

PLATE 6

Autoradiographs of ground section of composite resin restorations lined with *Addent Cavity Liner* in situ in dog teeth. Prior to the preparation of the sections, the specimens had been immersed in a $\text{Na}_2^{14}\text{CO}_3$ solution for 24 hours during which time they had been either kept at a constant temperature (Series 1) or subjected to thermal cycling (Series 2).

- A Twenty four hour control restoration and the corresponding six week restoration (Series 1) in contra-lateral mandibular 3rd incisor teeth. (Mag.X 2.5).
- B Twenty four hour control restoration and the corresponding twelve week restoration (Series 1) in contra-lateral mandibular 3rd incisor teeth. (Mag.X 2).
- C Twenty four hour control restoration and the corresponding six week restoration (Series 2) in contra-lateral mandibular 1st molar teeth. (Mag.X 2).
- D Twenty four hour control restoration and the corresponding twelve week restoration (Series 2) in contra-lateral mandibular canine teeth. (Mag.X 2.25).

SERIES 1

A24 HOUR
CONTROL

6 WEEKS

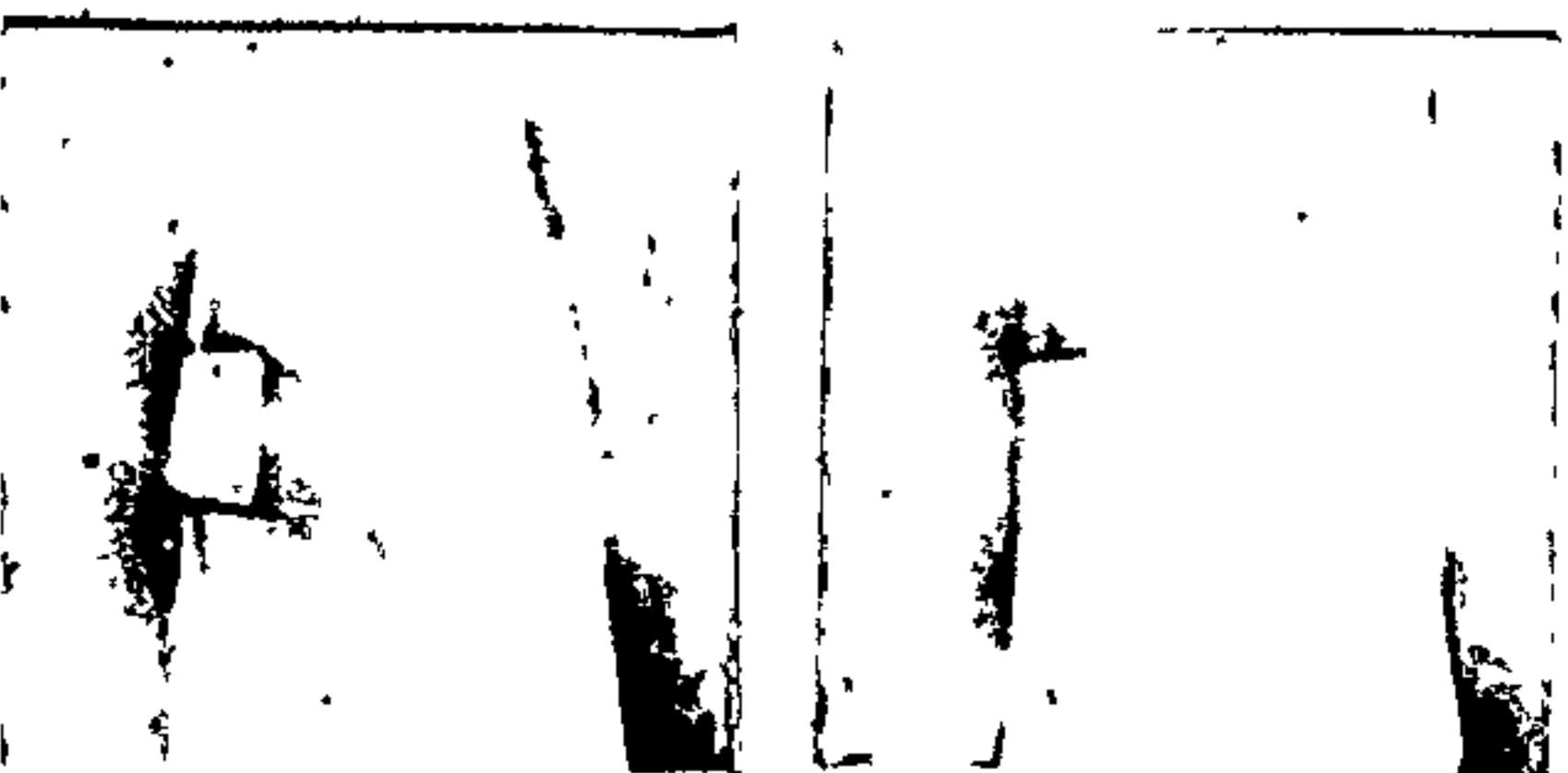
B24 HOUR
CONTROL

12 WEEKS

SERIES 2

A24 HOUR
CONTROL

6 WEEKS

B24 HOUR
CONTROL

12 WEEKS

restoration had a MPV lower than the corresponding 24 hour restoration and in two instances the reverse situation occurred, while in two instances the 12 week restoration and the 24 hour restoration had an identical MPV.

Each of the Series 2 twenty four hour control, six week and twelve week restorations had a maximum MPV.

The autoradiographs of the Series 1 twenty four hour control restorations, and the autoradiograph of the Series 1 six week restoration (Plate 6), each show an uptake of carbon-14 along the entire tooth-restoration interspace, whereas the autoradiograph of the Series 1 twelve week restoration only shows an uptake of carbon-14 along (i) the incisal cavity wall-restoration interspace, and (ii) the gingival cavity wall-restoration interspace. The autoradiographs of the Series 2 twenty four hour control, six week and twelve week restorations each show an uptake of carbon-14 along the entire tooth-restoration interspace.

b. Dentine Penetration Values

No general trend in DPV as a result of aging in vivo was apparent with the Series 1 composite resin restorations lined with *Addent Cavity Liner*, although the twelve week restorations did have appreciably lower

DPV than either the 24 hour control or 6 week restorations. In both groups of Series 1 twenty four hour restorations, as well as in the group of Series 1 six week restorations, 3 of the 5 restorations in each group had a DPV in the intermediate range and the other 2 restorations had a DPV in the low range. However, in the group of Series 1 twelve week restorations, only one of the 5 restorations had a DPV in the intermediate range, the other 4 restorations having a DPV in the low range. The data in Table 7-B show that with the 5 pairs of Series 1 twenty four hour control - six week restorations, in two instances the 6 week restoration had a lower DPV than the corresponding 24 hour restoration, while in three instances the reverse situation occurred. However, with the 5 pairs of Series 1 twenty four hour control - twelve week restorations, in four instances the twelve week restoration had a lower DPV than the corresponding 24 hour restoration and in only one instance did the reverse situation occur.

A trend towards lower DPV as a result of aging in vivo was observed with the Series 2 composite resin restorations lined with *Addent Cavity Liner*. In both groups of Series 2 twenty four hour restorations each of the 5 restorations had a DPV in the intermediate range, while in the group of Series 2 six week restorations,

3 of the 5 restorations had a DPV in the intermediate range and the other 2 restorations had a DPV in the low range. However, in the group of Series 2 twelve week restorations, only one of the 5 restorations had a DPV in the intermediate range, the other 4 restorations having a DPV in the low range. The data in Table 7-B show that with 4 of the 5 pairs of Series 2 twenty four hour - six week restorations, the six week restoration had a lower DPV than the corresponding 24 hour restoration although the reverse situation occurred with the other six week restoration. Furthermore, with each of the 5 pairs of Series 2 twenty four hour control - twelve week restorations, the 12 week restoration had a lower DPV than the corresponding 24 hour restoration.

Both autoradiographs of the Series 1 twenty four hour control restorations (Plate 6) show some penetration by carbon-14 into the dentine subjacent to the axial cavity wall, while the autoradiograph of the Series 1 six week restoration and the autoradiograph of the Series 1 twelve week restoration both show an absence of carbon-14 penetration in this region. The autoradiographs of the Series 2 twenty four hour control, six week and twelve week restorations each show some penetration of carbon-14 into the dentine subjacent to the axial cavity wall, although the autoradiographs of the

6 week and 12 week restorations both show less carbon-14 penetration in this region than the autoradiographs of their corresponding 24 hour restorations.

2. EFFECT OF THERMAL CYCLING

a. Marginal Penetration Values

A trend towards increased MPV as a result of thermal cycling was seen with composite resin restorations lined with *Addent Cavity Liner*.

The following table, taken from the summary of MPV data in Table 7-A, shows this trend:

		Number of Specimens with MPV							
		(a) <100 per cent				(b) 100 per cent			
		24 Hour Restorations				6 Week Restorations		12 Week Restorations	
		1st group		2nd group					
		(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Series 1		2	3	2	3	1	4	1	4
Series 2		Nil	5	Nil	5	Nil	5	Nil	5

A comparison of the Series 1 and Series 2 restorations shows that;

- (i) In both groups of Series 1 twenty four hour restorations 3 of the 5 restorations had a maximum MPV, whereas in both groups of Series 2 twenty four hour restorations each of the

5 restorations had a maximum MPV.

- (ii) Four of the 5 restorations in the group of Series 1 six week restorations had a maximum MPV, while each of the 5 restorations in the group of Series 2 six week restorations had a maximum MPV.
- (iii) Four of the 5 restorations in the group of Series 1 twelve week restorations had a maximum MPV, while each of the 5 restorations in the group of Series 2 twelve week restorations had a maximum MPV.

b. Dentine Penetration Values

The only apparent effect of thermal cycling on the DPV of composite resin restorations lined with *Addent Cavity Liner* was seen with the 24 hour restorations.

The following table is taken from the summary of DPV data in Table 7-A:

	Number of Specimens with DPV in											
	(a) Low, (b) Intermediate and (c) High Ranges											
	24 Hour Restorations						6 Week Restorations			12 Week Restorations		
	1st group			2nd group								
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
Series 1	2	3	Nil	2	3	Nil	2	3	Nil	4	1	Nil
Series 2	Nil	5	Nil	Nil	5	Nil	2	3	Nil	4	1	Nil

A comparison of the Series 1 and Series 2 restorations shows that, while none of the restorations had a DPV in the high range;

- (i) In both groups of Series 1 twenty four hour restorations 3 of the 5 restorations had a DPV in the intermediate range, while in both groups of Series 2 twenty four hour restorations each of the 5 restorations had a DPV in the intermediate range.
- (ii) In both the group of Series 1 six week restorations and the group of Series 2 six week restorations, 3 of the 5 restorations had a DPV in the intermediate range.
- (iii) In both the group of Series 1 twelve week restorations and the group of Series 2 twelve week restorations, 4 of the 5 restorations had a DPV in the low range.

3. COMPARISON WITH UNLINED COMPOSITE RESIN RESTORATIONS - EFFECT OF *ADDENT CAVITY LINER*

a. Marginal Penetration Values

The following table, taken from the summary of MPV data for (i) unlined composite resin restorations in Table 6-A, and (ii) composite resin restorations lined with *Addent Cavity Liner* in Table 7-A, shows the

comparative MPV of unlined composite resin restorations
and composite resin restorations lined with *Addent*
Cavity Liner:

Restoration Aging Period		Number of Specimens with MPV			
		(a) <100 per cent		(b) 100 per cent	
		Unlined Composite Resin Restorations		Composite Resin Restorations Lined with <i>Addent Cavity Liner</i>	
		(a)	(b)	(a)	(b)
Series 1	24 Hours (1st group)	1	4	2	3
	24 Hours (2nd group)	2	3	2	3
	6 Weeks	3	2	1	4
	12 Weeks	5	Nil	1	4
Series 2	24 Hours (1st group)	Nil	5	Nil	5
	24 Hours (2nd group)	Nil	5	Nil	5
	6 Weeks	Nil	5	Nil	5
	12 Weeks	Nil	5	Nil	5

The presence of *Addent Cavity Liner* under composite resin restorations had little appreciable effect on the marginal penetration of the newly placed Series 1 restorations, but tended to increase the marginal penetration of the older Series 1 restorations. As the above table shows, 7 of a total of 10 Series 1

twenty four hour unlined composite resin restorations had a maximum MPV, while 6 out of a total of 10 Series 1 composite resin restorations lined with *Addent Cavity Liner* had a maximum MPV. Two of the 5 Series 1 six week unlined composite resin restorations had a maximum MPV, whereas 4 of the 5 Series 1 six week composite resin restorations lined with *Addent Cavity Liner* had a maximum MPV. While none of the 5 Series 1 twelve week unlined composite resin restorations had a maximum MPV, 4 of the 5 Series 1 twelve week composite resin restorations lined with *Addent Cavity Liner* had a maximum MPV.

The presence of *Addent Cavity Liner* had no effect on the marginal penetration of the Series 2 restorations. Each of the Series 1 and Series 2 twenty four hour control, six week and twelve week (i) unlined composite resin restorations and (ii) composite resin restorations lined with *Addent Cavity Liner* had a maximum MPV.

b. Dentine Penetration Values

The following table, taken from the summary of DPV data for (i) unlined composite resin restorations in Table 6-A, and (ii) composite resin restorations lined with *Addent Cavity Liner* in Table 7-A, shows the comparative DPV of unlined composite resin restorations

and composite resin restorations lined with *Addent Cavity Liner*:

Restoration Aging Period		Number of Specimens with DPV in (a) Low, (b) Intermediate and (c) High Ranges					
		Unlined Composite Resin Restorations			Composite Resin Restorations Lined with <i>Addent Cavity Liner</i>		
		(a)	(b)	(c)	(a)	(b)	(c)
Series 1	24 Hours (1st group)	Nil	5	Nil	2	3	Nil
	24 Hours (2nd group)	Nil	5	Nil	2	3	Nil
	6 Weeks	2	3	Nil	2	3	Nil
	12 Weeks	5	Nil	Nil	4	1	Nil
Series 2	24 Hours (1st group)	Nil	Nil	5	Nil	5	Nil
	24 Hours (2nd group)	Nil	1	4	Nil	5	Nil
	6 Weeks	Nil	5	Nil	2	3	Nil
	12 Weeks	2	3	Nil	4	1	Nil

Although the presence of *Addent Cavity Liner* under composite resin restorations had no marked effect on dentine penetration, it did tend to reduce the dentine penetration of the Series 1 twenty four hour restorations and the Series 2 twenty four hour, six week and twelve week restorations. In both groups of Series 1 twenty four hour unlined composite resin

restorations, each of the 5 restorations had a DPV in the intermediate range, whereas in both groups of Series 1 twenty four hour composite resin restorations lined with *Addent Cavity Liner*, 3 of the 5 restorations had a DPV in the intermediate range and the remaining 2 restorations had a DPV in the low range. Nine out of a total of 10 Series 2 twenty four hour unlined composite resin restorations had a DPV in the high range, whereas each of the 10 Series 2 twenty four hour composite resin restorations lined with *Addent Cavity Liner* had a DPV in the intermediate range. Whereas each of the 5 Series 2 six week unlined composite resin restorations had a DPV in the intermediate range, 2 of the 5 Series 2 six week composite resin restorations lined with *Addent Cavity Liner* had a DPV in the low range and the remaining 3 restorations had a DPV in the intermediate range. While 2 of the 5 Series 2 twelve week unlined composite resin restorations had a DPV in the low range and the remaining 3 restorations had a DPV in the intermediate range, 4 of the 5 Series 2 twelve week composite resin restorations lined with *Addent Cavity Liner* had a DPV in the low range and the remaining restoration had a DPV in the intermediate range.

