite-coating blade implant	342.3
Vitallium	707.1

solution with 100 ml weighing bottles (Photo 2). The weighing bottles were placed in a constant temperature box*** at 37°C for seven days.

The quantitative analysis¹¹⁾ was carried out with an inductively coupled plasma emission spectroscopy[#]. Table 2 shows the measurement conditions.

RESULTS AND DISCUSSION

1. MEASUREMENT OF SURFACE AREAS ON DENTAL IMPLANTS

The amount of element solubilized from the implants was expressed as the solubility quantity per unit area ($\mu\text{g}/\text{cm}^2$). The surface areas of the implants were measured from 5 photographs and analyzed using a microcomputer^{##} and digitizer. The mean of surface area was calculated from seven determinations (Table 3).

2. SELECTION OF SOLUTIONS

The dental implant was placed in the oral cavity for 1 to 4 weeks¹⁶⁾ before the superstructure was fixed. In free-standing cases, it was placed in the oral cavity for 2 to 3 months¹⁷⁾. After fixing the superstructure, the implant neck was exposed about 1 or 2 mm in the oral cavity due to progressive retraction of the gingiva. The dental implant was also placed in an environment similar to that of dental alloy and dental resin. The three test

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ICPV-1012: Shimadzu Mfg. Co., Kyoto, Japan

NEC 9801F: NEC, Tokyo, Japan

Table 4 Solubility of elements in dental implant ($\mu\text{g}/\text{cm}^2$)

APA	Ca	P	Sr	Sr	Se	S
	Ring.	1.84×10^3 (38.43)	0.76 (0.08)	0.15 (0.05)	0.94 (0.18)	
	1.0%Lac.	2.98×10^3	4.16×10^3 (1.24×10^3)	3.52 (1.57)	4.79 (1.07)	1.09 (1.03)
	0.05%HCl	2.98×10^3	2.72×10^3 (66.58)	1.82 (0.14)	4.22 (1.34)	

FDI		Ti	Fe	Zn	Mo	S
	Ring.			0.20 (0.09)		3.49
	1.0%Lac.	4.62 (0.24)	0.70 (0.54)		3.44	
	0.05%HCl	4.60 (0.75)	0.87 (0.74)	2.90		

SMI		Ni	Ti	Cu	Zn	S
	Ring.	19.44 (4.57)		0.30	0.07 (0.06)	4.33 (1.94)
	1.0%Lac.	63.44 (7.48)	6.87 (1.62)	9.80 (5.70)		
	0.05%HCl	110.88 (7.01)	6.91 (0.30)	5.21 (0.49)	1.69 (1.23)	

HCl		Ca	P	Al	Sr	Se	Mo	S	Ti	Fe
	Ring.	2.63×10^3	3.53×10^3	68.17	4.59		3.83	3.30	3.83	0.57
	1.0%Lac.	2.07×10^3	6.48		0.49					
	0.05%HCl	2.63×10^3	1.70×10^3	150.40	2.08	1.97	1.47	1.53		

VIT		Co	Cr	Mn	Mo	
	Ring.	0.24 (0.17)				
	1.0%Lac.	17.57 (5.13)	0.58 (0.17)	0.70 (0.03)	1.97 (0.72)	
	0.05%HCl	2.51 (0.85)	0.77 (0.58)	0.10 (0.03)		() : SD

(): SD

solutions were selected on the basis of the above findings with reference to experimental studies¹²⁻¹⁵⁾ on immersing dental alloys, and a report on the corroding of metals for dental implants.

3. SOLUBILITY OF ELEMENTS

Table 4 shows the solubilities of the elements. The amounts of Ca and P solubilized from Apaceram were large, whereas very small quantities of Sr and S were detected. No visible changes were observed for Apaceram immersed in Ringer's solution, but immersion in lactate solution and HCl removed the shine on its surface and caused decalcification.

For an implant like Apaceram, with the hydroxyapatite partly exposed to the oral cavity, it is necessary to maintain safe and good oral hygiene because the oral surroundings are neutral or weakly acidic. In individuals who consumes highly acidic food and ignore oral hygiene, the hydroxyapatite part exposed to the oral cavity will become decalcified, and its mechanical strength will decrease.

