

Sorption and solubility of 12 soft denture liners

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The long-term stability of a soft denture liner depends to a large extent on the sorption and solubility of the liner. Because sorption and solubility are accompanied by a volumetric change, bacterial infestation, hardening, and color change, it is a physical property of importance. The purpose of this investigation was to determine the sorption and solubility of 12 soft denture liners (Verno-Soft, Super Soft, ProTech, Soft-Pak, Flexor, Novus, Molloplast-B, Durosoft, Justi Soft, Velve-soft, VinaSoft and Prolastic). They include nine copolymers, two silicones and one polyphosphazene fluoroelastomer. The sorption and solubility test was performed as outlined in American Dental Association (ADA) specification 12 for denture base polymers. Five specimens of each material were tested and data were collected at 1 week, 1 month, 3 months, 6 months, and 1 year. Sorption data varied from 0.2 to 5.6 mg/cm² at 1 week; 0.3 to 12.5 mg/cm² at 1 month; 0.1 to 22.0 mg/cm² at 3 months; 0.1 to 13.6 mg/cm² at 6 months; and 0.1 to 35.7 mg/cm² at 12 months. Solubility data varied from 0.0 to 0.4 mg/cm² at 1 week; 0.1 to 0.8 mg/cm² at 1 month; +0.1 to 1.2 mg/cm² at 3 months; 0.0 to 1.9 mg/cm² at 6 months; and -0.2 to 2.3 mg/cm² at 1 year. A statistical analysis of the data by two-way ANOVA and calculated Tukey intervals showed significant differences between materials at all time intervals. The results of this study have clinical implications because the sorption and solubility may affect the long-term life expectancy of the soft denture liner. (*J PROSTHET DENT* 1994;72:393-8.)

The use of soft denture liners is an important adjunct in the treatment of complete and partial denture patients, particularly those who are medically compromised.¹ Unfortunately, even the best materials available today do not last more than a year or two in service.^{2,3} These materials fail for many reasons, such as hardening, sorption of odors, support of bacteria, color changes, and debonding from the denture base.

Water sorption and solubility of soft denture liners are properties that are often overlooked in the evaluation of these elastomers. At present there is no specification for soft denture liners. Properties such as resiliency, tear strength, elongation, and bond strength have been studied in detail.^{4,5} However, water sorption and solubility can dramatically affect dimensional stability, stain resistance,

and the physical and mechanical properties mentioned. Several investigators have studied sorption and solubility of soft denture liners as a function of time.⁶⁻¹⁰

This study was performed to measure the water sorption and solubility of 12 laboratory-processed soft denture liners at various time intervals over a 1-year period. The results should provide clinicians and researchers with information that will aid them in the selection of materials for clinical use or in the development of new materials.

METHODS AND MATERIAL

Twelve soft denture liners (laboratory-processed type) were chosen on the basis of different chemical composition (Table I). The manufacturer of VinaSoft denture liners provided a sealing agent to apply to the surface of the denture liner. Tests were done with and without the sealer for comparison. Sorption and solubility were determined by use of the method described in American Dental Association (ADA) specification 12 for denture base polymers. Five samples of each material were processed into disks 50 mm in diameter by 0.5 mm thick. The disks were dried in a desiccator containing anhydrous calcium sulfate until a constant weight (± 0.5 mg) was obtained. The disks were then immersed in 50 ml of distilled water at $37 \pm 1^\circ$ C for 7 days and weighed again for calculation of the water sorption:

$$\frac{\text{weight after immersion (mg)} - \text{weight before immersion (mg)}}{\text{= sorption (mg/cm}^2\text{) surface area (cm}^2\text{)}}$$