COMPOSITE RESIN RESTORATIONS LINED WITH A CALCIUM
HYDROXIDE BASE

Micropenetration data for the 20 pairs of composite resin restorations lined with a calcium hydroxide base (24 hour control - 6 week restorations and 24 hour control - 12 week restorations from both Series 1 and Series 2) are shown in Appendix 3-A together with the differences in micropenetration values between each pair of test and control restorations. Marginal Penetration Values (MPV) and Dentine Penetration Values (DPV) are shown separately.

A summary of the MPV and DPV for the 24 hour control, 6 week and 12 week restorations from both Series 1 and Series 2 is shown in Table 8-A, and a summary of the differences in MPV and DPV between the paired test and control restorations is shown in Table 8-B.

Examples of the autoradiographic findings for the paired (i) Series 1 twenty four hour control - six week restorations, (ii) Series 1 twenty four hour control - twelve week restorations, (iii) Series 2 twenty four hour control - six week restorations, and (iv) Series 2 twenty four hour control - twelve week restorations are shown in Plate 7.

1. EFFECT OF AGING

a. Marginal Penetration Values

No definite trend in MPV as a result of aging in vivo was observed with either the Series 1 or Series 2 composite resin restorations lined with a calcium hydroxide base.

Each of the 24 hour control, 6 week and 12 week Series 1 restorations had a MPV less than 100 per cent. The data in Table 8-B show that with the 5 pairs of Series 1 twenty four hour control - six week restorations, in two instances the 6 week restoration had a lower MPV than the corresponding 24 hour restoration and in three instances the 6 week restoration had a higher MPV than the corresponding 24 hour restoration. Furthermore, with the 5 pairs of Series 1 twenty four hour control - twelve week restorations, in two instances the 12 week restoration had a lower MPV than the corresponding 24 hour restoration and in two instances the reverse situation occurred, while in one instance the 12 week restoration and the corresponding 24 hour restoration had the same MPV.

Each of the 24 hour control, 6 week and 12 week Series 2 restorations had a maximum MPV.

The autoradiographs of the Series 1 twenty four hour control, six week and twelve week restorations

TABLE 8

8-A SUMMARY OF MICROPENETRATION VALUES, FROM APPENDIX 3, FOR COMPOSITE RESIN

RESTORATIONS LINED WITH A CALCIUM HYDROXIDE BASE

Classification of Specimens According to Thermal Treatment	Restoration Aging Period	No. of Specimens	Marginal Penetration Values		Dentine Penetration Values		
			No. of Specimens with MPV	<100 per cent	100 per cent	No. of Specimens with DPV in	Low range Intermediate High range Range (0-20 per cent) (21-80 per cent) (81-100 per cent)
Series 1 - not thermally cycled							
Series 2 - thermally cycled							
Series 1	24 hours (1st group)*	5	5	Nil	5	Nil	Nil
	24 hours (2nd group)†	5	5	Nil	5	Nil	Nil
	6 weeks	5	5	Nil	5	Nil	Nil
	12 weeks	5	5	Nil	5	Nil	Nil
Series 2	24 hours (1st group)*	5	Nil	5	5	Nil	Nil
	24 hours (2nd group)†	5	Nil	5	5	Nil	Nil
	6 weeks	5	Nil	5	5	Nil	Nil
	12 weeks	5	Nil	5	5	Nil	Nil

* 24 hour restorations from paired 24 hour control - 6 week restorations
† 24 hour restorations from paired 24 hour control - 12 week restorations

8-B SUMMARY OF DIFFERENCES BETWEEN PAIRED TEST AND CONTROL COMPOSITE RESIN

RESTORATIONS LINED WITH A CALCIUM HYDROXIDE BASE (APPENDIX 3)

Details of Paired Restorations	Marginal Penetration Values			Dentine Penetration Values		
	No. of Specimens with MPV			No. of Specimens with DPV		
	(a) Less than 24 hour control	(b) Greater than 24 hour control	(c) Same as 24 hour control	(a) Less than 24 hour control	(b) Greater than 24 hour control	(c) Same as 24 hour control
Series 1 24 hour control - 6 week	2	3	0	Nil	1	4
Series 1 24 hour control - 12 week	2	2	1	Nil	1	4
Series 2 24 hour control - 6 week	Nil	Nil	5	1	Nil	4
Series 2 24 hour control - 12 week	Nil	Nil	5	1	Nil	4

PLATE 7

Autoradiographs of ground sections of composite resin restorations lined with a calcium hydroxide base in situ in dog teeth. Prior to the preparation of the sections, the specimens had been immersed in a $\text{Na}_2^{14}\text{CO}_3$ solution for 24 hours during which time they had been either kept at a constant temperature (Series 1) or subjected to thermal cycling (Series 2).

- A Twenty four control restoration and the corresponding six week restoration (Series 1) in contra-lateral mandibular canine teeth. (Mag.X 1.75).
- B Twenty four hour control restoration and the corresponding twelve week restoration (Series 1) in contra-lateral mandibular canine teeth. (Mag.X 1.75).
- C Twenty four hour control restoration and the corresponding six week restoration (Series 2) in contra-lateral mandibular 4th premolar teeth. (Mag.X 2.5).
- D Twenty four hour control restoration the corresponding twelve week restoration (Series 2) in contra-lateral mandibular 4th premolar teeth. (Mag.X 2.5).

SERIES 1

A

24 HOUR
CONTROL



6 WEEKS

B

24 HOUR
CONTROL



12 WEEKS

SERIES 2

A

24 HOUR
CONTROL



6 WEEKS

B

24 HOUR
CONTROL



12 WEEKS

(Plate 7) each show the presence of carbon-14 along (i) the incisal cavity wall-restoration interspace, and (ii) the gingival cavity wall-restoration interspace, while the examples of the autoradiographic findings for the 24 hour control, 6 week and 12 week Series 2 restorations each show the presence of carbon-14 along the entire tooth-restoration interspace. The autoradiograph of the 24 hour restoration from the paired Series 1 twenty four hour control - six week restoration also shows an uptake of carbon-14 along a small section of the base-restoration interspace. The autoradiograph of the Series 1 twelve week restoration also shows an uptake of carbon-14 along a small section of (i) the base-restoration interspace, and (ii) the axial cavity wall-restoration interspace.

b. Dentine Penetration Values

No definite trend in DPV as a result of aging in vivo was observed with composite resin restorations lined with a calcium hydroxide base. Each of the 24 hour control, 6 week and 12 week restorations from both Series 1 and Series 2 had a DPV in the low range. The data in Table 8-B show that with 4 of the 5 pairs of (i) 24 hour control - 6 week restorations, from both Series 1 and Series 2, and (ii) 24 hour control -

12 week restorations, from both Series 1 and Series 2, the 6 week or 12 week restoration had an identical DPV with that of the corresponding 24 hour restoration.

With the exception of the autoradiograph of the 24 hour control restoration from the paired Series 2 twenty four hour control - twelve week restorations, which shows some carbon-14 penetration into the dentine subjacent to the axial cavity wall, none of the autoradiographs of the Series 1 or Series 2 twenty four hour control, six week or twelve week restorations shows any carbon-14 penetration into the dentine subjacent to the axial cavity wall (Plate 7).

2. EFFECT OF THERMAL CYCLING

a. Marginal Penetration Values

Thermal cycling increased the MPV of composite resin restorations lined with a calcium hydroxide base. Each of the Series 1 twenty four hour control, six week and twelve week restorations had less than maximum MPV, whereas each of the Series 2 twenty four hour control, six week and twelve week restorations had a maximum MPV.

b. Dentine Penetration Values

No definite trend in DPV as a result of thermal cycling was observed with composite resin restorations lined with a calcium hydroxide base, since each of the

Series 1 and Series 2 (i) 24 hour control restorations, (ii) 6 week restorations and (iii) 12 week restorations had a DPV in the low range.

3. COMPARISON WITH UNLINED COMPOSITE RESIN RESTORATIONS - EFFECT OF A CALCIUM HYDROXIDE BASE

a. Marginal Penetration Values

The following table, taken from the summary of MPV data for (i) unlined composite resin restorations in Table 6-A, and (ii) composite resin restorations lined with a calcium hydroxide base in Table 8-A, shows the comparative MPV of unlined composite resin restorations and composite resin restorations lined with a calcium hydroxide base:

Restoration Aging Period		Number of Specimens with MPV (a) <100 per cent (b) 100 per cent			
		Unlined Composite Resin Restorations		Composite Resin Restorations lined with a Calcium Hydroxide Base	
		(a)	(b)	(a)	(b)
Series 1	24 Hours (1st group)	1	4	5	Nil
	24 Hours (2nd group)	2	3	5	Nil
	6 Weeks	3	2	5	Nil
	12 Weeks	5	Nil	5	Nil
Series 2	24 Hours (1st group)	Nil	5	Nil	5
	24 Hours (2nd group)	Nil	5	Nil	5
	6 Weeks	Nil	5	Nil	5
	12 Weeks	Nil	5	Nil	5

The presence of a calcium hydroxide base under composite resin restorations had some effect on the marginal penetration of Series 1 twenty four hour and six week restorations. As the preceding table shows, none of the Series 1 twenty four hour or six week composite resin restorations lined with a calcium hydroxide base had a maximum MPV, whereas 7 out of a total of 10 Series 1 twenty four hour unlined composite resin restorations had a maximum MPV, and 3 out of 5 Series 1 six week unlined composite resin restorations also had a maximum MPV. The presence of a calcium hydroxide base had no effect on the marginal penetration of Series 2 restorations since each of the Series 2 twenty four hour, six week and twelve week (i) unlined composite resin restorations, and (ii) composite resin restorations lined with a calcium hydroxide base, had a maximum MPV.

b. Dentine Penetration Values

The following table, taken from the summary of the DPV data for (i) unlined composite resin restorations in Table 6-A, and (ii) composite resin restorations lined with a calcium hydroxide base in Table 8-A, shows the comparative DPV of unlined

composite resin restorations and composite resin restorations lined with a calcium hydroxide base:

Restoration Aging Period		Number of Specimens with DPV in (a) Low, (b) Intermediate and (c) High Ranges					
		Unlined Composite Resin Restorations			Composite Resin Restorations Lined with a Calcium Hydroxide Base		
		(a)	(b)	(c)	(a)	(b)	(c)
Series 1	24 Hours (1st group)	Nil	5	Nil	.5*	Nil	Nil
	24 Hours (2nd group)	Nil	5	Nil	.5*	Nil	Nil
	6 Weeks	2	3	Nil	5†	Nil	Nil
	12 Weeks	5‡	Nil	Nil	5†	Nil	Nil
Series 2	24 Hours (1st group)	Nil	Nil	5	5†	Nil	Nil
	24 Hours (2nd group)	Nil	1	4	5‡	Nil	Nil
	6 Weeks	Nil	5	Nil	.5*	Nil	Nil
	12 Weeks	2	3	Nil	5†	Nil	Nil

* Each restoration had a DPV of zero (Appendix 3A)

† Four restorations had a DPV of zero (Appendix 3A)

‡ Three restorations had a DPV of zero (Appendix 3A)

Overall, the presence of a calcium hydroxide base under composite resin restorations resulted in less dentine penetration, the effect of the base being particularly apparent with the Series 1 twenty four hour

and six week restorations and the Series 2 twenty four hour, six week and twelve week restorations.

A comparison of the DPV of unlined composite resin restorations and composite resin restorations lined with a calcium hydroxide base shows that;

- (i) None of the 24 hour control unlined composite resin restorations from either Series 1 or Series 2 had a DPV in the low range, whereas each of the 24 hour composite resin restorations lined with a calcium hydroxide base from both Series 1 and Series 2 had a DPV in the low range.
- (ii) Although only 2 of the 5 Series 1 six week unlined composite resin restorations and none of the 5 Series 2 six week unlined composite resin restorations, had a DPV in the low range, each of the 6 week composite resin restorations lined with a calcium hydroxide base, from both Series 1 and Series 2, had a DPV in the low range.
- (iii) Each of the 5 Series 1 twelve week unlined composite resin restorations and each of the 5 Series 1 twelve week composite resin restorations lined with a calcium hydroxide base, had a DPV in the low range. However, whereas only 2 of the 5 Series 2 twelve week unlined composite resin restorations had a DPV in the low range, each of

the 5 Series 2 twelve week composite resin restorations with a calcium hydroxide base had a DPV in the low range.

COMPOSITE RESIN RESTORATIONS LINED WITH A CALCIUM HYDROXIDE BASE AND ADDENT CAVITY LINER

Micropenetration data for the 20 pairs of composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner* (24 hour control - 6 week restorations and 24 hour control - 12 week restorations from both Series 1 and Series 2) are shown in Appendix 3-A together with the differences in micropenetration values between each pair of test and control restorations. Marginal Penetration Values (MPV) and Dentine Penetration Values (DPV) are shown separately.

A summary of the MPV and DPV for the 24 hour control, 6 week and 12 week restorations from both Series 1 and Series 2 is shown in Table 9-A, and a summary of the differences in MPV and DPV between the paired test and control restorations is shown in Table 9-B.

Examples of the autoradiographic findings for the paired (i) Series 1 twenty four hour control - six week restorations, (ii) Series 1 twenty four hour control - twelve week restorations, (iii) Series 2 twenty four hour control - six week restorations and (iv) Series 2

twenty four hour control - twelve week restorations are shown in Plate 8.

1. EFFECT OF AGING

a. Marginal Penetration Values

A trend towards increased MPV with aging in vivo was observed with the Series 1 composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner*. In both groups of Series 1 twenty four hour restorations only one of the 5 restorations had a maximum MPV, while in the group of Series 1 six week restorations 3 of the 5 restorations had a maximum MPV, and in the group of Series 1 twelve week restorations each of the 5 restorations had a maximum MPV. The data in Table 9-B show that with 4 of the 5 pairs of (i) Series 1 twenty four hour control - six week restorations, and (ii) Series 1 twenty four hour control - twelve week restorations, the 6 week or 12 week restoration had a higher MPV than the corresponding 24 hour restoration.

Aging in vivo had no effect on the MPV of the Series 2 composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner*, since each of the Series 2 twenty four hour, six week and twelve week restorations had a maximum MPV.

