行政院國家科學委員會補助專題研究計畫成果報告

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（計畫名稱）金屬矯正支架之抗腐蝕處理與其生物相容性之研究

(1/3)

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計畫編號：91-2314-B-040-010-;

執行期間：91 年　8 月　1 日至 92 年　7 月 31 日

執行單位：中山醫學大學口腔醫學研究所

計畫主持人：高嘉澤

共同主持人：丁信智 黃翠賢

中　華　民　國　　92　年　05　　月　　1　日

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中英文摘要

口腔是一個複雜的環境，原本口內的酸鹼值是接近中性的環境。但因飲用酸性的飲料、食物或食物被微生物分解等都會產生酸，而使口腔變為酸性的環境，加上冷熱飲食，潮濕的環境以及黏稠食物不易去除口內氯離子的存在，微生物代謝出來的硫化物等不利因素影響，使得放置於口腔內的金屬托架更易受到侵蝕。金屬表面以 TiN 或 CrN 鍍膜可增加其抗腐蝕性。本研究之目的乃研究金屬矯正支架以氮化鈦處理後表面腐蝕性之變化。研究方法乃將四種不同之金屬矯正支架以氮化鈦處理後，經電化學腐蝕反應，以原子吸收光譜儀比較其金屬離子之釋出及以電子顯微鏡觀察其表面之變化。結果發現金屬矯正支架經氮化鈦處理後溶液中仍有 Ni, Cr, Fe, Mn 等金屬離子釋出，電子顯微鏡觀，金屬矯正支架其表面金屬亦有腐蝕反應發生。電化學腐蝕反應發現其氧化電位與無鍍膜亦有差異。

關鍵字: 氮化鈦 腐蝕性 人工唾液

The orthodontic metal bracket is made by stainless steel. It is proved that is easily to corrode in the acid and chloride rich environment. The **purposes** of the current study were to investigating the titanium nitride (TiN) ion plated stainless steel metal bracket anticorrosion ability. **Material and methods:** The four types of stainless steel brackets were used to test in acidic artificial saliva. The TiN plated metal bracket was performed by the titanium nitride (TiN) ion plating method. The TiN plating result was proved success on the bracket surface by the EDX analysis. The amount of the metallic ion release was analyzed with its immersion solutions by atomic absorption spectrophotometer. **Result:** Both TiN and without TiN plated bracket can release detectable ions, such as nickel, chromium, manganese, copper and ferric et, al., into the solution. The TiN plated metal bracket surface existed corrosion pattern in SEM observation. The oxidative potential is different between with and without TiN plated brackets.

Key words: Titanium nitride, corrosion, artificial saliva

計畫緣由與目的

The types of stainless steel most commonly used in bracket manufacture include AISI types 303, 304, 304L, 316, 316L and 317[1]. Stainless steel alloys containing 8 to 12% nickel and 17 to 22% chromium are generally used for the metallic parts of orthodontic appliances.[2] When producing stainless steel, the more chromium, nickel and molybdenum incorporated, and the less sulfur and carbon, the better the corrosion resistance of the final product. Approximately 10% of the general population exhibits a hypersensitive reaction to nickel. Peltonen[3] reported that women were 10 times more sensitive to nickel than men. Moffa[4] found that 31.9% of women and 20.7% of men in a population of 403 showed a positive reaction in a similar patch test with nickel sulfate.

In our previous study found that metal bracket will corrode in acidic solution and released undesired metal ion.[6] It is important to find a way to improving the bracket corrosion resistance. Since titanium is usually selected for the fixtures and abutments of dental implant systems, development of attachments coated with a titanium compound to reduce corrosion would be beneficial for metal bracket.

The purposes of the current study were to investigating the titanium nitride (TiN) ion plated stainless steel metal bracket anticorrosion ability.