The samples were then reconditioned to constant weight

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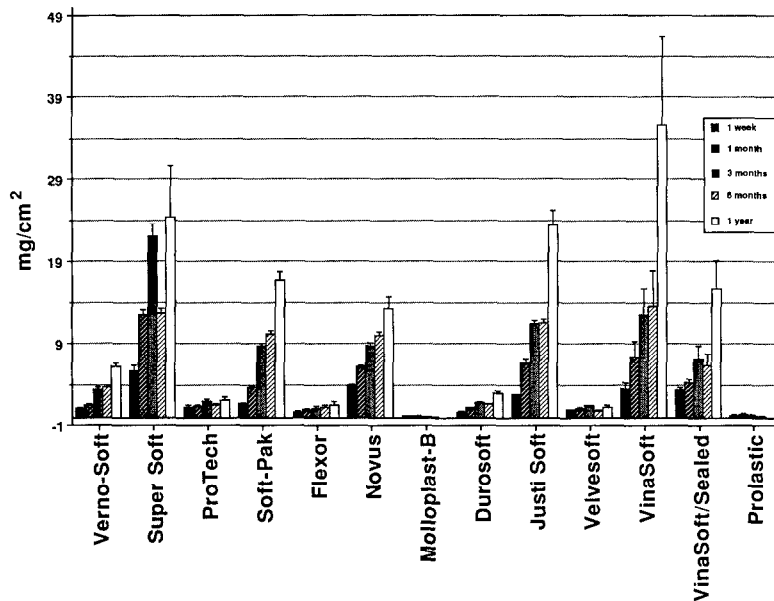


Fig. 1. Sorption of soft denture liners.

Table I. List of materials and manufacturers

Material	Type	Batch No.	Company
Durosoft	Polymer or copolymer	5265	Astron Dental Whelling, Ill.
Super Soft	Polymer or copolymer	P101089A L060189A	Coe Company Chicago, Ill.
ProTech	Polymer or copolymer	P816894 L502898	Pro-Tech, Inc. Dental Products Division Centereach, N.Y.
Justi Soft	Polymer or copolymer	P32366 L320	Justi Products/American Tooth Industries Oxnard, Calif.
Verno-Soft	Polymer or copolymer	P29006 L092989	Vernon-Benshoff Co. Albany, N.Y.
Velvesoft	Polymer or copolymer	None	Oral Health U.S.A., Inc. Piscataway, N.J.
Soft-Pak	Polymer or copolymer	P359901 L360901	General Dental Products Elk Grove, Ill.
Flexor	Polymer or copolymer	945004	Ticonium Co. Albany, N.Y.
VinaSoft	Polymer or copolymer	None	NuDansu Inc. Augusta, Ga.
Prolastic	Silicone	890301	Young Dental Maryland Heights, Mo.
Molloplast-B	Silicone	900103	Buffalo Dental Mfg. Co. Inc. Syosset, N.Y. 11791
Novus	Polyphosphazene Fluoroelastomer	31489A	Hygenic Corp. Akron, Ohio

(± 0.5 mg) in a desiccator containing anhydrous calcium sulfate at 37° C ± 1° C and then weighed to determine the solubility:

$$\frac{\text{weight before immersion (mg)} - \text{weight after reconditioning (mg)}}{\text{= solubility(mg/cm}^2\text{) surface area (cm}^2\text{)}}$$

The above procedure was repeated and sorption and solubility data were collected at 1 month, 3 months, 6 months,

and 1 year. The data were analyzed by use of two-way ANOVA and calculation of Tukey intervals.

RESULTS

Table II shows the mean value and standard deviation for each soft liner at each time interval. Figs. 1 and 2 graphically display this data for easier comparisons. Figs.

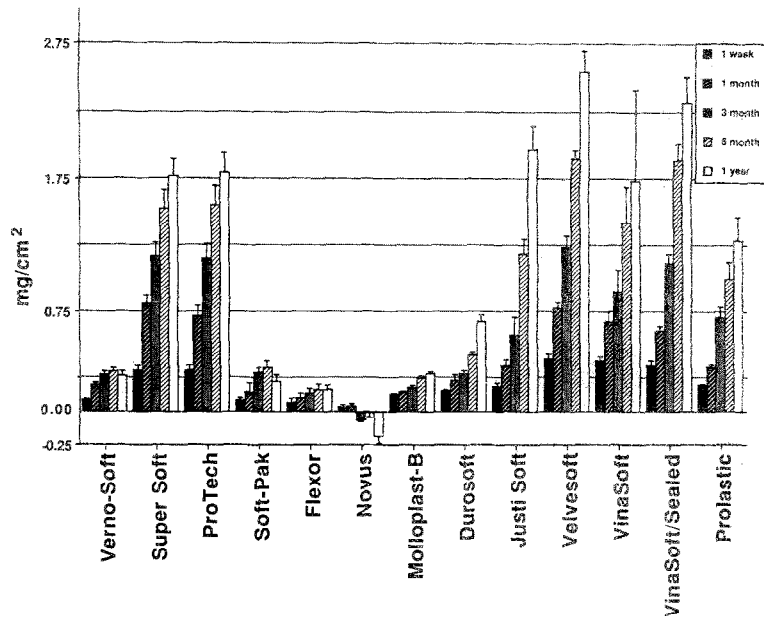


Fig. 2. Solubility of soft denture liners.