9-A SUMMARY OF MICROPENETRATION VALUES, FROM APPENDIX 3, FOR COMPOSITE RESIN

RESTORATIONS LINED WITH A CALCIUM HYDROXIDE BASE AND

ADDENT CAVITY LINER

Classification of Specimens According to Thermal Treatment		Restoration	No. of Specimens	Marginal Penetration Values		Dentine Penetration Values	
	Aging period	of Specimens	No. of Specimens with MPV	100 per cent	Low range Intermediate range	High range	
Series 1 - not thermally cycled		Specimens		cent	(0-20 per cent)	(21-80 per cent)	(81-100 per cent)
Series 2 - thermally cycled	24 hours (1st group)*	5	4	1	5	Nil	Nil
	24 hours (2nd group)†	5	4	1	5	Nil	Nil
	6 weeks	5	2	3	5	Nil	Nil
	12 weeks	5	Nil	5	5	Nil	Nil
	24 hours (1st group)*	5	Nil	5	5	Nil	Nil
	24 hours (2nd group)†	5	Nil	5	5	Nil	Nil
	6 weeks	5	Nil	5	5	Nil	Nil
	12 weeks	5	Nil	5	5	Nil	Nil

* 24 hour restorations from paired 24 hour control - 6 week restorations
† 24 hour restorations from paired 24 hour control - 12 week restorations

9-B SUMMARY OF DIFFERENCES BETWEEN PAIRED TEST AND CONTROL COMPOSITE RESIN
RESTORATIONS LINED WITH A CALCIUM HYDROXIDE BASE AND
ADDENT CAVITY LINER (APPENDIX 3)

Details of Paired Restorations	Marginal Penetration Values			Dentine Penetration Values		
	No. of Specimens with MPV			No. of Specimens with DPV		
	(a)	(b)	(c)	(a)	(b)	(c)
	Less than 24 hour control	Greater than 24 hour control	Same as 24 hour control	Less than 24 hour control	Greater than 24 hour control	Same as 24 hour control
Series 1 24 hour control - 6 week	Nil	4	1	Nil	Nil	5
Series 1 24 hour control - 12 week	Nil	4	1	1	Nil	4
Series 2 24 hour control - 6 week	Nil	Nil	5	Nil	Nil	5
Series 2 24 hour control - 12 week	Nil	Nil	5	Nil	Nil	5

PLATE 8

Autoradiographs of ground sections of composite resin restorations lined with *Addent Cavity Liner* and a calcium hydroxide base in situ in dog teeth. Prior to the preparation of the sections, the specimens had been immersed in a $\text{Na}_2^{14}\text{CO}_3$ solution for 24 hours during which time they had been either kept at a constant temperature (Series 1) or subjected to thermal cycling (Series 2).

- A Twenty four hour control restoration and the corresponding six week restoration (Series 1) in contra-lateral mandibular 1st molar teeth. (Mag.X 2).
- B Twenty four hour control restoration and the corresponding twelve week restoration (Series 1) in contra-lateral mandibular 4th premolar teeth. (Mag.X 2.5).
- C Twenty four hour control restoration and the corresponding six week restoration (Series 2) in contra-lateral mandibular 1st molar teeth. (Mag.X2).
- D Twenty four hour control restoration and the corresponding twelve week restoration (Series 2) in contra-lateral mandibular 3rd premolar teeth. (Mag.X 2.5).

SERIES 1

A24 HOUR
CONTROL

6 WEEKS

B24 HOUR
CONTROL

12 WEEKS

SERIES 2

A24 HOUR
CONTROL

6 WEEKS

B24 HOUR
CONTROL

12 WEEKS

The autoradiographs of the Series 1 twenty four hour control restorations (Plate 8) both show the presence of carbon-14 along (i) the incisal cavity wall-restoration interspace and (ii) the gingival cavity wall-restoration interspace. The autoradiograph of the Series 1 six week restoration shows the presence of carbon-14 along (i) the entire occlusal cavity wall-restoration interspace, (ii) the entire gingival cavity wall-restoration interspace, and (iii) a small section of both the axial cavity wall-restoration interspace and the base-restoration interspace. The autoradiographs of the Series 1 twelve week restoration and the autoradiographs of the 24 hour control, 6 week and 12 week restorations from Series 2, each show the presence of carbon-14 along the entire tooth-restoration interspace.

b. Dentine Penetration Values

Aging in vivo had no effect on the DPV of composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner* since, with the exception of one Series 1 twenty four hour restoration and one Series 1 twelve week restoration, each of the 24 hour control, 6 week and 12 week restorations from both Series 1 and Series 2 had a DPV of zero (Appendix 3-A).

None of the autoradiographs of the Series 1 or Series 2 twenty four hour control, six week or twelve week restorations (Plate 8) shows any carbon-14 penetration into the dentine subjacent to the axial cavity wall.

2. EFFECT OF THERMAL CYCLING

a. Marginal Penetration Values

A trend towards increased MPV as a result of thermal cycling was observed with the 24 hour and 6 week composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner*, but not with the 12 week restorations. In both groups of Series 1 twenty four hour restorations only one of the 5 restorations had a maximum MPV, whereas in both groups of Series 2 twenty four hour restorations each of the 5 restorations had a maximum MPV. Furthermore, 3 of the 5 Series 1 six week restorations had a maximum MPV, while each of the 5 Series 2 six week restorations had a maximum MPV. However, each of the 5 Series 1 twelve week restorations and each of the 5 Series 2 twelve week restorations had a maximum MPV.

b. Dentine Penetration Values

Thermal cycling had no effect on the DPV of composite resin restorations lined with a calcium

hydroxide base and *Addent Cavity Liner*. With the exception of one Series 1 twenty four hour restoration and one Series 1 twelve week restoration (both of which had a DPV in the low range) each of the Series 1 and Series 2 twenty four hour control, six week and twelve week restorations had a DPV of zero (Appendix 3-A).

3. COMPARISON WITH UNLINED COMPOSITE RESIN RESTORATIONS - EFFECT OF A CALCIUM HYDROXIDE BASE AND *ADDENT CAVITY LINER*

a. Marginal Penetration Values

The following table, taken from the summary of MPV data for (i) unlined composite resin restorations in Table 6-A, and (ii) composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner* in Table 9-A, shows the comparative MPV of unlined composite resin

restorations and composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner*:

		Number of Specimens with MPV			
		(a) <100 per cent		(b) 100 per cent	
Restoration	Aging Period	Unlined Composite Resin Restorations		Composite Resin Restorations Lined with a Calcium Hydroxide Base and <i>Addent Cavity Liner</i>	
		(a)	(b)	(a)	(b)
Series 1	24 Hours (1st group)	1	4	4	1
	24 Hours (2nd group)	2	3	4	1
	6 Weeks	3	2	2	3
	12 Weeks	5	Nil	Nil	5
Series 2	24 Hours (1st group)	Nil	5	Nil	5
	24 Hours (2nd group)	Nil	5	Nil	5
	6 Weeks	Nil	5	Nil	5
	12 Weeks	Nil	5	Nil	5

The presence of a calcium hydroxide base and *Addent Cavity Liner* under newly placed Series 1 composite resin restorations tended to reduce marginal penetration, but in the older Series 1 restorations resulted in increased marginal penetration. As the above table shows, 7 out of a total of 10 Series 1 twenty four hour control unlined composite resin restorations had a maximum MPV, while only 2 out of a

total of 10 Series 1 twenty four hour composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner* had a maximum MPV. However, after 12 weeks aging in vivo, none of the 5 Series 1 twelve week unlined composite resin restorations had a maximum MPV, whereas each of the 5 Series 1 twelve week composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner* had a maximum MPV.

The presence of a calcium hydroxide base and *Addent Cavity Liner* had no effect on the marginal penetration of the Series 2 restorations, since each of the 24 hour control, 6 week and 12 week Series 1 and Series 2 (i) unlined composite resin restorations, and (ii) composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner*, had a maximum MPV.

b. Dentine Penetration Values

Overall, the presence of a calcium hydroxide base and *Addent Cavity Liner* under composite resin restorations resulted in a marked reduction in dentine penetration. Out of a combined total of 40 Series 1 and Series 2 twenty four hour control, six week and twelve week unlined composite resin restorations, 4 restorations had a DPV of zero, whereas out of a combined total of 40 Series 1 and Series 2 composite resin restorations

lined with a calcium hydroxide base and *Addent Cavity Liner*, 38 restorations had a DPV of zero (Appendix 3-A). The effect of a calcium hydroxide base and *Addent Cavity Liner* on dentine penetration was not as apparent with the Series 1 twelve week restorations, since 3 of the 5 Series 1 twelve week unlined composite resin restorations had a DPV of zero, while 4 of the 5 Series 1 twelve week composite resin restorations lined with a calcium hydroxide base and *Addent Cavity Liner* also had a DPV of zero.

MICROPENETRATION OF SILICATE CEMENT RESTORATIONS

UNLINED SILICATE CEMENT RESTORATIONS

Micropenetration data for the 24 pairs of unlined silicate cement restorations (24 hour control - 6 week restorations and 24 hour control - 12 week restorations from both Series 1 and Series 2) are shown in Appendix 3-B and summarised in Table 10. Marginal Penetration Values (MPV) and Dentine Penetration Values (DPV) are shown separately.

Representative autoradiographic findings for the paired (i) Series 1 twenty four hour - six week restorations, (ii) Series 1 twenty four hour - twelve week restorations, (iii) Series 2 twenty four hour -

six week restorations and (iv) Series 2 twenty four hour - twelve week restorations are shown in Plate 9.

EFFECT OF AGING AND THERMAL CYCLING

a. Marginal Penetration Values

Neither aging in vivo nor thermal cycling had any effect on the MPV of unlined silicate cement restorations, since each of the Series 1 and Series 2 twenty four hour, six week and twelve week restorations had a maximum MPV.

b. Dentine Penetration Values

Neither aging in vivo nor thermal cycling had any effect on the DPV of unlined silicate cement restorations, since each of the Series 1 and Series 2 twenty four hour control, six week and twelve week restorations had a maximum DPV.

Each of the autoradiographs of the Series 1 and Series 2 twenty four hour control, six week and twelve week restorations (Plate 9) shows an uptake of carbon-14 along the entire tooth-restoration interspace and a marked uptake of carbon-14 in the dentine between the axial cavity wall and the pulp chamber.

TABLE 10

SUMMARY OF MICROPENETRATION VALUES, FROM APPENDIX 3, FOR UNLINED SILICATE

CEMENT RESTORATIONS

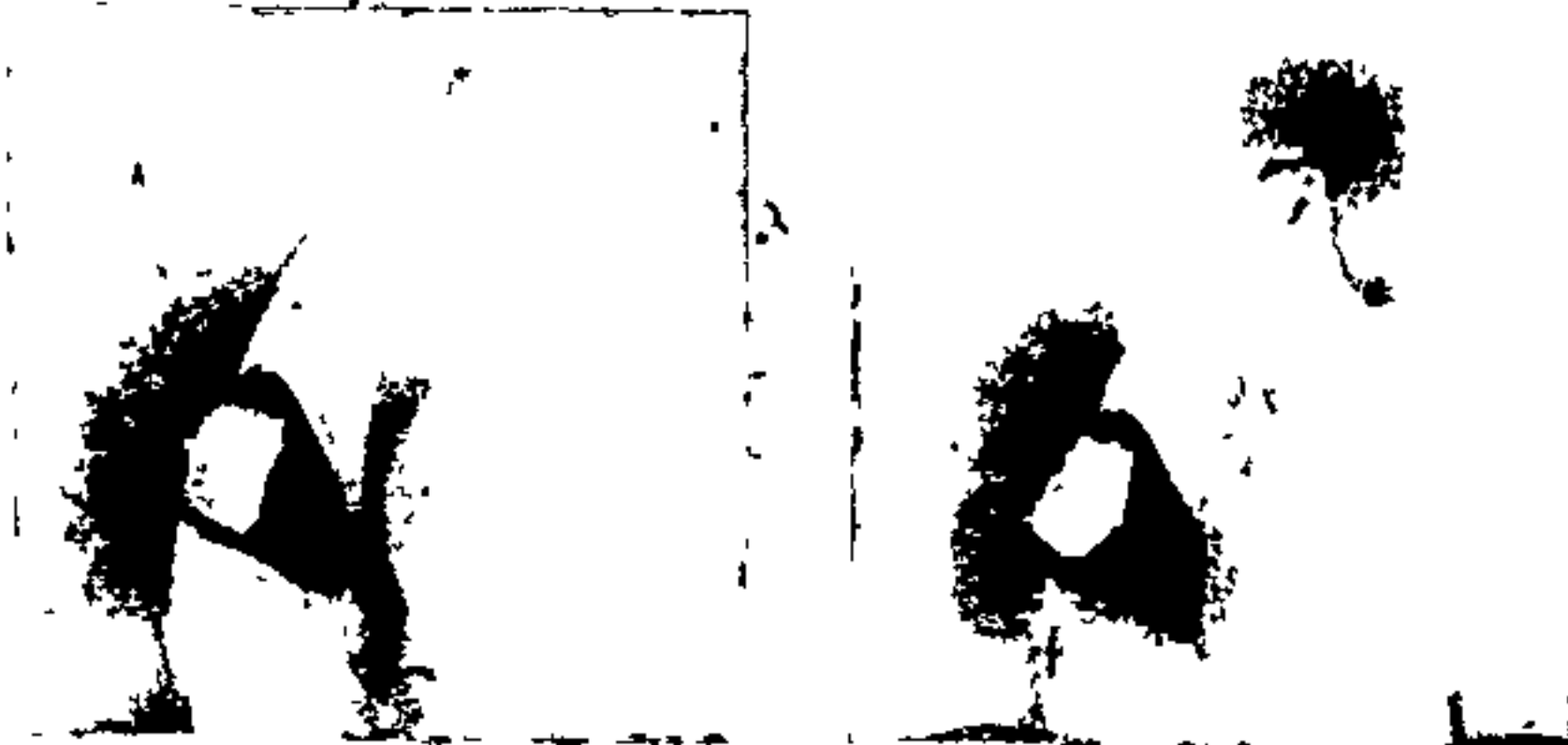
Classification of Specimens According to Thermal Treatment	Restoration	No. of Specimens	Marginal Penetration Values		Dentine Penetration Values				
			Aging Period	No. of Specimens with MPV	No. of Specimens with DPV in	Low range (0-20 per cent)	Intermediate range (21-80 per cent)	High range (81-100 per cent)	
Series 1 - not thermally cycled				<100 per cent	100 per cent				
Series 2 - thermally cycled									
Series 1	24 hours (1st group)*	6	Nil	6	Nil	Nil	6 ‡		
	24 hours (2nd group)†	6	Nil	6	Nil	Nil	6 ‡		
	6 weeks	6	Nil	6	Nil	Nil	6 ‡		
	12 weeks	6	Nil	6	Nil	Nil	6 ‡		
Series 2	24 hours (1st group)*	6	Nil	6	Nil	Nil	6 ‡		
	24 hours (2nd group)†	6	Nil	6	Nil	Nil	6 ‡		
	6 weeks	6	Nil	6	Nil	Nil	6 ‡		
	12 weeks	6	Nil	6	Nil	Nil	6 ‡		
* 24 hour restorations from paired 24 hour control - 6 week restorations									
† 24 hour restorations from paired 24 hour control - 12 week restorations									
‡ Each restoration had a DPV of 100 per cent									