Free design blade implant is made of pure Ti, but very small quantities of impurity elements — Fe, Mo and S — were detected.

With the shape memory blade implant, Ni was detected in all three solutions tested. In Europe and America, this substance often causes allergies or cancers. However, it is reported that the solubility of Ni is low from Ni-Ti alloy and it causes no such problems in many studies¹⁸⁻²¹⁾ on the biocompatibility of Ni-Ti alloy. In addition, Ni-deficiency disease²²⁾ has been noted in animals, and the element's necessity to man has been proven.

In Hydroxyapatite-coating blade implant, the amounts of solubilized Ca and P were as large as those with Apaceram. Al, Se, Mo, S, Ti and Fe, which dissolved from the metal part of the blade, were also detected.

As to the osteointegrated implant material, a very small quantity of Co was solubilized from Vitallium in Ringer's solution. In lactate solution and HCl, the main elements were Co and Cr, as well as very small quantities of Mn and Mo.

No elements were solubilized from Bioceram.

CONCLUSION

Six kinds of implant materials were immersed in the Ringer's solution, 1.0 % lactate acid solution and 0.05 % HCl solution for seven days, after which the amount of elements in the solutions were analyzed using inductively coupled plasma emission spectroscopy. Elements were solubilized from all of the implant materials except Bioceram. Very strong decalcification was noted with Apaceram and Hydroxyapatite-coating blade implant. A very small amount of Ni was solubilized from shape memory blade implant.

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牛歯エナメル質のコンポジットレジンによる摩耗は Clearfil F II によるものが最も強く、以下 Clearfil Posterior, P-10, Palfique, P-30, Silar の順となった。

Microjar と Microrest AP による牛歯エナメル質の摩耗は認められなかった。

歯科用インプラントにおける成分元素の溶出について

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口腔内における歯科用インプラントの成分元素の挙動を考察する基礎的資料を蓄積するために、5種類の市販インプラント：アパセラム、バイオセラム、フリーデザインブレードインプラント、形状記憶ブレードインプラント、バイタリウムと松本歯科大学で試作したハイドロキシアパタイトコーティングインプラントをリングル液、1.0%乳酸溶液、0.05%塩酸溶液の3種類の溶液に7日間全浸漬し、成分元素の溶出について検討した。溶

出元素の定量は、誘導結合プラズマ発光分光分析装置で行った。その結果、バイオセラムを除く5種類のインプラントに成分元素の溶出がみられ、アパセラム、ハイドロキシアパタイトコーティングブレードインプラントについては、きわめて強い脱灰現象がみられた。また、形状記憶ブレードインプラントからは、微量ではあるが、Niの溶出がみられた。

アマルガム粉末含有飼料を用いて飼育したラットの臓器内水銀量について

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アマルガム粉末を10 wt %, 20 wt %の割り合いで混入した飼料、ならびに10 ppm, 20 ppm 硝酸第一水銀水溶液をラットに4週間投与し、各臓器(脳, 肝臓, 腎臓)の水銀量と病理学的観察の結果を先に報告した。本研究では、さらに長期間の観察を行なうために、8週間投与し、ラットの発育ならびに各臓器への影響と各臓器の水銀量について検討した。さらに、人工胃液, 人工腸液内での水銀の溶出についても検討を加えた。ラットの発育

は、アマルガム粉末20 wt %投与群においてその抑制が認められた。10 wt %, 20 wt %アマルガム粉末投与群ならびに10 ppm, 20 ppm 硝酸第一水銀投与群の両者とも腎臓の発育を抑制する傾向が認められた。ラット臓器内の水銀量は腎臓に最も多く認められ、次いで肝臓, 脳の順であった。人工胃液, 人工腸液内での水銀の溶出は時間の経過とともに増加する傾向を示し、水銀量は人工胃液に多く認められた。

生体膜モデルとしてのりん脂質リポソームと光重合開始剤の相互作用に関する熱量的研究

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光重合開始剤(増感剤:ベンジル, カンファキノン, 9-フルオレノン+還元剤:ジメチルアミノエチルメタ

クリレート)は可視光線照射による高い溶血性を示した。このメカニズムを明らかにするため、生体膜モデルとし