SORPTION
(Significant Difference between Times @ p = 0.05)*

Material	Time	mg/cm ²	Material	Time	mg/cm ²
Verno-Soft	1 week	1.19	Molloplast-B	1 year	0.05
	1 month	1.57		3 months	0.11
	3 months	3.44		6 months	0.11
	6 months	3.62		1 week	0.23
	1 year	6.17		1 month	0.27
Super Soft	1 week	5.57	Durosoft	1 week	0.76
	1 month	12.52		1 month	1.26
	6 months	12.71		6 months	1.71
	3 months	22.01		3 months	1.81
	1 year	24.39		1 year	2.98
ProTech	1 week	1.27	Justi Soft	1 week	2.80
	1 month	1.40		1 month	6.68
	6 months	1.50		3 months	11.44
	3 months	1.95		6 months	11.50
	1 year	2.18		1 year	23.32
Soft-Pak	1 week	1.73	VelveSoft	6 months	0.90
	1 month	3.65		1 week	0.93
	3 months	8.78		1 month	1.17
	6 months	10.17		1 year	1.27
	1 year	16.77		3 months	1.53
Flexor	1 week	0.72	VinaSoft	1 week	3.47
	1 month	1.00		1 month	7.26
	3 months	1.20		3 months	12.58
	6 months	1.32		6 months	13.57
	1 year	1.59		1 year	35.65
Novus	1 week	4.01	Sealed VinaSoft	1 week	2.35
	1 month	6.13		1 month	4.21
	3 months	8.71		6 months	6.38
	6 months	10.03		3 months	7.11
	1 year	13.29		1 year	15.76
			Prolastic	1 year	-0.06
				6 months	0.12
				3 months	0.28
				1 week	0.31
				1 month	0.43

*Connecting bars = no significant difference
Tukey Interval = 0.9

Fig. 3. Sorption; significant differences between times at p = 0.05.*

SORPTION
(Significant Difference between Materials @ p = 0.05)*

Time	Material	mg/cm ²	Time	Material	mg/cm ²		
1 WEEK	Molloplast-B	0.23	6 MONTHS	Molloplast-B	0.11		
	Prolastic	0.31		Prolastic	0.12		
	Flexor	0.72		VelveSoft	0.90		
	Durosoft	0.76		Flexor	1.32		
	VelveSoft	0.93		ProTech	1.50		
	Verno-Soft	1.19		Durosoft	1.71		
	ProTech	1.27		Verno-Soft	3.62		
	Soft-Pak	1.73		Sealed VinaSoft	5.38		
	Sealed VinaSoft	2.35		Novus	10.03		
	Justi Soft	2.80		Soft-Pak	10.17		
	VinaSoft	3.47		Justi Soft	11.50		
	Novus	4.01		Super Soft	12.71		
	Super Soft	5.57		VinaSoft	13.57		
	1 MONTH	Molloplast-B		0.27	1 YEAR	Prolastic	-0.06
		Prolastic		0.43		Molloplast-B	0.05
Flexor		1.00	VelveSoft	1.27			
VelveSoft		1.17	Flexor	1.59			
Durosoft		1.26	ProTech	2.18			
ProTech		1.40	Durosoft	2.98			
Verno-Soft		1.57	Verno-Soft	6.17			
Soft-Pak		3.65	Novus	13.29			
Sealed VinaSoft		4.21	Sealed VinaSoft	15.76			
Novus		6.13	Soft-Pak	16.77			
Justi Soft		6.68	Justi Soft	23.32			
VinaSoft		7.26	Super Soft	24.39			
Super Soft		12.52	VinaSoft	35.65			
3 MONTHS		Molloplast-B	0.11	1 YEAR		Prolastic	-0.06
		Prolastic	0.28			Molloplast-B	0.05
	Flexor	1.20	VelveSoft		1.27		
	VelveSoft	1.53	Flexor		1.59		
	Durosoft	1.81	ProTech		2.18		
	ProTech	1.95	Durosoft		2.98		
	Verno-Soft	3.44	Verno-Soft		6.17		
	Sealed VinaSoft	7.11	Novus		13.29		
	Novus	8.71	Sealed VinaSoft		15.76		
	Soft-Pak	8.78	Soft-Pak		16.77		
	Justi Soft	11.44	Justi Soft		23.32		
	VinaSoft	12.58	Super Soft		24.39		
	Super Soft	22.01	VinaSoft		35.65		