PLATE 9

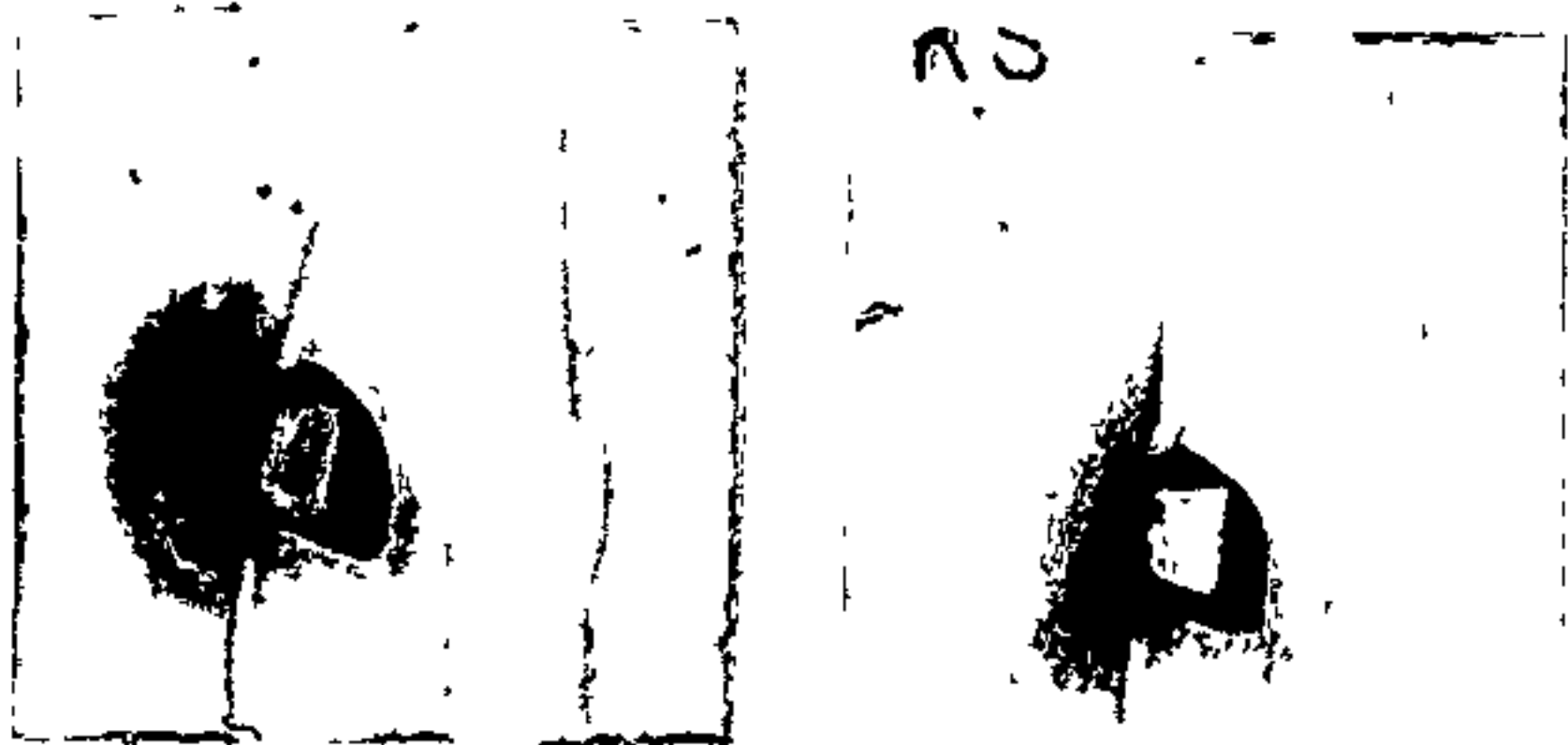
Autoradiographs of ground sections of unlined silicate cement restorations in situ in dog teeth. Prior to the preparation of the sections, the specimens had been immersed in a $\text{Na}_2^{14}\text{CO}_3$ solution for 24 hours during which time they had been either kept at a constant temperature (Series 1) or subjected to thermal cycling (Series 2).

- A Twenty four hour control restoration and the corresponding six week restoration (Series 1) in contra-lateral maxillary 3rd incisor teeth. (Mag.X 2.5).
- B Twenty four hour control restoration and the corresponding twelve week restoration (Series 1) in contra-lateral maxillary canine teeth. (Mag.X 1.75).
- C Twenty four hour control restoration and the corresponding six week restoration (Series 2) in contra-lateral maxillary 3rd incisor teeth. (Mag.X 2.5).
- D Twenty four hour control restoration and corresponding twelve week restoration (Series 2) in contra-lateral maxillary 1st molar teeth. (Mag.X 2.5).

SERIES 1

A24 HOUR
CONTROL

6 WEEKS

B24 HOUR
CONTROL

12 WEEKS

SERIES 2

A24 HOUR
CONTROL

6 WEEKS

B24 HOUR
CONTROL

12 WEEKS

SILICATE CEMENT RESTORATIONS LINED WITH A ZINC
PHOSPHATE CEMENT BASE

Micropenetration data for the 24 pairs of silicate cement restorations lined with a zinc phosphate cement base (24 hour control - 6 week restorations and 24 hour control - 12 week restorations from both Series 1 and Series 2) are shown in Appendix 3-B together with the differences in micropenetration values between each pair of test and control restorations. Marginal Penetration Values (MPV) and Dentine Penetration Values (DPV) are shown separately.

A summary of the MPV and DPV for the 24 hour, 6 week and 12 week restorations from both Series 1 and Series 2 is shown in Table 11-A, while a summary of the differences in DPV between the paired test and control restorations is shown in Table 11-B.

Examples of the autoradiographic findings for the paired (i) Series 1 twenty four hour - six week restorations, (ii) Series 1 twenty four hour - twelve week restorations, (iii) Series 2 twenty four hour - six week restorations, and (iv) Series 2 twenty four hour - twelve week restorations are shown in Plate 10.

1. EFFECT OF AGING

a. Marginal Penetration Values

A tendency towards lower MPV as a result of aging in vivo was observed with the Series 1 silicate cement restorations lined with a zinc phosphate cement base. In both groups of Series 1 twenty four hour control restorations, each of the 6 restorations had a maximum MPV, while in the group of Series 1 six week restorations, 5 of the 6 restorations had a maximum MPV, whereas in the group of Series 1 twelve week restorations, 4 of the 6 restorations had a maximum MPV. The data in Table 11-B show that, with 5 of the 6 pairs of Series 1 twenty four hour control - six week restorations, the 6 week and corresponding 24 hour restoration had an identical MPV, and with the remaining pair of restorations, the 6 week restoration had a lower MPV than the corresponding 24 hour restoration. Furthermore, with 4 of the 6 pairs of Series 1 twenty four hour control - twelve week restorations, the 12 week and corresponding 24 hour restoration had an identical MPV, and with the remaining 2 pairs of restorations, the 12 week restoration had a lower MPV than the corresponding 24 hour restoration.

No definite trend in MPV as a result of aging in vivo was seen with the Series 2 silicate cement

TABLE 11

11-A SUMMARY OF MICROPENETRATION VALUES, FROM APPENDIX 3, FOR SILICATE CEMENT RESTORATIONS LINED WITH A ZINC PHOSPHATE CEMENT BASE

Classification of Specimens According to Thermal Treatment	Restoration Aging Period	No. of Specimens	Marginal Penetration Values		Dentine Penetration Values		
			No. of Specimens with MPV	<100 per cent	100 per cent	No. of Specimens with DPV in range	Low range Intermediate High range (0-20 per cent) (21-80 per cent) (81-100 per cent)
Series 1 - not thermally cycled							
Series 2 - thermally cycled							
Series 1	24 hours (1st group)*	6	Nil	Nil	6	Nil	1 5
	24 hours (2nd group)†	6	Nil	Nil	6	Nil	5 1
	6 weeks	6	1	Nil	5	Nil	3 3
	12 weeks	6	2	Nil	4	Nil	6 Nil
Series 2	24 hours (1st group)*	6	Nil	Nil	6	Nil	4 2
	24 hours (2nd group)†	6	Nil	Nil	6	Nil	2 4
	6 weeks	6	Nil	Nil	6	Nil	4 2
	12 weeks	6	1	Nil	5	Nil	6 Nil

* 24 hour restorations from paired 24 hour control - 6 week restorations

† 24 hour restorations from paired 24 hour control - 12 week restorations

11-B SUMMARY OF DIFFERENCES BETWEEN PAIRED TEST AND CONTROL SILICATE CEMENT
RESTORATIONS LINED WITH A ZINC PHOSPHATE CEMENT BASE
(APPENDIX 3)

Details of Paired Restorations	Marginal Penetration Values			Dentine Penetration Values		
	No. of Specimens with MPV			No. of Specimens with DPV		
	(a)	(b)	(c)	(a)	(b)	(c)
Series 1 24 hour control - 6 week	1	Nil	5	4	2	Nil
Series 1 24 hour control - 12 week	2	Nil	4	6	Nil	Nil
Series 2 24 hour control - 6 week	Nil	Nil	6	3	2	1
Series 2 24 hour control - 12 week	1	Nil	5	6	Nil	Nil

PLATE 10

Autoradiographs of ground sections of silicate cement restorations lined with a zinc phosphate cement base in situ in dog teeth. Prior to the preparation of the sections, the specimens had been immersed in a $\text{Na}_2^{14}\text{CO}_3$ solution for 24 hours during which time they had been either kept at a constant temperature (Series 1) or subjected to thermal cycling (Series 2).

- A Twenty four hour control restoration and corresponding six week restoration (Series 1) in contra-lateral maxillary 4th premolar teeth. (Mag.X 2).
- B Twenty four hour control restoration and corresponding twelve week restoration (Series 1) in contra-lateral maxillary 3rd incisor teeth. (Mag.X 2.5).
- C Twenty four hour control restoration and corresponding six week restoration (Series 2) in contra-lateral mandibular 2nd molar teeth. (Mag.X 3).
- D Twenty four hour control restoration and corresponding twelve week restoration (Series 2) in contra-lateral maxillary 3rd incisor teeth. (Mag.X 2.5).

SERIES 1

A24 HOUR
CONTROL

6 WEEKS

B24 HOUR
CONTROL

12 WEEKS

SERIES 2

A24 HOUR
CONTROL

6 WEEKS

B24 HOUR
CONTROL

12 WEEKS

restorations lined with a zinc phosphate cement base. With the exception of one twelve week restoration, each of the Series 2 twenty four hour control, six week and twelve week restorations had a maximum MPV.

Each of the autoradiographs of the Series 1 and Series 2 twenty four hour control, six week and twelve week restorations (Plate 10), with the exception of the autoradiograph of the Series 1 twelve week restoration, shows the presence of carbon-14 along the entire tooth-restoration interspace. The autoradiograph of the Series 1 twelve week restoration shows the presence of carbon-14 along (i) the entire incisal cavity wall-restoration interspace, (ii) the entire gingival cavity wall-restoration interspace, and (iii) a section of the axial cavity wall-restoration interspace.

b. Dentine Penetration Values

No general trend as a result of aging in vivo was apparent with either the Series 1 or Series 2 silicate cement restorations lined with a zinc phosphate cement base. There was considerable variation between the DPV recorded for individual restorations particularly the 24 hour control restorations.

None of the Series 1 or Series 2 twenty four hour control, six week or 12 week restorations had a DPV in

the low range. The number of Series 1 restorations with a DPV in the high and intermediate ranges were respectively (i) 5 and 1 for the first group of 24 hour control restorations, (ii) 1 and 5 for the second group of 24 hour control restorations, (iii) 3 and 3 for the group of 6 week restorations, and (iv) zero and 6 for the group of 12 week restorations. The number of Series 2 restorations in the high and intermediate DPV ranges were respectively (i) 2 and 4 for the first group of 24 hour restorations, (ii) 4 and 2 for the second group of 24 hour restorations, (iii) 2 and 4 for the group of 6 week restorations, and (iv) zero and 6 for the group of 12 week restorations.

Although there was no general trend in DPV as a result of aging in vivo, the data in Table 11-B show that in each of the 6 pairs of (i) Series 1 twenty four hour control - twelve week restorations and (ii) Series 2 twenty four hour control - twelve week restorations, the 12 week restoration had a lower DPV than the corresponding 24 hour restoration. With the 6 pairs of Series 1 twenty four hour control - six week restorations, in two instances the 6 week restoration had a higher DPV than the corresponding 24 hour restoration, and in four instances the 6 week restoration had a DPV lower than the corresponding

24 hour restoration. With the 6 pairs of Series 2 twenty four hour control - six week restorations, in two instances the 6 week restoration had a DPV higher than the corresponding 24 hour restoration, and in two instances the 6 week restoration had a DPV lower than the corresponding 24 hour restoration, while in one instance the 6 week and corresponding 24 hour restoration had an identical DPV.

The autoradiographs of the Series 1 and Series 2 twenty four hour, six week and twelve week restorations (Plate 10) each show some carbon-14 penetration into the dentine subjacent to the axial cavity wall. However the autoradiographs of the Series 1 six week restoration, the Series 1 twelve week restoration and the Series 2 twelve week restoration each show less carbon-14 penetration in this region than the autoradiographs of the corresponding 24 hour restorations.

2. EFFECT OF THERMAL CYCLING

a. Marginal Penetration Values

Thermal cycling had no appreciable effect on the MPV of silicate cement restorations lined with a zinc phosphate cement base. Each of the Series 1 and Series 2 twenty four hour control restorations had a maximum MPV, while each of the Series 1 and Series 2 six week

restorations, with the exception of one Series 2 restoration, also had a maximum MPV. Four of the 6 Series 1 twelve week restorations had a maximum MPV and 5 of the 6 Series 2 twelve week restorations also had a maximum MPV.

b. Dentine Penetration Values

Thermal cycling had no appreciable effect on the DPV of silicate cement restorations lined with a zinc phosphate cement base. The considerable variation in DPV between the individual restorations from the 2 groups of Series 1 twenty four hour restorations and between the individual restorations from the 2 groups of Series 2 twenty four hour restorations was such that any effects due to thermal cycling were not apparent.

The following table is taken from the summary of DPV data in Table 11-A:

Number of Specimens with DPV in														
(a) Low, (b) Intermediate and (c) High Ranges														
24 Hour Restorations						6 Week Restorations			12 Week Restorations					
1st group			2nd group											

A comparison of the Series 1 and Series 2 restorations

shows that while none of Series 1 or Series 2 restorations had a DPV in the low range:

- (i) The number of 24 hour restorations with a DPV in the high range was 5 out of 6, and 1 out of 6 respectively, for the first and second groups from Series 1, and 2 out of 6, and 4 out of 6, respectively, for the first and second groups from Series 2.
- (ii) Three out of 6 Series 1 six week restorations had a DPV in the high range, while 2 of the 6 Series 2 six week restorations had a DPV in the high range.
- (iii) Each of the 6 Series 1 twelve week restorations and each of the 6 Series 2 twelve week restorations had a DPV in the intermediate range.

