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가

르

:RMO, III : Dentaurum,IV : 4 (I : TP,II)

1.20mm (99.2g) 82%

2. 1

20mm

72.1% ~ 76.7

73.0%

3. 2 IV I 가

II 가

4. 1

(L*)

(b*)

가

(:)

1

가

(Heavea Brasiliensis)

polyurethane

가

1,2,3,4)

1)

(isoprene)

II , III

가

가

가

, prestretch

가



Fig. 1. Latex rubber band



Fig. 2. Silicone rubber band

가 . 1960 Barnhart⁵⁾

가 가 .

가

가 가 (Fig. 1, 2).

2.1

3 (RMO Energy Pak^R, Dentarum Olympia^R, TP Plain Latex^R)가 1/4 " 4.5oz RMO 3.5oz, Dentaurum TP 3.5oz 4 (Table 1).

Table 1. The specification of the used materials

Group	Brand (company)	Composition	Size	oz. Pull
I	Plain Latex (TP)	Latex	1/4"	4,5oz
II	Energy Pak (RMO)	Latex	1/4"	3,5oz
III	Olympia (Dentaurum)	Latex	1/4"	4,5oz
IV	Experiment (JEPE)	Silicone	1/4"	3,5oz

2.2

2.2.1

1

2.2.1.1

25 15mm, 20mm, 30mm 300 Force Digital force

gauge(IMADA, Japan)

0.7mm

2.2.1.2

1

(15 × 40 × 15mm)

15mm, 20mm, 30mm

(22 ± 3)

(37)

Indiana

pH 6.75

24

2.2.1.3

24

(37)

(spectrophotometer, CM - 3500d, MINOLTA)

L*, a*, b* system 가

2.2.2

2.2.2.1

Ethylene oxide

gas

48

gas

4g

culture

25ml

37

24

0.045μm pore size membrane

(Fig. 3)

20μℓ

MTT(Microrotiter Tetrazolium Test)

(Fig. 4).

2.2.2.2

(L - 929,

)

95%

5%

5%

FBS가 가 Eagle's MEM

7~10

5~7

(Fig. 5).

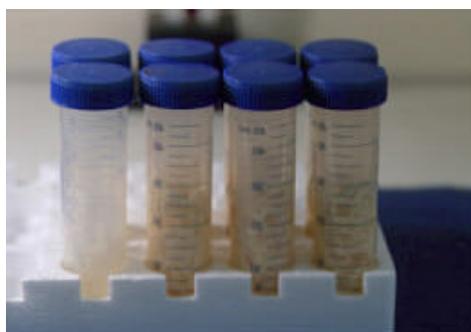


Fig. 3. Extraction from rubber bands

2.2.2.3 MTT

96 - well microtiter plate 1×10^4 ,
 10% FBS가 - MEM 37 24 ,
 24
 1 , 2 MTT
 100 μ l MTT 4 . MTT

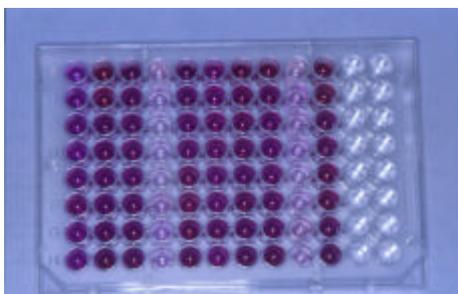


Fig. 4. Prepared 96-well dish for MTT



Fig. 5. Incubator for cell culture

, 50 μ l DMSO(dimethyl sulfoxide) 가
 formazan . 570nm light filter ELISA
 reader(MRX, Dynatech lab) .

2.2.3.

2.2.3.1

20

1

3

(,

, ,)

가 .

2.2.3.2

I (RMO)

IV

30

II

. 1 3

10

10

2.2.3.3

1

가

2.3

2.3.1

Paired t - test

ANOVA

2.3.2

Wilcox signed Rank test

Kruskal - wallis test

Tukey

Scheffe grouping

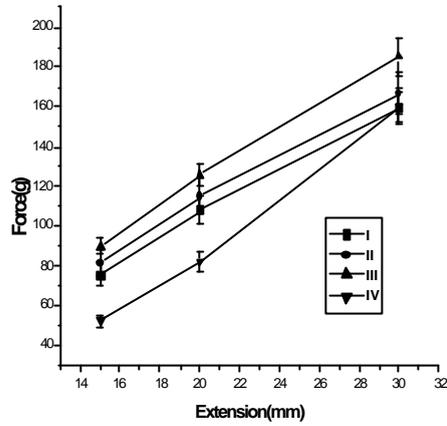


Fig. 6. Graph of Initial force level by extension length.