結果與討論

After energy dispersive -ray (EDX) analyzer detecting, the non TiN plated bracket EDX graph showed the content of the bracket were nickel, chromium, ferric, manganese, and copper (Fig 1.A-G). The TiN plated bracket EDX graph showed only the Ti peak was found on the surface of the bracket (Fig 1.H). The TiN plating on the bracket surface was success. The electrochemical corrosion test showed on figure 2. The SEM observation of the metal brackets showed some of the bracket surface existed corrosion. Fig 3. The amount of metal ions (nickel, chromium, ferric, manganese, copper and cobalt ions) release from the TiN plated and without TiN plated brackets were shown in the table III.

The results indicate that the TiN film can be effectively plated onto the bracket surface, the EDX data demonstrating that the bracket's external surface was completely covered by the titanium. From the results of the corrosion test, however, both the TiN-plated bracket and the non TiN-plated bracket were found to release metal ions into the artificial saliva solution, suggesting that, under such conditions, both brackets will suffer some degree of corrosion. From the SEM observation the TiN plated bracket surface were more even than that without TiN plated bracket. There existed corrode surface might be from surface incomplete plating.

Most of the TiN-plated bracket groups revealed a greater degree of metal ion release than was the case for the non TiN-plated group, suggesting that the anti-corrosion properties of the TiN-plated brackets were not well. Such a result appears to be contrary to the 1992 study by Ono et, al.[7], in which the authors indicate that TiN plating is an excellent anti-corrosion procedure for stainless steel orthodontic appliances.[7] The low anti-corrosion ability of the TiN plated bracket was inferred as follows. This would appear to be related to the observation that the higher energy non–physical vapour deposition (PVD) technique of plating, such as ion implantation, cannot uniformly coat the substrate, although the resulting bond between the bracket and the substrate is quite strong. The irregular shape of the bracket could be another inference that could be formed uneven plating effects. The third factor might be caused by the

galvanic corrosion between the TiN coating and the metal bracket.[8]

Park and Shearer indicated in 1983 that in a 0.05% sodium chloride (NaCl) solution, the average release of metal was 40 micrograms nickel and 36 micrograms chromium per day for a full mouth appliance.[9] The dietary intake of nickel has been reported to be 300 to 500 micrograms per day, while the average chromium intake varies from five micrograms to more than 100 micrograms per day.[10] Our study has indicated that the level of nickel ions released into the test solution was several times greater than that of chromium ions released, for all groups apart from the Tomy group, although for both ions, the level of their release into the oral cavity was lower than the level of their respective dietary intake[10], the result appearing to be compatible with a relatively "safe" release of such ions to the body.

計畫成果自評

The TiN plating is a naro coating technique on the subject surface. The plating on polymorphism is not so easy. The present study we have demonstrated that TiN coated brackets less corroded in electrochemical analysis. The amount of metal ions fom the TiN plated bracket is lower than that amount of body tolerance. It is still needed to demonstrate the biologic effects of released ions in future research.

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Table I. Details of the metal brackets

Company	Bracket type	Position	Slot	Order No.
Tomy Co. (Tokyo, Japan)	Micro-LOC Bracket Standard edgewise	upper bicuspid	.018’	920-45
Ormco Co. (Orange, Ca, USA)	Diamond Bracket Standard edgewise	upper bicuspid	.018’	340-0604
Unitek 3M. Co. (Monrovia, Ca, USA)	Twin Torque bracket Andrew	upper bicuspid	.018’	018-203
Dentaurum Co. (Pforzheim, Germany)	Discovery Direct Bond Bracket System Ricketts Universal	upper bicuspid	.018’	790-136-00

Table II. The content of the artificial saliva.

Company	Sinphar Pharm Co.LTD. Taipei, Taiwan	
Content	Sali Lube (Saliva substitute)	
	Soldium Chloride	0.844 mg
	Potassium Chloride	1.2 mg
	Calcium Chloride Anhydrous	0.146 mg
	Magnesium Chloride 6 H2O	0.052 mg
	Potassium Phosphate dibasic	0.34 mg
	Sorbitol Solution 70%	60 mg
	Methyl Paraben	2 mg
	Hydroxyethyl Cellulose	3.5 mg

Table III. The amount of metal ion(Mean ± standard deviation, μ g/ml) release from immersion metal brackets in pH 4 artificial saliva.