3. COMPARISON WITH UNLINED SILICATE CEMENT RESTORATIONS - EFFECT OF A ZINC PHOSPHATE CEMENT BASE

a. Marginal Penetration Values

The following table, taken from the summary of the MPV data for (i) unlined silicate cement restorations in Table 10, and (ii) silicate cement restorations lined with a zinc phosphate cement base in Table 11-A, shows the comparative MPV of unlined silicate cement

restorations and silicate cement restorations lined with a zinc phosphate cement base:

Restoration Aging Period		Number of Specimens with MPV			
		(a) <100 per cent		(b) 100 per cent	
		Unlined Silicate Cement Restorations		Silicate Cement Restorations Lined with a Zinc Phosphate Cement Base	
		(a)	(b)	(a)	(b)
Series 1	24 Hours (1st group)	Nil	6	Nil	6
	24 Hours (2nd group)	Nil	6	Nil	6
	6 Weeks	Nil	6	1	5
	12 Weeks	Nil	6	2	4
Series 2	24 Hours (1st group)	Nil	6	Nil	6
	24 Hours (2nd group)	Nil	6	Nil	6
	6 Weeks	Nil	6	Nil	6
	12 Weeks	Nil	6	1	5

The presence of a zinc phosphate cement base under silicate cement restorations had little overall effect on marginal penetration. As the above table shows, each of the unlined silicate cement restorations had a maximum MPV, and, with the exception of one Series 1 six week restoration, two Series 1 twelve week restorations and one Series 2 twelve week restoration, each of the silicate cement restorations lined with a zinc phosphate cement base also had a maximum MPV.

b. Dentine Penetration Values

The following table, taken from the summary of the DPV data for (i) unlined silicate cement restorations in Table 10, and (ii) silicate cement restorations lined with a zinc phosphate cement base in Table 11-A, shows the comparative DPV of unlined silicate cement restorations and silicate cement restorations lined with a zinc phosphate cement base:

Restoration Aging Period		Number of Specimens with DPV in (a) Low, (b) Intermediate and (c) High Ranges					
		Unlined Silicate Cement Restorations			Silicate Cement Restorations Lined with a Zinc Phosphate Cement Base		
		(a)	(b)	(c)	(a)	(b)	(c)
Series 1	24 Hours (1st group)	Nil	Nil	6*	Nil	1	5
	24 Hours (2nd group)	Nil	Nil	6*	Nil	5	1
	6 Weeks	Nil	Nil	6*	Nil	3	3
	12 Weeks	Nil	Nil	6*	Nil	6	Nil
Series 2	24 Hours (1st group)	Nil	Nil	6*	Nil	4	2
	24 Hours (2nd group)	Nil	Nil	6*	Nil	2	4†
	6 Weeks	Nil	Nil	6*	Nil	4	2
	12 Weeks	Nil	Nil	6*	Nil	6	Nil

* Each restoration had a maximum DPV (Appendix 3-B)

† 2 restorations had a maximum DPV (Appendix 3-B)

The presence of a zinc phosphate cement base under silicate cement restorations had some effect on dentine penetration. As the preceding table shows, each of the unlined silicate cement restorations had a maximum DPV, whereas, with the exception of 2 restorations from the second group of Series 2 restorations, each of the silicate cement restorations lined with a zinc phosphate cement base had a DPV less than 100 per cent. The effect of a zinc phosphate cement base was more marked with the 12 week restorations than with the 24 hour or 6 week restorations. Each of the Series 1 and Series 2 twelve week silicate cement restorations, lined with a zinc phosphate cement base, had a DPV in the intermediate range, whereas the 24 hour and 6 week silicate cement restorations lined with a zinc phosphate cement base, from Series 1 and Series 2, had DPV in both the high and intermediate ranges.

SILICATE CEMENT RESTORATIONS LINED WITH A ZINC OXIDE -
EUGENOL BASE

Micropenetration data for the 24 pairs of silicate cement restorations lined with a zinc oxide - eugenol base (24 hour control - 6 week restorations and 24 hour control - 12 week restorations from both Series 1 and

Series 2) are shown in Appendix 3-B together with the differences in micropenetration values between each pair of test and control restorations. Marginal Penetration Values (MPV) and Dentine Penetration Values (DPV) are shown separately.

A summary of the MPV and DPV for the 24 hour, 6 week and 12 week restorations from both Series 1 and Series 2 is shown in Table 12-A, while a summary of the differences in DPV between the paired test and control restorations is shown in Table 12-B.

Examples of the autoradiographic findings for the paired (i) Series 1 twenty four hour - six week restorations, (ii) Series 1 twenty four hour - twelve week restorations, (iii) Series 2 twenty four hour - six week restorations, and (iv) Series 2 twenty four hour - twelve week restorations are shown in Plate 11.

1. EFFECT OF AGING

a. Marginal Penetration Values

No general trend in MPV as a result of aging in vivo was apparent with the silicate cement restorations lined with a zinc oxide - eugenol base. Although over half the 24 hour restorations had less than maximum MPV (3 of the 6 restorations in both groups of Series 1 restorations, and 3 of the 6, and 4 of the 6

TABLE 12

12-A SUMMARY OF MICROPENETRATION VALUES, FROM APPENDIX 3, FOR SILICATE

CEMENT RESTORATIONS LINED WITH A ZINC OXIDE-EUGENOL BASE

Classification of Specimens According to Thermal Treatment	Restoration Aging Period	No. of Specimens	Marginal Penetration Values		Dentine Penetration Values		
			No. of Specimens with MPV	<100 per cent	No. of Specimens with DPV in range	Low range (0-20 per cent)	High range (81-100 per cent)
Series 1 - not thermally cycled	24 hours (1st group) *	6	3	3	4	2	Nil
Series 2 - thermally cycled	24 hours (2nd group) †	6	3	3	2	4	Nil
	6 weeks	6	Nil	6	Nil	5	1
Series 1	12 weeks	6	Nil	6	Nil	3	3
	24 hours (1st group) *	6	3	3	5	1	Nil
	24 hours (2nd group) †	6	4	2	5	1	Nil
	6 weeks	6	Nil	6	Nil	6	Nil
Series 2	12 weeks	6	Nil	6	Nil	4	2

* 24 hour restorations from paired 24 hour control - 6 week restorations

† 24 hour restorations from paired 24 hour control - 12 week restorations

12-B SUMMARY OF DIFFERENCES BETWEEN PAIRED TEST AND CONTROL SILICATE CEMENT

RESTORATIONS LINED WITH A ZINC OXIDE-EUGENOL BASE

(APPENDIX 3)

Details of Paired Restorations	Marginal Penetration Values			Dentine Penetration Values		
	No. of Specimens with MPV			No. of Specimens with DPV		
	(a) Less than 24 hour control	(b) Greater than 24 hour control	(c) Same as 24 hour control	(a) Less than 24 hour control	(b) Greater than 24 hour control	(c) Same as 24 hour control
Series 1 24 hour control - 6 week	Nil	3	3	Nil	6	Nil
Series 1 24 hour control - 12 week	Nil	3	3	Nil	6	Nil
Series 2 24 hour control - 6 week	Nil	3	3	Nil	6	Nil
Series 2 24 hour control - 12 week	Nil	4	2	Nil	6	Nil

PLATE 11

Autoradiographs of ground sections of silicate cement restorations lined with a zinc oxide-eugenol base in situ in dog teeth. Prior to the preparation of the sections, the specimens had been immersed in a $\text{Na}_2^{14}\text{CO}_3$ solution for 24 hours during which time they had been either kept at a constant temperature (Series 1) or subjected to thermal cycling (Series 2).

- A Twenty four hour control restoration and the corresponding six week restoration (Series 1) in contra-lateral maxillary 4th premolar teeth. (Mag.X 2).
- B Twenty four hour control restoration and the corresponding twelve week restoration (Series 1) in contra-lateral maxillary 1st molar teeth. (Mag.X 2.5).
- C Twenty four hour control restoration and the corresponding six week restoration (Series 2) in contra-lateral mandibular 2nd molar teeth. (Mag.X 3).
- D Twenty four hour control restoration and the corresponding twelve week restoration (Series 2) in contra-lateral mandibular 2nd molar teeth. (Mag.X 3).

SERIES 1

A

24 HOUR
CONTROL



6 WEEKS

B

24 HOUR
CONTROL



12 WEEKS

SERIES 2

A

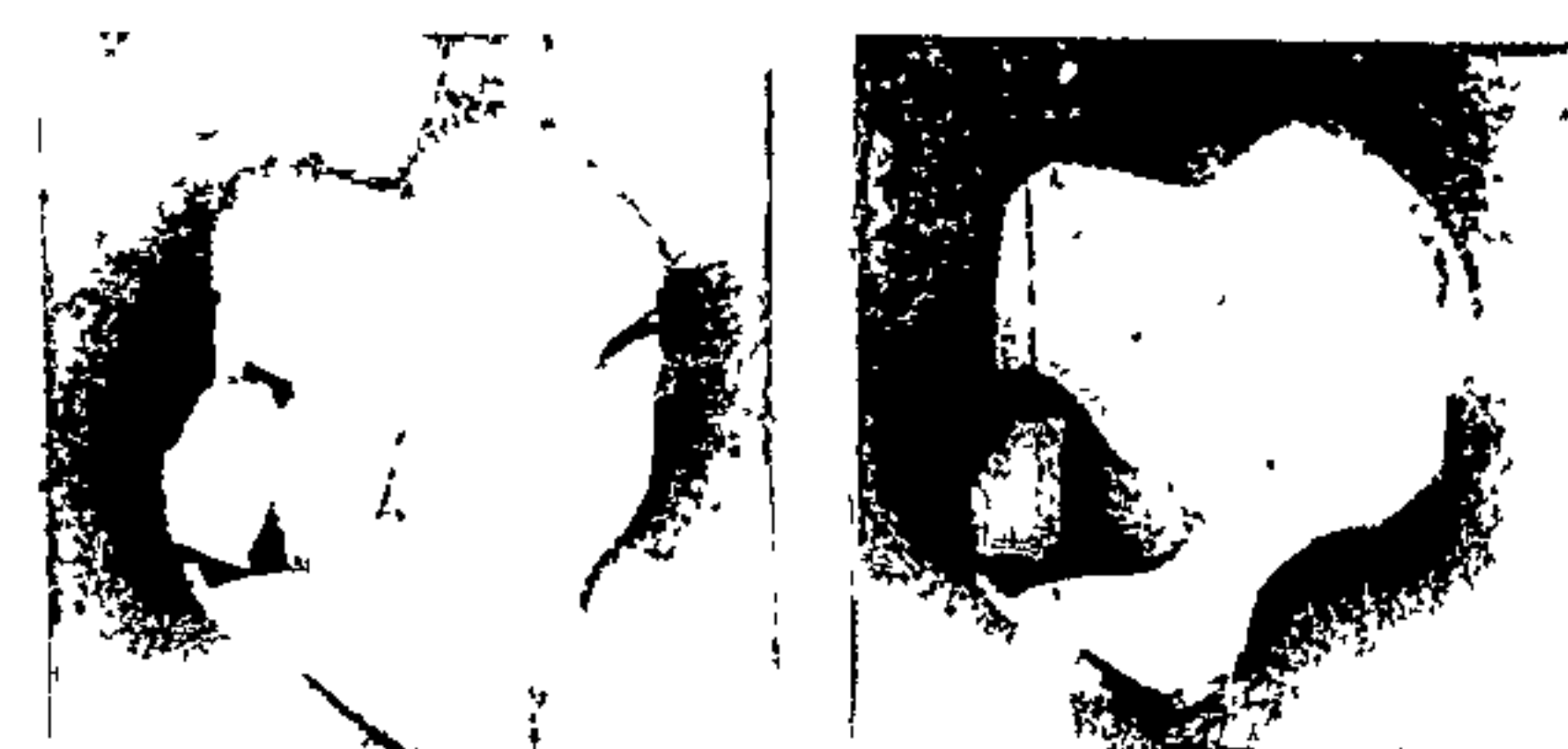
24 HOUR
CONTROL



6 WEEKS

B

24 HOUR
CONTROL



12 WEEKS

restorations, respectively, in the first and second groups of Series 2 restorations), each of the 6 week and 12 week restorations from both Series 1 and Series 2 had a maximum MPV. The data in Table 12-B show that with the 6 pairs of (i) Series 1 twenty four hour control - six week restorations, (ii) Series 1 twenty four hour control - twelve week restorations, and (iii) Series 2 twenty four hour control - six week restorations, in three instances the 6 week or 12 week restoration had a higher MPV than the corresponding 24 hour restoration, and in the remaining three instances the 6 week or 12 week restoration had the same MPV as the corresponding 24 hour restoration. With the 6 pairs of Series 2 twenty four hour control - twelve week restorations, in four instances the 12 week restoration had a higher MPV than the corresponding 24 hour restoration, and in the remaining two instances the 12 week restoration and the corresponding 24 hour restoration had the same MPV.

Each of the autoradiographs of the Series 1 and Series 2 twenty four hour control restorations (Plate 11) shows the presence of carbon-14 along (i) the entire occlusal cavity wall-restoration interspace, (ii) the entire gingival cavity wall-restoration interspace, and (iii) a section of the axial cavity wall-restoration

interspace. However, the autoradiographs of the 6 week and 12 week restorations, from both Series 1 and Series 2, each show the presence of carbon-14 along the entire tooth-restoration interspace.

b. Dentine Penetration Values

A trend towards increased DPV as a result of aging in vivo was observed with both the Series 1 and Series 2 silicate cement restorations lined with a zinc oxide - eugenol base.

None of the Series 1 or Series 2 twenty four hour restorations had a DPV in the high range, whereas none of the Series 1 or Series 2 six week or twelve week restorations had a DPV in the low range. The first and second groups of Series 1 twenty four hour restorations had 4 and 2, and 2 and 4 restorations respectively in the low and intermediate DPV ranges, whereas 5 of the 6 Series 1 six week restorations had a DPV in the intermediate range and the other restoration had a DPV in the high range. However, 3 of the 6 Series 1 twelve week restorations had a DPV in the high range, and the other 3 restorations had a DPV in the intermediate range. In both the first and second groups of Series 2 twenty four hour restorations, 5 of the 6 restorations had a DPV in the low range and the remaining restoration

in each group had a DPV in the intermediate range, and each of the 6 Series 2 six week restorations had a DPV in the intermediate range. However, 2 of the 6 Series 2 twelve week restorations had a DPV in the high range and the other 4 restorations had a DPV in the intermediate range.

The data in Table 12-B show that, in each of the paired (i) 24 hour control - 6 week restorations, and (ii) 24 hour control - 12 week restorations, from both Series 1 and Series 2, the 6 week or 12 week restoration had a higher DPV than the corresponding 24 hour restoration.

Although each of the autoradiographs of the Series 1 and Series 2 twenty four hour control restorations (Plate 11) shows some uptake of carbon-14 in the dentine subjacent to the axial cavity wall, the autoradiographs of the corresponding 6 week or 12 week restorations each show a greater uptake of carbon-14 in this region. This difference in carbon-14 uptake is particularly marked in the autoradiographs of the paired 24 hour control - 12 week restorations from both Series 1 and Series 2.

2. EFFECT OF THERMAL CYCLING

a. Marginal Penetration Values

Thermal cycling had no appreciable effect on the MPV of silicate cement restorations lined with a zinc oxide - eugenol base. In both groups of Series 1 twenty four hour restorations, 3 of the 6 restorations had a maximum MPV, while in the first and second groups of Series 2 twenty four hour restorations, 3 out of 6 and 2 out of 6 restorations respectively had a maximum MPV. Each of the 6 week and 12 week restorations from Series 1 and Series 2 had a maximum MPV.

b. Dentine Penetration Values

Thermal cycling had no appreciable effect on the DPV of silicate cement restorations lined with a zinc oxide - eugenol base.

The following table is taken from the summary of DPV data in Table 12-A:

	Number of Specimens with DPV in											
	(a) Low, (b) Intermediate and (c) High Ranges											
	24 Hour						6 Week			12 Week		
	Restorations			Restorations			Restorations			Restorations		
	1st group	2nd group		1st group	2nd group		1st group	2nd group		1st group	2nd group	
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
Series 1	4	2	Nil	2	4	Nil	Nil	5	1	Nil	3	3
Series 2	5	1	Nil	5	1	Nil	Nil	6	Nil	Nil	4	2

A comparison of the DPV for the Series 1 and Series 2 restorations shows that:

- (i) None of the Series 1 or Series 2 twenty four hour restorations had a DPV in the high range. The number of Series 1 and Series 2 twenty four hour restorations in the low DPV range was 4 of 6, and 2 of 6, respectively, for the first and second groups from Series 1, and 5 of 6 for both groups from Series 2.
- (ii) None of the Series 1 or Series 2 six week restorations had a DPV in the low range. The Series 1 restorations had 5 of 6 restorations in the intermediate DPV range and the Series 2 restorations had each of 6 restorations in the intermediate DPV range.
- (iii) None of the Series 1 or Series 2 twelve week restorations had a DPV in the low range. The Series 1 restorations had 3 of 6 restorations in the high DPV range and the Series 2 restorations had 2 of 6 restorations in the high DPV range.