*Connecting bars = no significant difference
Tukey interval = 2.7

Fig. 4. Sorption; significant differences between materials at p = 0.05.*

3 through 6 show mean values and rankings of sorption and solubility between time and materials. The two-way ANOVA tables for sorption and solubility are shown in Tables III and IV.

The sorption values for the soft denture liners tested ranged from a low of 0.05 mg/cm² for Molloplast-B liner at 1 year to a high of 35.65 mg/cm² for VinaSoft liner at 1 year. For most materials, the water sorption values increased

Table II. Sorption and solubility values at each time interval

Soft liner	Time	Sorption		Solubility	
		mg/cm ²	SD	mg/cm ²	SD
Verno-Soft	1 week	1.19	0.03	0.08	0.01
	1 month	1.57	0.10	0.19	0.02
	3 months	3.44	0.26	0.28	0.03
	6 months	3.62	0.28	0.30	0.03
	1 year	6.17	0.44	0.26	0.03
Super Soft	1 week	5.57	0.77	0.31	0.03
	1 month	12.52	0.58	0.81	0.07
	3 months	22.01	1.58	1.17	0.10
	6 months	12.71	0.56	1.53	0.14
	1 year	24.39	6.12	1.77	0.12
ProTech	1 week	1.27	0.21	0.30	0.04
	1 month	1.40	0.22	0.72	0.07
	3 months	1.95	0.33	1.15	0.11
	6 months	1.50	0.19	1.56	0.14
	1 year	2.18	0.30	1.80	0.15
Soft-Pak	1 week	1.73	0.13	0.09	0.01
	1 month	3.65	0.11	0.15	0.07
	3 months	8.78	0.29	0.29	0.03
	6 months	10.17	0.33	0.32	0.06
	1 year	16.77	0.99	0.22	0.05
Flexor	1 week	0.72	0.09	0.07	0.03
	1 month	1.00	0.17	0.10	0.04
	3 months	1.20	0.25	0.14	0.04
	6 months	1.32	0.27	0.17	0.04
	1 year	1.59	0.37	0.16	0.04
Novus	1 week	4.01	0.09	0.03	0.01
	1 month	6.13	0.25	0.05	0.02
	3 months	8.71	0.39	+0.07	0.01
	6 months	10.03	0.36	+0.01	0.04
	1 year	13.29	1.33	+0.19	0.05
Molloplast-B	1 week	0.23	0.01	0.13	0.01
	1 month	0.27	0.02	0.14	0.01
	3 months	0.11	0.02	0.18	0.02
	6 months	0.11	0.02	0.25	0.02
	1 year	0.05	0.02	0.28	0.02
Durosoft	1 week	0.76	0.10	0.16	0.01
	1 month	1.26	0.06	0.23	0.04
	3 months	1.81	0.13	0.28	0.03
	6 months	1.71	0.03	0.42	0.03
	1 year	2.98	0.20	0.67	0.05
Justi Soft	1 week	2.80	0.08	0.19	0.03
	1 month	6.68	0.40	0.34	0.04
	3 months	11.44	0.47	0.57	0.14
	6 months	11.50	0.53	1.19	0.11
	1 year	23.32	1.88	1.97	0.18
Velvessoft	1 week	0.93	0.03	0.40	0.03
	1 month	1.17	0.06	0.77	0.05
	3 months	1.53	0.09	1.24	0.08
	6 months	0.90	0.14	1.89	0.07
	1 year	1.27	0.30	2.55	0.15
VinaSoft	1 week	3.47	0.75	0.37	0.04
	1 month	7.26	1.97	0.67	0.08
	3 months	12.58	3.18	0.89	0.17
	6 months	13.57	4.37	1.42	0.27
	1 year	35.65	10.74	1.73	0.69