3.1.2

1

($p < 0.05$)가 . (20mm) I
 84.4% II 87.1% III 84.9% IV 76%
 가 (Table 3).
 I 76.7%, II 72.1%,
 III 71.4% IV 73.0% I
 (Table 4). IV 가
 30mm 65.3% 가
 (Fig. 7, 8)

Table 3, Force degradation after 1 day (in air)

unit : grams

Extension	15mm	20mm	30mm
Group	Remained force mean \pm S.D.	Remained force mean \pm S.D.	Remained force mean \pm S.D.
I	64,9 \pm 5,4	91,3 \pm 7,2	138,1 \pm 8,3
II	67,8 \pm 5,7	100,2 \pm 7,0	149,7 \pm 6,8
III	76,1 \pm 5,2	106,6 \pm 5,5	161,9 \pm 11,6
IV	44,4 \pm 3,5	62,5 \pm 6,2	106,9 \pm 7,3

Table 4, Force degradation after 1 day (in saliva)

unit : grams

Extension	15mm	20mm	30mm
Group	Remained force mean \pm S.D.	Remained force mean \pm S.D.	Remained force mean \pm S.D.
I	55,5 \pm 3,5	83,3 \pm 3,9	122,4 \pm 6,2
II	56,9 \pm 4,0	83,0 \pm 7,6	126,5 \pm 11,1
III	61,6 \pm 3,5	89,7 \pm 5,4	135,1 \pm 6,2
IV	42,3 \pm 2,0	60,0 \pm 2,6	104,4 \pm 5,2

1

I 7.7%

II 15%

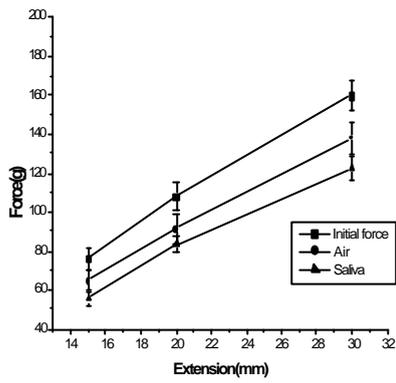
III 13.5%

II 가

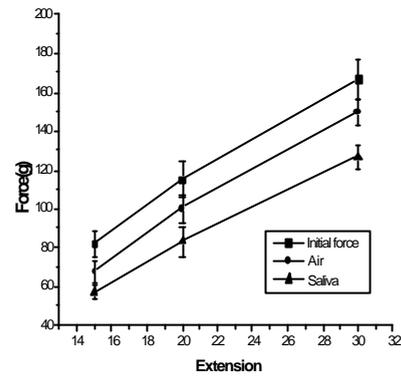
IV 2%

가

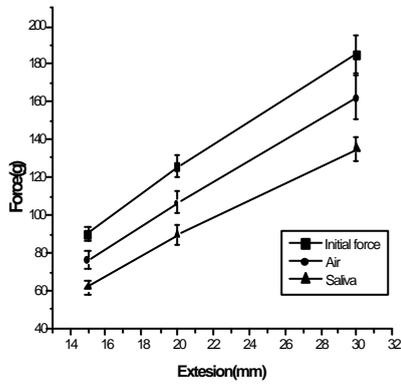
(Fig. 7, 8, 9).