	Control	Dentaurum		Tomy		Unitek		Ormco	
		TiN	Non-TiN	TiN	Non-TiN	TiN	Non-TiN	TiN	Non-TiN
Ni	8.07±0.88	162.28±14.28	125.70±4.84	20.79±2.06	13.98±5.00	558.7±2.55	586.52±11.95	460.13±10.37	253.90±23.58
Cr	9.31±0.81	78.07±4.45	49.72±2.64	19.38±1.36	12.02±0.35	17.91±0.51	12.8±0.42	59.84±7.96	22.58±13.01
Fe	51.43±1.11	142.24±2.93	124.06±1.77	79.11±2.27	68.73±1.15	81.13±2.24	67.25±2.89	196.00±7.92	115.20±34.36
Mn	1.08±0.02	22.11±1.97	15.11±2.11	6.36±1.20	8.49±1.36	8.52±0.34	5.60±0.49	14.54±3.00	5.39±3.88
Cu	2.40±0.33	526.04±21.08	628.26±20.77	31.97±16.15	39.52±16.79	7.94±2.38	10.26±2.64	10.19±4.46	14.00±2.03
Co	0.05±0.05	2.78±0.48	1.14±0.14	0.45±0.12	0.15±0.13	1.16±0.18	0.49±0.06	3.02±0.37	0.72±0.36

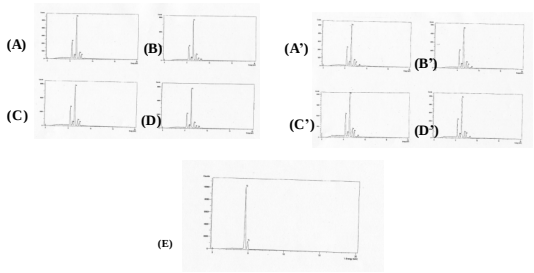


Figure 1 . The EDX analysis of the different brackets frontal su rface.
A: Dentaurum . B: Unitek. C:Tomy. D: Ormco,
The EDAX analysis of the different brackets base.
A': Dentaurum . B': Unitek. C' :Tomy . D' : Ormco,
E: After T iN coating.

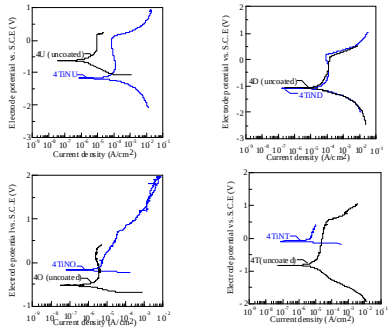
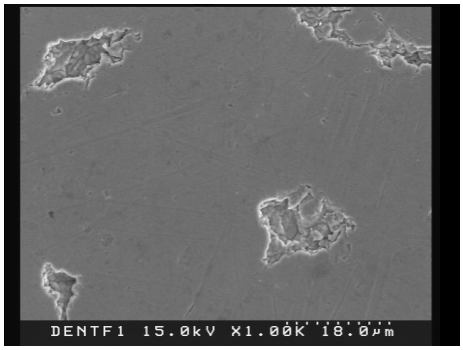


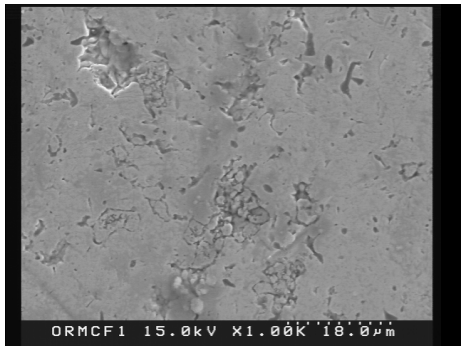
Figure 2. Polarization curves of Dentaurum (D), Unitek (U), Tomy (T) and Ormco (O) as immersed in artificial saliva (pH=4).

Figure 3. The SEM of the TiN coated bracket surface after electrochemical corrosion test.

Dentaurum



Ormco



TOMY

Unitek