SOLUBILITY

(Significant Difference Between Times @ $p = 0.05$)*

	Time	mg/cm ²		Time	mg/cm ²
Verno-Soft	1 week	0.08	Molloplast-B	1 week	0.13
	1 month	0.19		1 month	0.14
	1 year	0.26		3 months	0.18
	3 months	0.28		6 months	0.25
	6 months	0.30		1 year	0.28
Super Soft	1 week	0.31	Durosoft	1 week	0.16
	1 month	0.81		1 month	0.23
	3 months	1.17		3 months	0.28
	6 months	1.53		6 months	0.42
	1 year	1.77		1 year	0.67
ProTech	1 week	0.30	Justi Soft	1 week	0.19
	1 month	0.72		1 month	0.34
	3 months	1.15		3 months	0.57
	6 months	1.56		6 months	1.19
	1 year	1.80		1 year	1.97
Soft-Pak	1 week	0.09	Velvesoft	1 week	0.40
	1 month	0.15		1 month	0.77
	1 year	0.22		3 months	1.24
	3 months	0.29		6 months	1.89
	6 months	0.32		1 year	2.55
Flexor	1 week	0.07	VinaSoft	1 week	0.37
	1 month	0.10		1 month	0.67
	3 months	0.14		3 months	0.89
	1 year	0.16		6 months	1.42
	6 months	0.17		1 year	1.73
Novus	6 months	+0.01	Sealed VinaSoft	1 week	0.35
	1 week	0.03		1 month	0.61
	1 month	0.05		3 months	1.12
	3 months	+0.07		6 months	1.88
	1 year	+0.19		1 year	2.32
			Prolastic	1 week	0.19
				1 month	0.33
				3 months	0.70
				6 months	1.00
				1 year	1.28

*Connecting bars = no significant difference
Tukey Interval = 0.05

Fig. 5. Solubility; significant differences between times at $p = 0.05$.*

SOLUBILITY

(Significant Difference Between Materials @ $p = 0.05$)*

	1 WEEK	mg/cm ²	6 MONTHS	mg/cm ²
Novus	0.03		Novus	+0.01
Flexor	0.07		Flexor	0.17
Verno-Soft	0.08		Molloplast-B	0.25
Soft-Pak	0.09		Verno-Soft	0.30
Molloplast-B	0.13		Soft-Pak	0.32
Durosoft	0.16		Durosoft	0.42
Justi Soft	0.19		Prolastic	1.00
Prolastic	0.19		Justi Soft	1.19
ProTech	0.30		VinaSoft	1.42
Super Soft	0.31		Super Soft	1.53
Sealed VinaSoft	0.35		ProTech	1.56
VinaSoft	0.37		Sealed VinaSoft	1.88
Velvesoft	0.40		Velvesoft	1.89
	1 MONTH		1 YEAR	
Novus	0.05		Flexor	0.16
Flexor	0.10		Novus	+0.19
Molloplast-B	0.14		Soft-Pak	0.22
Soft-Pak	0.15		Verno-Soft	0.28
Verno-Soft	0.19		Molloplast-B	0.28
Durosoft	0.23		Durosoft	0.67
Prolastic	0.33		Prolastic	1.28
Justi Soft	0.34		VinaSoft	1.73
Sealed VinaSoft	0.61		Super Soft	1.77
VinaSoft	0.67		ProTech	1.80
ProTech	0.72		Justi Soft	1.97
Velvesoft	0.77		Sealed VinaSoft	2.32
Super Soft	0.81		Velvesoft	2.55
	3 MONTHS			
Novus	+0.07			
Flexor	0.14			
Molloplast-B	0.18			
Verno-Soft	0.28			
Durosoft	0.28			
Soft-Pak	0.29			
Justi Soft	0.57			
Prolastic	0.70			
VinaSoft	0.89			
Sealed VinaSoft	1.12			
ProTech	1.15			
Super Soft	1.17			
Velvesoft	1.24			