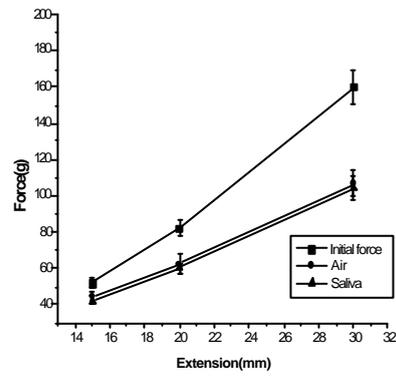
A. Group I



B. Group II

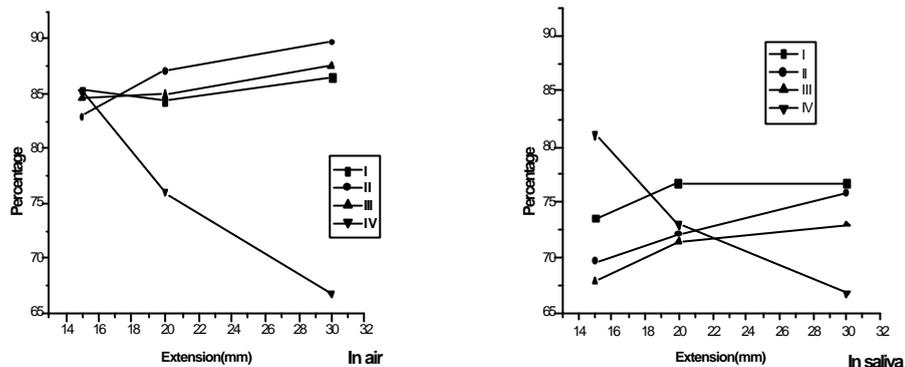


C. Group III



D. Group IV

Fig. 7. Force - extension change for each group in air and artificial saliva condition(after 1 day)



A. Force degradation in air(%)

B. Force degradation in artificial saliva(%)

Fig. 8. Mean percentage equivalents of force change at extension rate in air and artificial saliva condition(A : in air , B : in artificial saliva)

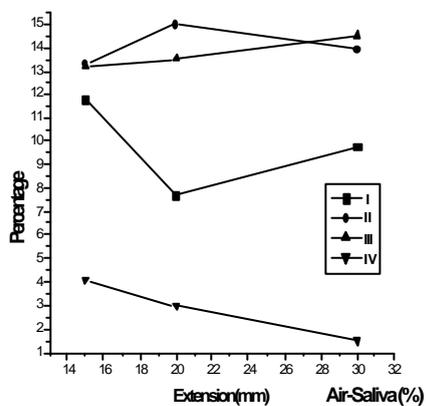


Fig. 9. Discrepancy of remained force(%) between air and artificial saliva condition for each brand

3.1.3

L^*, b^*

(ΔL^*) III 3.79, II 3.74

IV 0.29 가 ($p < 0.05$). (Δb^*)

III 0.79 가 IV 0.31 가

($p < 0.05$). IV 가 가

(Table 5).

1

(Fig. 10).

Table 5. Color change after 1 day

L^* : index of lightness

a^*, b^* : index of color

Group		L^* mean \pm S.D.	ΔL^*	a^* mean \pm S.D.	Δa^*	b^* mean \pm S.D.	Δb^*
I	Before	26.09 \pm 0.16	3.11**	-0.23 \pm 0.04	-0.12	0.71 \pm 0.04	0.61**
	After	29.21 \pm 0.42		-0.12 \pm 0.05		1.32 \pm 0.19	
II	Before	25.41 \pm 0.16	3.74**	0.01 \pm 0.04	0.21	0.46 \pm 0.08	0.79**
	After	29.16 \pm 0.22		0.22 \pm 0.06		1.25 \pm 0.13	
III	Before	25.52 \pm 0.15	3.79**	-0.08 \pm 0.04	0.09	0.56 \pm 0.07	0.58*
	After	29.31 \pm 0.38		0.01 \pm 0.07		1.15 \pm 0.17	
IV	Before	24.89 \pm 0.07	0.29**	-0.02 \pm 0.05	0.02	0.03 \pm 0.04	0.31*
	After	25.19 \pm 0.18		-0.04 \pm 0.07		0.34 \pm 0.07	

*P < 0.05, **P < 0.001

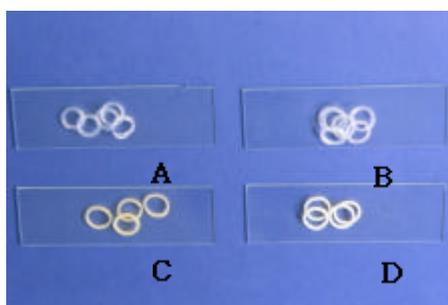


Fig. 10. Discoloration of rubber band

- A: Silicone rubber band before using
- B: Silicone rubber band after using
- C: Latex rubber band before using
- D: Latex rubber band after using

3.2

Table 6. Observation degree for each day (n=8)
unit : O.D.(570nm)

	Size Group	1/4"				Negative control
		I	II	III	IV	
1 day	O.D.	0,392	0,265	0,342	0,394	0,388
	S.D.	0,043	0,027	0,033	0,028	0,025
2 day	O.D.	0,318	0,269	0,281	0,363	0,408
	S.D.	0,018	0,018	0,021	0,022	0,020

(, , ,)

3.3.2

Table 7 . Percentage failure of rubber bands during 10 days

Group	Number of total failure (n=15)	Percentage failure	Mean failure
II	2	0.44%	0.13
IV	21	4.7%	1.4

II 0.44%
(Table 7). IV
10 1.4 4.7%

3.3.3

1
(Fig. 10).