3. COMPARISON WITH UNLINED SILICATE CEMENT RESTORATIONS - EFFECT OF A ZINC OXIDE - EUGENOL BASE

a. Marginal Penetration Values

The following table, taken from the summary of MPV data for (i) unlined silicate cement restorations in Table 10, and (ii) silicate cement restorations lined with a zinc oxide - eugenol base in Table 12-A, shows the comparative MPV of unlined silicate cement restorations and silicate cement restorations lined with a zinc oxide - eugenol base:

Restoration Aging Period		Number of Specimens with MPV			
		(a) <100 per cent		(b) 100 per cent	
		Unlined Silicate Cement Restorations		Silicate Cement Restorations Lined with a Zinc Oxide - Eugenol Base	
		(a)	(b)	(a)	(b)
Series 1	24 Hours (1st group)	Nil	6	3	3
	24 Hours (2nd group)	Nil	6	3	3
	6 Weeks	Nil	6	Nil	6
	12 Weeks	Nil	6	Nil	6
Series 2	24 Hours (1st group)	Nil	6	3	3
	24 Hours (2nd group)	Nil	6	4	2
	6 Weeks	Nil	6	Nil	6
	12 Weeks	Nil	6	Nil	6

The presence of a zinc oxide - eugenol base under silicate cement restorations had no effect on the marginal penetration of the 6 week or 12 week restorations since, as the preceding table shows, each of the Series 1 and Series 2 (i) 6 week and 12 week unlined silicate cement restorations and (ii) 6 week and 12 week silicate cement restorations lined with a zinc oxide - eugenol base, had a maximum MPV. The presence of a zinc oxide - eugenol base had some effect on the marginal penetration of the 24 hour restorations, since, out of a combined total of 24 Series 1 and Series 2 twenty four hour silicate cement restorations lined with a zinc oxide - eugenol base, 11 restorations had a maximum MPV, whereas out of a combined total of 24 Series 1 and Series 2 twenty four hour unlined silicate cement restorations, each restoration had a maximum MPV.

b. Dentine Penetration Values

The following table, taken from the summary of the DPV data for (i) unlined silicate cement restorations in Table 10, and (ii) silicate cement restorations lined with a zinc oxide - eugenol base in Table 12-A, shows the comparative DPV of unlined

silicate cement restorations and silicate cement restorations lined with a zinc oxide - eugenol base:

Restoration Aging Period		Number of Specimens with DPV in (a) Low, (b) Intermediate and (c) High Ranges					
		Unlined Silicate Cement Restorations			Silicate Cement Restorations Lined with a Zinc Oxide - Eugenol Base		
		(a)	(b)	(c)	(a)	(b)	(c)
Series 1	24 Hours (1st group)	Nil	Nil	6 *	4	2	Nil
	24 Hours (2nd group)	Nil	Nil	6 *	2	4	Nil
	6 Weeks	Nil	Nil	6 *	Nil	5	1
	12 Weeks	Nil	Nil	6 *	Nil	3	3 †
Series 2	24 Hours (1st group)	Nil	Nil	6 *	5	1	Nil
	24 Hours (2nd group)	Nil	Nil	6 *	5	1	Nil
	6 Weeks	Nil	Nil	6 *	Nil	6	Nil
	12 Weeks	Nil	Nil	6 *	Nil	4	2

* Each restoration had a maximum DPV (Appendix 3-B).

† One restoration had a maximum DPV (Appendix 3-B)

The presence of a zinc oxide - eugenol base under silicate cement restorations had some effect on dentine penetration. As the above table shows, each of the unlined silicate cement restorations had a maximum DPV, whereas, with the exception of one Series 1 twelve week restoration and one Series 2 twelve week restoration,

each of the silicate cement restorations lined with a zinc oxide - eugenol base had a DPV less than 100 per cent. The effect of a zinc oxide - eugenol base was more marked with the 24 hour restorations than with the 6 week or 12 week restorations, since only the 24 hour silicate cement restorations lined with a zinc phosphate cement base had all restorations in the low and intermediate DPV ranges.

SILICATE CEMENT RESTORATIONS LINED WITH A CALCIUM HYDROXIDE BASE

Micropenetration data for the 24 pairs of silicate cement restorations lined with a calcium hydroxide base (24 hour control - 6 week restorations and 24 hour control - 12 week restorations from both Series 1 and Series 2) are shown in Appendix 3-B together with the differences in micropenetration values between each pair of test and control restorations. Marginal Penetration Values (MPV) and Dentine Penetration Values (DPV) are shown separately.

A summary of the MPV and DPV for the 24 hour, 6 week and 12 week restorations from both Series 1 and Series 2 is shown in Table 13-A, while a summary of the differences in DPV between the paired test and control restorations is shown in Table 13-B.

Examples of the autoradiographic findings for the paired (i) Series 1 twenty four hour - six week restorations, (ii) Series 1 twenty four hour - twelve week restorations, (iii) Series 2 twenty four hour - six week restorations, and (iv) Series 2 twenty four hour - twelve week restorations, are shown in Plate 12.

1. EFFECT OF AGING

a. Marginal Penetration Values

Aging in vivo had no effect on the MPV of silicate cement restorations lined with a calcium hydroxide base, since each of the 24 hour, 6 week and 12 week restorations from both Series 1 and Series 2 had a maximum MPV.

Each of the autoradiographs of the Series 1 and Series 2 twenty four hour control, 6 week and 12 week restorations (Plate 12), shows an uptake of carbon-14 along the entire tooth-restoration interspace, together with an uptake of carbon-14 in the region approximating the area occupied by the calcium hydroxide base.

b. Dentine Penetration Values

A trend towards increased DPV with aging in vivo was observed with both the Series 1 and Series 2

TABLE 13

13-A SUMMARY OF MICROPENETRATION VALUES, FROM APPENDIX 3, FOR SILICATE

CEMENT RESTORATIONS LINED WITH A CALCIUM HYDROXIDE BASE

Classification of Specimens According to Thermal Treatment	Restoration	No. of Specimens	Marginal Penetration Values		Dentine Penetration Values				
			Aging Period	No. of Specimens with MPV	No. of Specimens with DPV in	Low range Intermediate High range			
						(0-20 per cent)	(21-80 per cent)	(81-100 per cent)	
Series 1 - not thermally cycled									
Series 2 - thermally cycled									
Series 1	24 hours (1st group)*	6	Nil	6	5	1	Nil		
	24 hours (2nd group)†	6	Nil	6	6	Nil	Nil		
	6 weeks	6	Nil	6	2	4	Nil		
	12 weeks	6	Nil	6	Nil	6	Nil		
Series 2	24 hours (1st group)*	6	Nil	6	5	1	Nil		
	24 hours (2nd group) †	6	Nil	6	6	Nil	Nil		
	6 weeks	6	Nil	6	1	5	Nil		
	12 weeks	6	Nil	6	Nil	6	Nil		

* 24 hour restorations from paired 24 hour control - 6 week restorations
 † 24 hour restorations from paired 24 hour control - 12 week restorations

13-B SUMMARY OF DIFFERENCES BETWEEN PAIRED TEST AND CONTROL SILICATE CEMENT
RESTORATIONS LINED WITH A CALCIUM HYDROXIDE BASE (APPENDIX 3)

Details of Paired Restorations	Marginal Penetration Values			Dentine Penetration Values		
	No. of Specimens with MPV			No. of Specimens with DPV		
	(a) Less than 24 hour control	(b) Greater than 24 hour control	(c) Same as 24 hour control	(a) Less than 24 hour control	(b) Greater than 24 hour control	(c) Same as 24 hour control
Series 1 24 hour control - 6 week	Nil	Nil	6	Nil	6	Nil
Series 1 24 hour control - 12 week	Nil	Nil	6	Nil	6	Nil
Series 2 24 hour control - 6 week	Nil	Nil	6	Nil	6	Nil
Series 2 24 hour control - 12 week	Nil	Nil	6	Nil	6	Nil

PLATE 12

Autoradiographs of ground sections of silicate cement restorations lined with a calcium hydroxide base in situ in dog teeth. Prior to the preparation of the sections, the specimens had been immersed in a $\text{Na}_2^{14}\text{CO}_3$ solution for 24 hours during which time they had been either kept at a constant temperature (Series 1) or subjected to thermal cycling (Series 2).

- A Twenty four hour control restoration and the corresponding six week restoration (Series 1) in contra-lateral maxillary 3rd incisor teeth. (Mag.X 3).
- B Twenty four hour control restoration and the corresponding twelve week restoration (Series 1) in contra-lateral maxillary 3rd premolar teeth. (Mag.X 3).
- C Twenty four hour control restoration and the corresponding six week restoration (Series 2) in contra-lateral maxillary 4th premolar teeth. (Mag.X 2).
- D Twenty four hour control restoration and the corresponding twelve week restoration (Series 2) in contra-lateral maxillary 4th premolar teeth. (Mag.X 2).

SERIES 1

A24 HOUR
CONTROL

6 WEEKS

B24 HOUR
CONTROL

12 WEEKS

SERIES 2

A24 HOUR
CONTROL

6 WEEKS

B24 HOUR
CONTROL

12 WEEKS

silicate cement restorations lined with a calcium hydroxide base.

Although none of the Series 1 or Series 2 restorations had a DPV in the high range, the proportion of restorations in the intermediate DPV range was higher with the older than with the newer restorations. Only one of the 12 Series 1 twenty four hour restorations (from the first group) had a DPV in the intermediate range, while 4 of the 6 Series 1 six week restorations and each of the 6 Series 1 twelve week restorations had a DPV in this range. Similarly, only one of the 12 Series 2 twenty four hour restorations (from the first group) had a DPV in the intermediate range, while one of the 6 Series 2 six week restorations and each of the 6 Series 2 twelve week restorations had a DPV in this range.

The data in Table 13-B show that in each of the paired (i) 24 hour control - 6 week restorations, and (ii) 24 hour control - 12 week restorations, from both Series 1 and Series 2, the 6 week or 12 week restoration had a higher DPV than the corresponding 24 hour restoration.

Each of the autoradiographs of the Series 1 and Series 2 twenty four hour control restorations (Plate 12) shows an absence of carbon-14 in the dentine subjacent

to the axial cavity wall, while each of the autoradiographs of the corresponding 6 week or 12 week restorations shows some uptake of carbon-14 in this region.

2. EFFECT OF THERMAL CYCLING

a. Marginal Penetration Values

Thermal cycling had no effect on the MPV of silicate cement restorations lined with a calcium hydroxide base, since each of the 24 hour, 6 week and 12 week restorations from both Series 1 and Series 2 had a maximum MPV.

b. Dentine Penetration Values

Thermal cycling did not appear to have any marked effect on the DPV of silicate cement restorations lined with a calcium hydroxide base.

The following table is taken from the summary of DPV data in Table 13-A:

	Number of Specimens with DPV in											
	(a) Low, (b) Intermediate and (c) High Ranges											
	24 Hour			6 Week			12 Week					
	Restorations			Restorations			Restorations					
	1st group	2nd group										
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
Series 1	5	1	Nil	6	Nil	Nil	2	4	Nil	Nil	6	Nil
Series 2	5	1	Nil	6	Nil	Nil	1	5	Nil	Nil	6	Nil

A comparison of the Series 1 and Series 2 restorations showed that:

- (i) With the exception of one Series 1 twenty four hour control restoration: (from the first group) and one Series 2 twenty four hour restoration. (from the first group), each of the Series 1 and Series 2 twenty four hour restorations had a DPV in the low range.
- (ii) Four of the 6 Series 1 six week restorations had a DPV in the intermediate range and 5 of the 6 Series 2 six week restorations had a DPV in the intermediate range. In both instances, the remaining restorations had a DPV in the low range.
- (iii) Each of the 6 Series 1 twelve week restorations and each of the 6 Series 2 twelve week restorations had a DPV in the intermediate range.

3. COMPARISON WITH UNLINED SILICATE CEMENT RESTORATIONS - EFFECT OF A CALCIUM HYDROXIDE BASE

a. Marginal Penetration Values

The presence of a calcium hydroxide base under silicate cement restorations had no effect on marginal penetration, since each of the Series 1 and Series 2 unlined silicate cement restorations and each of the Series 1 and Series 2 silicate cement restorations lined with a calcium hydroxide base had a maximum MPV.

b. Dentine Penetration Values

The following table, taken from the summary of the DPV data for (i) unlined silicate cement restorations in Table 10, and (ii) silicate cement restorations lined with a calcium hydroxide base in Table 13-A, shows the comparative DPV of unlined silicate cement restorations and silicate cement restorations lined with a calcium hydroxide base:

Restoration Aging Period		Number of Specimens with DPV in (a) Low, (b) Intermediate and (c) High Ranges					
		Unlined Silicate Cement Restorations			Silicate Cement Restorations Lined with a Calcium Hydroxide Base		
		(a)	(b)	(c)	(a)	(b)	(c)
Series 1	24 Hours (1st group)	Nil	Nil	6 *	5†	1	Nil
	24 Hours (2nd group)	Nil	Nil	6 *	6	Nil	Nil
	6 Weeks	Nil	Nil	6 *	2	4	Nil
	12 Weeks	Nil	Nil	6 *	Nil	6	Nil
Series 2	24 Hours (1st group)	Nil	Nil	6 *	5‡	1	Nil
	24 Hours (2nd group)	Nil	Nil	6 *	6†	Nil	Nil
	6 Weeks	Nil	Nil	6 *	1	5	Nil
	12 Weeks	Nil	Nil	6 *	Nil	6	Nil

* Each restoration had a maximum DPV (Appendix 3-B)

† Five restorations had a DPV of zero (Appendix 3-B)

‡ Four restorations had a DPV of zero (Appendix 3-B)

The presence of a calcium hydroxide base under silicate cement restorations reduced dentine penetration. As the above table shows, each of the Series 1 and Series 2 unlined silicate cement restorations had a maximum DPV, whereas none of the Series 1 or Series 2 silicate cement restorations lined with a calcium hydroxide base had a maximum DPV. The effect of a calcium hydroxide base was particularly marked with the 24 hour restorations, since, out of a combined total of 24 Series 1 and Series 2 twenty four hour silicate cement restorations lined with a calcium hydroxide base, 17 restorations had no dentine penetration at all (Appendix 3-B).

DISCUSSION

In 1952, Nelsen, Wolcott and Paffenbarger⁽⁷⁰⁾ suggested that there may be a relationship between fluid exchange at tooth-restoration margins and the occurrence of secondary caries. The tooth-restoration margins of acrylic resin restorations were thought to be particularly susceptible, since acrylic resin had no bacteriostatic properties and has a coefficient of thermal expansion approximately 7 times that of tooth structure. They calculated, allowing for a polymerisation shrinkage of 7 per cent, that a space of 10 microns could develop at the tooth-restoration margins of acrylic resin restorations during the imbibition of hot (60°C) and cold (4°C) liquids. However, to date, no direct relationship between fluid exchange at tooth-restoration margins and secondary caries has been established.

Ellis and Brown⁽³¹⁾, using what they described as an "in vitro cariogenic technique", showed that the tooth-restoration margins of newly placed unlined amalgam restorations were more susceptible to caries than were the tooth-restoration margins of newly placed amalgam restorations lined with a copal resin varnish. However

there appears to be little relationship between the conditions in their experiment and those in the oral cavity, since in their experiment, the initiation of carious lesions depended on the diffusion of nutrients from the pulp chamber, along the tooth-restoration interspace, to the enamel surface which was completely bathed in acid producing micro-organisms.