*Connecting bars = no significant difference
Tukey Interval = 0.19

Fig. 6. Solubility; significant differences between materials at $p = 0.05$.*

Table II.— cont'd

Soft liner	Time	Sorption		Solubility	
		mg/cm ²	SD	mg/cm ²	SD
Sealed VinaSoft	1 week	2.35	0.28	0.35	0.03
	1 month	4.21	0.38	0.61	0.04
	3 months	7.11	1.65	1.12	0.07
	6 months	6.38	1.31	1.88	0.13
	1 year	15.76	3.45	2.32	0.19
Prolastic	1 week	0.31	0.11	0.19	0.01
	1 month	0.43	0.16	0.33	0.02
	3 months	0.28	0.08	0.70	0.08
	6 months	0.12	0.18	1.00	0.13
	1 year	-0.06	0.15	1.28	0.19

steadily over the 1-year period of this study. Five materials (ProTech, Flexor, Molloplast-B, Velvesoft, and Prolastic) had much less water sorption than the other materials studied.

The solubility values for the soft denture liners tested ranged from a low of 0.16 mg/cm² for Flexor liner at 1 year to 2.55 mg/cm² for Velvesoft liner at 1 year. For most materials the solubility increased throughout the 1-year test period, some rather dramatically. Five materials (Mollo-

plast-B, Novus, Flexor, Soft-Pak and Verno-Soft) demonstrated low solubility values. One material, Novus, gained mass during the study and this became evident after 3 months. However, the weight gain was small.

DISCUSSION

High sorption and solubility of soft denture liners are associated with swelling, distortion, hardening, absorption of odors, support of bacteria, color changes, and debonding

Table III. Two-way ANOVA table for sorption

Source	Sum of squares	DF	Mean square	F Statistic
Material	8954.061	12	746.171	224.98
Time	3058.720	4	746.680	230.56
Material × time	4033.086	48	84.022	25.33
Error	862.289	260	3.316	—
Total	16908.156	324	—	—

Table IV. Two-way ANOVA table for solubility

Source	Sum of squares	DF	Mean square	F Statistic
Material	68.717	12	5.726	385.723
Time	39.182	4	9.795	659.820
Material × time	26.577	48	0.553	37.296
Error	3.860	260	0.015	—
Total	138.336	324	16.089	—

of liners from denture bases. Therefore, sorption and solubility properties are important as a means to evaluate the longevity of a particular liner. Ideally, a soft liner should have low sorption and low solubility values.

Presently there is no ADA specification for soft denture liners. However, if ADA specification 12 for denture base polymers is used as a guide, after 1 week the sorption value should not be more than 0.8 mg/cm² and the solubility should not be more than 0.04 mg/cm². On the basis of this specification there are only four soft liners (Flexor, Molloplast-B, Durosoft, Prolastic) evaluated in this study that meet the values for sorption (Table II) at the 1-week time interval. According to ADA specification 12 the time interval for evaluation is 1 week. However, if the time interval is extended to 1 year, only two soft liners (Molloplast-B, Prolastic) meet the 1 week sorption requirements of 0.8 mg/cm² in ADA specification 12.

Only one soft liner (Novus) complied with ADA specification 12 on solubility (no more than 0.04 mg/cm²) at the 1-week time interval (Table II). There was an unexpected observation. The solubility of Novus at the 3- and 6-month and 1-year time interval changed from losing mass to a slight gain in mass. A possible explanation could be that at 3 months the polyphosphazene fluoroelastomer will begin to absorb water and retain it permanently. Another explanation could be that a chemical change is taking place in the polyphosphazene fluoroelastomer contributing to an increase in mass.

CONCLUSIONS

1. At 1 week, Flexor, Molloplast-B, Durosoft and Prolastic soft denture liners met the sorption value of 0.8 mg/cm² in ADA specification 12.

2. After 1 year only Molloplast-B and Prolastic soft denture liners had sorption values of less than 0.8 mg/cm² (ADA specification 12 requirement at 1 week).

3. Only Novus soft denture liner, at 0.03 mg/cm², met the solubility limit required in ADA specification 12.

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