4

가

가
가 6).

가

1000%

가 7).

가

Andreasen Bishara⁴⁾

37

, Thomas⁸⁾

latex band

가

Wong⁹⁾,

¹⁰⁾, ¹¹⁾

37

polymeric thread

가

. RMO

Dentaurum

가

13%~15%

1

76%

73%

3%

Bell Walter¹²⁾

24

20%~24%

, Wong⁹⁾ 37 1 17%
 11)
 24 , 37 1
 55%~65% . Kanchana Godfrey²⁾
 24 32.6% 13)
 24 21.7%~24.3%
 23.3%~28.6%
 Bell
 2,13)
 가
 RMO 20%
 가
 RMO
 RMO 가
 82%
 가
 가 Bales¹⁴⁾
 Kanchana Godfrey²⁾
 60mm
 S
 30mm 가 30mm
 가 가
 가 가 가
 20mm 가
 가 가
 Wong⁹⁾ Taloumis¹⁵⁾ 가

, Hershey Reynolds¹⁶⁾ Ware¹⁷⁾

가

가

가

가

가

latex glove

가

18,19,20)

agar overlay

. Agar overlay

(agar diffusion test)

(zone index)

가

0 5

. agar overlay

가

Ikarachi ²¹⁾

가

cell culture

agar overlay

cell colony assay

가

Holmes ²²⁾

Gabriela ²³⁾ cell colony assay

MTT

가 . MTT
tetrazolium salt가
formazan
Agar overlay 가
2
TP 가 RMO
가 2
가
가
25%~40% rubber hydrocarbon (cis - 1,4 polyisoprene)
24) 3%
가 sulfur zinc oxide, age resistor
가
25)
dithiocaborates가 N - nitro - isopiperidine
N - nitrosodibutylamin 26,27)
latex glove
19)
가
22) silicone
가
28)

29)

가

30)

mouth guard

31)

가

가

Bishara Andreasen³²⁾

가

가

Huget³³⁾

polyurethanes

가

backbone

가

가

가

4.7%

가

가

가

가

5

가

1

MTT

1. 20mm

(99.2g) 82%

2. 1

20mm

72.1%~76.7%

73%

3.

2

IV

I

가

II

가

4.

1

(ΔL^2)

(Δ)

b²)

가

5.

II 0.44%의 파절율을 나타내었다. 반면 실리

콘 고무밴드의 경우 4.7%의 파절율을 나타내 강도에 있어 취약점을 보였다.

가

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ABSTRACT

A study of the clinical, physical properties and cytotoxicity about the silicone rubber bands

Jung-Yul Cha

Department of Dentistry, The Graduate School, Yonsei University

(Directed by Associate Professor **Chung-Ju Hwang**, D.D.S., Ph.D.)

Orthodontic rubber bands are used to correct horizontal and vertical problems between lower and upper dentition to establish proper occlusion. They are also used to correct crossbite and midline discrepancy. However, when rubber bands made with natural rubber are worn intra-orally, due to the surface weakness of the molecular structure, the saliva and bacteria penetration causes expansion and discoloration, thereby decreasing the force. In order to overcome the above problems, new rubber bands has been developed using silicone. Silicone has excellent durability intra-orally, and it is colorless and odorless. After rubber bands were divided to four groups(group I : TP, group II : RMO, group III : Dentaurum, group IV : silicone rubber band) we evaluated the physical and biological properties of silicone rubber band. Results were as followed:

1. Initial force of silicone rubber band was 82% of product instruction(99.2g) at 20mm extension length.
2. After 1 day remained force of the saliva condition was 72.1%~76.7%, it was more greater than that of the air condition. And silicone rubber band showed 73% at the saliva condition.
3. After 2 days group II showed the highest cell toxicity, group IV and I

showed lower amount of cell toxicity compared to other group.

4. In all natural rubber bands, the color changed from initial yellow to opaque white. However in silicone products the initial brightness(L^*) and color(a^*) were maintained after one day, showing color stability and esthetics.

5. Group II showed less than 0.44% chance of tearing during 3 weeks, while silicone rubber bands showed 4.7%.

We could observe that silicone rubber bands showed biocompatibility and color stability, especially stability of physical properties in artificial salival condition. But in the aspect of physical characteristics silicone rubber bands required reinforcement about initial force and failure.

key word : Rubber band, Force degradation, toxicity, elastomer