It is doubtful whether the penetration of tracers of ionic dimensions along the space between a restoration and the adjacent cavity walls provides any useful information regarding the likelihood of secondary caries at the tooth-restoration margins. It appears that a space much larger than the size of these tracers (Appendix 1) is necessary before secondary caries is likely to occur. Jørgensen and Wakumoto⁽⁵⁴⁾, in a study of 134 occlusal amalgam restorations aged in situ for one to nine years, found that if a space of 50 microns existed at the tooth-restoration margins (which they indicated can be detected by ordinary clinical examination), secondary caries usually resulted.

Broadhurst⁽¹⁸⁾, in a report on the occurrence of caries at the margins of amalgam restorations based on an examination of 4242 restored surfaces in 460 school children between 12 and 13 years of age, expressed the opinion that the factors most responsible for secondary

caries were :

- (i) The failure to remove all enamel sub-surface caries during cavity preparation.
- (ii) Conditions existing at the tooth-restoration margins which encourage the accumulation of debris and plaque, such as defective finishing in grooves and marginal excesses.

Any relationship between micropenetration and secondary caries at the margins of silicate cement restorations would appear to be extremely tenuous, since the fluoride normally present in silicate cement restorations has been reported to reduce the caries susceptibility of the adjacent enamel margins⁽⁹⁷⁾.

Schouboe and Macdonald⁽⁹¹⁾ have reported the prolonged viability of organisms under amalgam restorations, and have suggested that nutrients may have reached these organisms by diffusion along the tooth-restoration interspace and/or by diffusion from the pulp along the involved dentinal tubules.

The significance of micropenetration at the ionic level most probably lies in its effect on the pulp. Evidence to date indicates that there is a relatively free flow of fluid through intact human enamel in vivo⁽¹¹⁾, and in vitro^{(9) (10)}, with certain molecules such as

^{14}C -labelled urea⁽¹⁰⁸⁾, and methyl, ethyl and propyl alcohol⁽⁸⁴⁾ also being able to penetrate through intact enamel in vitro. Lindén and Brännström⁽⁵⁹⁾ have suggested that there is a continuous liquid phase between the saliva and pulp in vital teeth. It would appear therefore that any disruption to the integrity of the outer enamel layer, such as occurs at tooth-restoration margins, if continued into the more permeable underlying dentine, for example along the tooth-restoration interspace, would allow the penetration of ions and molecules from the saliva to the pulp, and vice versa, in greater amounts than normal, as well as allowing the penetration of matter of larger dimensions than normally penetrate through intact enamel. Conceivably such a saliva:pulp imbalance would have a pathological effect on the pulp.

Brännström⁽¹⁶⁾ and Dachi and Stigers⁽²⁷⁾ have suggested that micropenetration may have been responsible for the pulpal inflammation they observed under unlined amalgam restorations. Brännström made this suggestion after having histologically examined the pulps of 38 pairs of contra-lateral premolar teeth from patients between 10 and 15 years of age. A Class V cavity had been prepared in each tooth of the 38 tooth pairs, and

the cavity in one tooth of each tooth pair had been lined with a varnish containing zinc oxide and calcium hydroxide and then restored with amalgam, while the cavity in the other tooth of each tooth pair had been left unlined and restored with amalgam. The teeth had been extracted after one week. Twenty two of the 38 tooth pairs had shown no pulpal reactions while in 15 of the remaining 16 tooth pairs, the tooth containing the unlined restoration had shown the greater pulp reaction.

In a well controlled experiment, Dachi and Stigers⁽²⁷⁾ using 50 pairs of teeth in situ in 16 patients, prepared a Class V cavity in each tooth with the floor of the cavity as close to the pulp as possible (to ensure pulp reaction). In one series of 25 tooth pairs, one cavity from each tooth pair was lined with a copal resin varnish then restored with amalgam while the remaining cavity was restored with amalgam but left unlined. In a second series of 25 tooth pairs, prednisolone was applied to each cavity for 60 seconds before one cavity from each tooth pair was lined with copal resin varnish and restored with amalgam and the other cavity restored with amalgam. After 7 days, prior to extraction and the preparation of histological sections, the teeth were tested for vitality and sensitivity to hot and cold

stimuli. In both series, teeth containing restorations lined with copal resin varnish showed less thermal sensitivity and less pulpal inflammation than the corresponding teeth containing unlined amalgam restorations. The authors suggested that these differences were due to the efficacy of copal resin varnish in preventing micropenetration. They indicated that prednisolone applied to the cavity walls after cavity preparation reduced the inflammation already present in the pulp due to cavity preparation, whereas the application of a cavity varnish probably prevented a subsequent source of irritation to the pulp, i.e. micropenetration.

After placement of a restoration in the mouth, it is possible that one or both of two factors could operate to return the saliva⁷pulp flow of fluids to a normal level. Firstly, the permeability of the tooth-restoration interspace may be reduced by the interspace becoming occluded with oral debris or corrosion products from the filling material⁽⁶⁹⁾. Secondly, the permeability of the dentinal tubules involved in the cavity preparation could be reduced by the formation of sclerotic dentine (a defence reaction of the dentine⁽⁹⁸⁾) and/or the formation of reparative dentine (a defence reaction of the pulp⁽⁹²⁾). The presence of sclerotic dentine has

been shown to reduce the permeability of the affected tubules to dyes^{(12) (13)} and radioactive tracers of ionic dimensions⁽⁸⁾, while the presence of reparative dentine has been shown to seal the pulpal end of the affected tubules to dyes⁽³⁵⁾ and ¹⁴C-labelled glucose⁽⁴⁹⁾. Furthermore, Barber and Massler⁽⁴⁾ have shown that the presence of both sclerotic dentine and reparative dentine renders the affected tubules impermeable to both dyes and radioactive tracers.

It is possible that one, or both, of the above factors may have been responsible for the overall trend towards reduced micropenetration with aging observed with unlined composite resin restorations*. Buonocore⁽²¹⁾ has indicated that a reduction in micropenetration with aging in vivo could possibly be expected with composite resin restorations due to an expansion of the composite resin, caused by a gradual absorption of water during the first months in situ[†].

There was no reduction in the micropenetration of unlined silicate cement restorations with aging,

* The Series 1 unlined composite resin restorations showed a trend towards reduced marginal penetration and reduced dentine penetration with aging, while the Series 2 unlined composite resin restorations showed a trend towards reduced dentine penetration with aging.

† *Addent* 35 restorations absorb water for approximately 15 weeks after placement⁽²¹⁾.

although the unlined silicate cement restorations and the unlined composite resin restorations in each treatment group were aged in the same animals, for the same period of time (Appendix 3). Seltzer and Bender⁽⁹⁵⁾ have indicated that reparative dentine formation beneath unlined silicate cement restorations can be inhibited as a result of the death of underlying odontoblasts and other pulp cells, while Clarke and Hampson⁽²⁵⁾ have shown changes occurring in the dentine subjacent to unlined silicate cement restorations similar to the "dead tracts" described by Fish⁽³⁴⁾⁽³⁵⁾. It is therefore possible that sclerotic and reparative dentine formation were prevented, or at least inhibited, under the unlined silicate cement restorations, with the result that the dentinal tubules remained highly permeable.

Regardless of aging or thermal cycling, dentine penetration was either limited or absent with composite resin restorations lined with a calcium hydroxide base, while the combination of a calcium hydroxide base and *Addent Cavity Liner* under composite resin restorations virtually eliminated all dentine penetration. The use of *Addent Cavity Liner* alone under composite resin restorations did not provide as effective a barrier against dentine penetration as that provided by a

calcium hydroxide base or a calcium hydroxide base in combination with *Addent Cavity Liner*. A possible explanation for this situation is provided by Langeland⁽⁵⁸⁾, who reported that while film forming liners (including *Addent Cavity Liner*) could form an impermeable film on a glass slab, they failed to form a continuous, and therefore impermeable, film on dentine.

The presence of a calcium hydroxide base or a zinc oxide-eugenol base under newly placed silicate cement restorations provided a reasonably effective barrier against dentine penetration, however the efficacy of these bases in this regard tended to be reduced as the restorations aged in vivo. Possibly, with time, some of the free acid from the silicate cement* was able to penetrate around the calcium hydroxide or zinc oxide-eugenol base and cause some inhibition of sclerotic and reparative dentine formation, thereby keeping the affected dentinal tubules permeable to some degree. It is generally thought that one of the advantages of using a calcium hydroxide base under silicate cement restorations is that the OH^- ions available from the base neutralise the free H^+ ions

* At the time of insertion into a prepared cavity, silicate cement has a pH of 2.8, after 28 days it has a pH of 5.2(97).

from the silicate cement. However, Seltzer and Bender⁽⁹⁵⁾ have suggested in some instances there are not enough OH^- ions available from the base to neutralise all the free acid in the silicate cement restoration.

After 12 weeks in vivo, each silicate cement restoration lined with a zinc phosphate cement base showed less dentine penetration than its corresponding 24 hour control restoration. This situation is somewhat confusing in view of the trend towards increased dentine penetration with aging observed with silicate cement restorations lined with a calcium hydroxide or zinc oxide-eugenol base. Previous reports, based on findings obtained with newly placed silicate cement or amalgam restorations^{(3) (42)}, have indicated that a zinc phosphate cement base under these restorations increases dentine penetration by radioactive tracers, however, Baumgartner, Bustard and Feierabend⁽⁷⁾ have indicated that the presence of a zinc phosphate cement base under amalgam restorations aged 5 or more years in vivo provided an effective barrier against ^{131}I penetration. Clearly more work is needed to clarify this situation.

The disparity between the coefficient of thermal expansion of *Addent 35* and that of tooth structure *

* Coefficient of thermal expansion for *Addent 35* between 75°F and 190°F is 33×10^{-6} per degree centigrade (61), while the coefficient of thermal expansion of a tooth across its crown is 11.4×10^{-6} per degree centigrade (96).

was reflected in the trend towards increased micropenetration observed with unlined *Addent 35* restorations subjected to thermal cycling. However, the results of this study indicate that assessments of the effect of thermal cycling on the micropenetration of composite resin restorations based on data obtained only from newly placed restorations could be misleading, since in this study the adverse effects of thermal cycling on the micropenetration of unlined *Addent 35* restorations tended to be reduced with aging.

The procedures involved in cavity preparation may also contribute to the permeability of the tooth-restoration interspace by preventing a complete adaptation between a restoration and the adjacent tooth structure. Scott and O'Neil⁽⁹³⁾ and Provenza and Sardana⁽⁸⁵⁾ have reported that after cavity preparation a layer of loosened tooth substance covers the walls of a cavity. Provenza and Sardana tried several methods in an attempt to remove this layer but found that none of them were completely successful.

Roydhouse⁽⁸⁸⁾ has suggested that stress waves from cutting procedures may induce fractures in the surrounding enamel shell. It is not known whether such a situation occurred in this study, but if it did, it could explain the uptake of carbon-14 seen in the enamel

adjacent to the incisal/occlusal and gingival tooth-restoration margins noticed in many of the sections from the in vivo study (Plates 5-12).

Possibly because the enamel in human teeth is thicker than that in dog teeth, sections from the preliminary study did not show radioactive tracer uptake in these areas.

In practice restorations are not placed in sound teeth, as used in micropenetration studies, but are placed in teeth most probably involved by dental caries. Therefore some doubts may be expressed as to the validity of this type of micropenetration study since the defence reactions of the dentine and pulp accompanying dental caries (if the progress of the lesion is not too rapid⁽⁴⁾) have been shown to block the penetration of ions and molecules⁽⁴⁾ into the pulp. However, restorations placed in the mouth rarely involve just the area affected by caries, because sound tooth structure, and therefore patent dentinal tubules, can be involved in gaining access to the lesion, in extending the cavity, and in preparing areas for the mechanical retention of the subsequent restoration. As a result fluids and particulate matter may penetrate from the saliva to the pulp, and vice versa, along the tooth-restoration interspace and through the patent dentinal tubules.

Despite this and other micropenetration studies performed to date, much more needs to be known about such factors as:

- (i) The actual dynamics of ionic and molecular penetration from the saliva to the pulp, and vice versa, via the tooth-restoration interspace.
- (ii) The effect of individual ions and molecules on odontoblastic processes, odontoblasts and the underlying pulp tissue, since it is quite possible that the penetration of some ions and molecules may have a more harmful effect than the penetration of others.
- (iii) The relationship between the occurrence of secondary caries at the margins of a restoration and the size of the tooth-restoration interspace at constant temperature and during temperature changes. This would be of particular interest with acrylic resin restorations, since the results of one clinical study in particular⁽⁵¹⁾ suggest that the margins of acrylic resin restorations are quite susceptible to secondary caries.

SUMMARY AND CONCLUSIONS

A review of the literature showed that four different radioactive tracers (^{45}Ca , ^{35}S , ^{22}Na and ^{131}I) have been used to test the cavity sealing efficiency of silicate cement restorations, while only one radioactive tracer (^{45}Ca) has been used to test the cavity sealing efficiency of composite resin restorations. A study by Going, Massler and Dute⁽³⁹⁾ showed that not all radioactive tracers of ionic dimensions are able to penetrate along the space between a restoration and the adjacent cavity walls with equal facility. Therefore, on the basis of their findings, an initial investigation was made to determine which of five different radioactive tracers of ionic dimensions had the properties most suitable for investigating the cavity sealing efficiency of composite resin and silicate cement restorations. The five tracers used were - ^{45}Ca as $^{45}\text{CaCl}_2$, ^{35}S as $\text{Na}_2^{35}\text{SO}_4$, ^{22}Na as $^{22}\text{NaCl}$, ^{131}I as Na^{131}I , and ^{14}C as $\text{Na}_2^{14}\text{CO}_3$.

The test restorations were placed in box type cavities prepared in 90 freshly extracted human teeth. The specimens were immersed in the appropriate radioactive tracer solution for 24 hours. During the immersion period, one series of specimens was kept at

constant temperature, while the other series of specimens was subjected to thermal cycling. Assessments of the comparative penetrating ability of the five tracers were made from autoradiographs of ground sections prepared through the restorations and the surrounding tooth structure.

The findings of this preliminary study showed that:

1. Calcium-45 was the least effective of the five tracers in penetrating the space between the test restorations and the adjacent tooth structure.

2. Sodium-22 penetrated deeply into the body of the silicate cement restorations, but the diffuse autoradiographic image produced by sodium-22 obscured the details of the surrounding tooth structure and made an assessment of the degree of micropenetration impossible.

3. Sulphur-35 penetrated the space between the test restorations and the adjacent tooth structure as readily as iodine-131 and carbon-14 did under similar thermal conditions, however, in comparison to these two tracers, its ability to penetrate the dentine subjacent to the test restorations was limited.

4. Iodine-131 and carbon-14 penetrated the tooth-restoration interspace of, and the dentine subjacent to,

the test restorations far more readily than the other tracers did under similar thermal conditions.

5. Carbon-14 was the most suitable tracer for the subsequent in vivo study. Carbon-14 showed the path of micropenetration more clearly than iodine-131, and, unlike iodine-131, only penetrated the areas under investigation, i.e. the tooth-test restoration interspace and the subjacent dentine.

The purpose of the in vivo study was to investigate the effect of aging, cavity linings and thermal cycling, individually and in combination, on the micropenetration of composite resin and silicate cement restorations by carbon-14. The test and control restorations were placed in box type cavities prepared in 176 pairs of contra-lateral dog teeth. Composite resin restorations were left unlined or lined with either *Addent Cavity Liner*, a calcium hydroxide base, or *Addent Cavity Liner* over a calcium hydroxide base. Silicate cement restorations were left unlined or lined with either a zinc phosphate cement base, a zinc oxide-eugenol base, or a calcium hydroxide base. Each test restoration was placed in the appropriate tooth of each contra-lateral tooth pair at the first operative session and then allowed to age in vivo for either 6 or 12 weeks. At the end

of the aging period, the appropriate control restoration was placed in the remaining tooth of each contra-lateral tooth pair. The teeth were removed surgically and, after 24 hours, immersed in a $\text{Na}_2^{14}\text{CO}_3$ solution to test the cavity sealing efficiency of the restorations placed therein. During the immersion period of 24 hours, one series of specimens was kept at constant temperature (non-cycled specimens), and the other series of specimens was subjected to thermal cycling (cycled specimens). An assessment of the degree of micropenetration of each restoration by carbon-14 was made from an autoradiograph of a ground section prepared through the restoration and surrounding tooth structure.

The findings of this study showed that:

1. There was an overall trend towards reduced micropenetration with aging with the non-cycled and cycled unlined composite resin restorations. The non-cycled restorations showed a trend towards reduced marginal penetration and reduced dentine penetration with aging, while the cycled restorations showed a trend towards reduced dentine penetration with aging.

2. Although thermal cycling tended to increase the marginal penetration and the dentine penetration of unlined composite resin restorations, the adverse

effect of thermal cycling on dentine penetration tended to be reduced with aging.

3. *Addent Cavity Liner* tended to reduce the marginal penetration of the newly placed non-cycled composite resin restorations, but tended to increase the marginal penetration of the older non-cycled composite resin restorations. *Addent Cavity Liner* had no effect on the marginal penetration of the cycled composite resin restorations.

4. *Addent Cavity Liner* tended to reduce dentine penetration under the cycled composite resin restorations and tended to reduce dentine penetration under the newly placed non-cycled composite resin restorations.

5. A calcium hydroxide base tended to reduce the marginal penetration of the newly placed non-cycled composite resin restorations, but had no effect on the marginal penetration of the cycled composite resin restorations.

6. A calcium hydroxide base limited, or prevented entirely, dentine penetration under composite resin restorations.

7. *Addent Cavity Liner* over a calcium hydroxide base tended to reduce the marginal penetration of the newly placed non-cycled composite resin restorations

but tended to increase the marginal penetration of the older non-cycled composite resin restorations. *Addent Cavity Liner* over a calcium hydroxide base had no effect on the marginal penetration of the cycled composite resin restorations.

8. *Addent Cavity Liner* over a calcium hydroxide base virtually eliminated all dentine penetration under composite resin restorations.

9. Thermal cycling had no appreciable effect on the micropenetration of unlined or lined silicate cement restorations.

10. Aging had no effect on the micropenetration of unlined silicate cement restorations; since each unlined silicate cement restoration had a maximum degree of marginal penetration and a maximum degree of dentine penetration.

11. A zinc phosphate cement base had no appreciable effect on the marginal penetration of silicate cement restorations, but tended to reduce slightly the dentine penetration under these restorations. Its efficacy as a barrier to dentine penetration appeared to be most pronounced with the oldest restorations.

12. A zinc oxide-eugenol base had some effect in limiting marginal penetration with the newly placed silicate cement restorations, but had no effect on the marginal penetration of the older silicate cement

restorations.

13. A zinc oxide-eugenol base reduced the dentine penetration under silicate cement restorations, but its efficacy in this regard tended to be reduced with aging.

14. A calcium hydroxide base had no effect on the marginal penetration of silicate cement restorations.

15. A calcium hydroxide base reduced dentine penetration under silicate cement restorations, but its efficacy in this regard tended to be reduced with aging.

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APPENDIX 1

COMPARATIVE SIZE OF SOME TRACERS

Tracer	Size	Studies in which Tracer Used
$^{45}\text{Ca}^{++}$	Ionic radii $0.99 \text{ \AA}^{\circ}$ *	(1)(3)(5)(19)(26)(29)(30)(39) (42)(48)(50)(60)(64)(72)(77) (80)(90)(101)(102)(110)(112)
$^{22}\text{Na}^{+}$	Ionic radii $0.95 \text{ \AA}^{\circ}$ *	(17)(39)(42)
$^{131}\text{I}^{-}$	Ionic radii $2.16 \text{ \AA}^{\circ}$ *	(7)(40)(42)(100)(109)
$^{35}\text{SO}_4 =$	A regularly co-ordinated tetrahedral ion, S-O distance approx. $1.5 \text{ \AA}^{\circ}$ *	(3)(5)(39)(42)(60)
$^{14}\text{CO}_3 =$	Oxygen atoms symmetrically disposed at corners of an equilateral triangle, C-O distance $1.31 \text{ \AA}^{\circ}$ *	(73)
Toluidine Blue	approx. $13.3 \text{ \AA}^{\circ}$ x $3.5 \text{ \AA}^{\circ}$ †	(5)(60)
Prontosil Red	$17.0 \text{ \AA}^{\circ}$ x $4.5 \text{ \AA}^{\circ}$ †	(52)
Methylene Blue	$14.5 \text{ \AA}^{\circ}$ x $4.0 \text{ \AA}^{\circ}$ †	(20)(46)(62)
Crystal Violet	$14.5 \text{ \AA}^{\circ}$ x $6.0 \text{ \AA}^{\circ}$ †	(40)
Aniline Blue	$18.5 \text{ \AA}^{\circ}$ x $6.0 \text{ \AA}^{\circ}$ †	(55)(57)(75)
Bacillus prodigiosus (syn.- Serratia marcescens)	$0.7-1.0 \mu$ x 0.7μ †	(46)(69)(94)
Bacillus globigii	$1.5-3.0 \mu$ x $0.5-0.8 \mu$ †	(94)
Bacillus proteus	$1.0-3.0 \mu$ x $0.4-0.6 \mu$ †	(36)

* Evans (32)

† In calculating these values all bond lengths were based on data from Cartmell and Fowles (24)

‡ Wilson and Miles (111)

APPENDIX 2

TEST FOR HOMOGENEITY OF VARIANCE OF DENTINE PENETRATION.VALUE (DPV) ASSESSMENTS

To determine whether the errors in assessing DPV were homogeneous over the range of readings, six autoradiographs were selected at random and re-read randomly six times.

Autoradiograph Number	1	2	3	4	5	6	Mean	Sum of Squares	d.f.	Variance
(Subsamples)										(s ²)
1	28	30	32	32	28	31	30.2	16.8	5	3.4
2	16	15	16	15	15	18	15.8	6.8	5	1.4
3	74	67	72	70	71	70	70.7	27.3	5	5.5
4	96	95	94	94	95	96	95.0	4.0	5	0.8
5	95	94	97	96	94	97	95.5	9.5	5	1.9
6	71	75	77	77	79	78	76.2	40.8	5	8.2

Using Hartley's Maximum F Test (Peatman ⁽⁷⁶⁾, page 331):

$$F_{\max} = \frac{s^2_{\text{maximum}}}{s^2_{\text{minimum}}}$$

$$= \frac{8.2}{0.8} = 10.25$$

The critical value of $F_{\max}$ at the 5 per cent level of significance for 5 d.f. and 6 subsamples is 18.7, and since in this instance $F_{\max} < 18.7$, the variances are homogeneous. Therefore, the errors in assessing DPV were homogeneous over the range of readings.

APPENDIX 3

3-A MICROPENETRATION VALUES FOR COMPOSITE RESIN RESTORATIONS PLACED IN VIVO

Type of Cavity Lining and/or Base	Classification of Specimens According to Thermal Treatment Series 1 - not thermally cycled Series 2 - thermally cycled	Animal Ident- ification Number	No. of Paired 24 hour Control- Restora- tions	Restoration Aging Period	Marginal Penetration Values* (per cent)					Dentine Penetration Values* (per cent)				
					a	b	c	d	e	a	b	c	d	e
Unlined	Series 1	15	5	24 hours 6 weeks	100	100	90	100	100	70	37	30	27	75
					100	100	83	80	96	20	4	24	23	41
		20	5	24 hours 12 weeks	(0) (0) (+ 7)	(+ 20) (+ 49)	(+ 11)	(+ 33)	(+ 37)	(+ 50) (+ 33)	(+ 6)	(+ 4)	(+ 34)	
					100	100	77	83	93	67	25	28	45	48
	Series 2	29	5	24 hours 6 weeks	80	51	66	50	56	20	0	19	0	0
					(+ 20) (+ 49)	(+ 11)	(+ 33)	(+ 37)		(+ 47) (+ 25)	(+ 9)	(+ 45)	(+ 48)	
		16	5	24 hours 12 weeks	100	100	100	100	100	89	93	95	88	86
					100	100	100	100	100	52	60	50	55	75
Addent Cavity Liner	Series 1	17	5	24 hours 6 weeks	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(+ 37) (+ 33)	(+ 45)	(+ 33)	(+ 11)	
					100	100	100	100	100	74	100	83	88	96
		18	5	24 hours 12 weeks	100	100	100	100	100	18	34	30	27	20
					(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(+ 56) (+ 66)	(+ 53)	(+ 61)	(+ 76)	
	Series 2	30	5	24 hours 6 weeks	100	65	100	47	100	36	0	26	0	22
					100	100	100	100	74	0	46	48	24	0
		19	5	24 hours 12 weeks	(0) (- 35)	(0) (- 53)	(+ 26)			(+ 36)	(- 46)	(- 22)	(- 24)	(+ 22)
					100	64	100	100	56	32	12	36	30	0
Addent Cavity Liner	Series 1	18	5	24 hours 12 weeks	40	100	100	100	100	0	0	0	27	13
					(+ 60) (- 36)	(0) (0) (0) (- 44)				(+ 32)	(+ 12)	(+ 36)	(+ 3)	(- 13)
	Series 2	30	5	24 hours 6 weeks	100	100	100	100	100	76	27	60	35	26
					100	100	100	100	100	36	50	46	18	16
		19	5	24 hours 12 weeks	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(+ 40)	(- 23)	(+ 14)	(+ 17)	(+ 10)
					100	100	100	100	100	76	64	31	60	42
	Series 2	19	5	24 hours 12 weeks	100	100	100	100	100	15	10	0	5	23
					(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(0) (0) (0) (0) (0)	(+ 61)	(+ 54)	(+ 31)	(+ 55)	(+ 19)

Calcium Hydroxide Base	Series 1	21	5	24 hours	58	48	66	72	48	0	0	0	0	0
				6 weeks	64	52	56	60	84	0	0	17	0	0
		8	5	24 hours	(-6) (-4) (+10) (+12) (-36)					(0) (0) (-17) (0) (0)				
					52	33	64	59	49	0	0	0	0	0
					44	34	57	58	64	12	0	0	0	0
	Series 2	23	5	24 hours	(+8) (-1) (+7) (+1) (-15)					(-12) (0) (0) (0) (0)				
					100	100	100	100	100	0	0	0	0	11
		9	5	24 hours	(0) (0) (0) (0) (0)					(0) (0) (0) (0) (0)				
					100	100	100	100	100	0	0	8	0	10
					100	100	100	100	100	0	0	0	0	10
Addent Cavity Liner	Series 1	24	5	24 weeks	39	46	50	100	48	0	0	0	0	0
					42	100	100	100	67	0	0	0	0	0
		11	5	24 hours	(-3) (-54) (-50) (0) (-19)					(0) (0) (0) (0) (0)				
					100	72	55	48	69	0	0	0	0	30
					100	100	100	100	100	0	0	0	0	18
	Series 2	25	5	24 hours	(0) (-28) (-45) (-52) (-31)					(0) (0) (0) (0) (0)				
					100	100	100	100	100	0	0	0	0	0
		22	5	24 hours	(0) (0) (0) (0) (0)					(0) (0) (0) (0) (0)				
					100	100	100	100	100	0	0	0	0	0
					100	100	100	100	100	0	0	0	0	0

* Marginal Penetration Values and Dentine Penetration Values for paired test and 24 hour control restorations are presented in the following order:

- a - Values for restorations in contra-lateral mandibular 3rd incisor teeth
- b - Values for restorations in contra-lateral mandibular canine teeth
- c - Values for restorations in contra-lateral mandibular 3rd premolar teeth
- d - Values for restorations in contra-lateral mandibular 4th premolar teeth
- e - Values for restorations in contra-lateral mandibular 1st molar teeth

The value in parenthesis beneath the (i) Marginal Penetration Values, and (ii) Dentine Penetration Values for each pair of test and 24 hour control restorations represents the difference in the appropriate penetration values between that pair of restorations.

CEMENT RESTORATIONS PLACED IN VIVO

**Zinc
Phosphate
Cement
Base**

Zinc Oxide- Eugenol Base	Series 1	21	6	24 hours	100	100	100	100	89	80	94	0	27	74	2	0	2+
				6 weeks	100	100	100	100	100	100	100	70	74	90	57	50	33
		8	6	24 hours	100	100	100	100	73	93	91	31	25	0	12	34	51
				12 weeks	100	100	100	100	100	100	100	83	53	76	86	71	100
	Series 2	23	6	24 hours	100	100	100	81	100	69	71	0	25	8	14	0	18
				6 weeks	100	100	100	100	100	100	100	42	48	22	16	42	35
		9	6	24 hours	77	100	85	83	100	62	62	20	0	2+	30	18	4
				12 weeks	100	100	100	100	100	100	100	77	40	50	82	63	96
				24 hours	100	100	100	100	100	100	100	0	25	8	14	0	18
				6 weeks	100	100	100	100	100	100	100	42	48	22	16	42	35
Calcium Hydroxide Base	Series 1	24	6	24 hours	100	100	100	100	100	100	100	0	0	0	0	0	23
				6 weeks	100	100	100	100	100	100	100	38	53	20	10	55	76
		11	6	24 hours	100	100	100	100	100	100	100	0	0	4	9	0	12
				12 weeks	100	100	100	100	100	100	100	39	50	50	66	59	64
	Series 2	25	6	24 hours	100	100	100	100	100	100	100	20	0	0	0	0	33
				6 weeks	100	100	100	100	100	100	100	75	49	42	61	20	60
		22	6	24 hours	100	100	100	100	100	100	100	0	0	0	0	0	0
				12 weeks	100	100	100	100	100	100	100	63	66	73	78	71	57
				24 hours	100	100	100	100	100	100	100	0	0	0	0	0	0
				6 weeks	100	100	100	100	100	100	100	63	66	73	78	71	57

* Marginal Penetration Values and Dentine Penetration Values for paired test and 24 hour control restorations are presented in the following order:

- a - Values for restorations in contra-lateral maxillary 3rd incisor teeth
- b - Values for restorations in contra-lateral maxillary canine teeth
- c - Values for restorations in contra-lateral maxillary 3rd premolar teeth
- d - Values for restorations in contra-lateral maxillary 4th premolar teeth
- e - Values for restorations in contra-lateral maxillary 1st molar teeth
- f - Values for restorations in contra-lateral mandibular 2nd molar teeth

The value in parenthesis beneath the (i) Marginal Penetration Values, and (ii) Dentine Penetration Values for each pair of test and 24 hour control restorations represents the difference in the appropriate penetration values between that pair of restorations.

† In these specimens a very fine strip of dentine penetration emanated from the region of the axio-gingival line angle but there was no penetration from the region of the axio-occlusal line angle. The Dentine Penetration Values given here are approximate and were calculated according to the method described on page 78.

