CHAPTER FIVE

RESULTS

5.1. Compatibility between finger spreaders and accessory core materials (Gutta-percha and RealSeal™)

Appendix II, Table A (Page 181) shows the diameter of 12 stainless-steel finger spreaders, size medium and 24 accessory gutta-percha core material, size medium and 24 accessory RealSeal™ core material, size medium. The mean diameter for finger spreaders at 1 mm (D1), 3 mm (D3) and 6 mm (D6) from the spreader tip were 0.241 mm, 0.349 mm and 0.497 mm respectively. The mean diameter for accessory gutta-percha cores at 1 mm (D1), 3 mm (D3) and 6 mm (D6) from the gutta-percha core tip were 0.214 mm, 0.332 mm and 0.482 mm respectively and mean diameter for accessory RealSeal™ cores at 1 mm (D1), 3 mm (D3) and 6 mm (D6) from the tip of the core were 0.214 mm, 0.333 mm and 0.491 mm respectively. The mean diameter of accessory core materials was smaller than the mean diameter of spreaders. The results indicated that the sizes of finger spreaders and accessory core materials were compatible.

5.2. Post-operative radiographic evaluation

Post-operative radiographs taken to evaluate the quality of obturation showed that each root filling had variable degree of radio-density. The criteria used to evaluate adaptation of the filling materials to the root canal wall was assessed as either acceptable when no visible voids were present, or unacceptable when visible voids were present. After assessing all specimens, the worst two cases that showed visible voids were discarded. These were replaced with another two acceptably obturated canals.

5.3. Time taken for obturation

The obturation time for each tooth is shown in Appendix II, Table B (Page 182). Mean time taken for each technique and material is shown in Table 5.1. One-way analysis of variance (ANOVA) showed that the mean difference between the obturation groups is significantly different (p=0.000) (Appendix II, Table C, Page 182). However, the variances were not similar and homogeneity of variances assumption was not met (p=0.033) (Appendix II, Table D, Page 182). Thus, a further analysis was done using the multiple comparisons (Dunnetts T3) (Appendix II, Table E, Page 183). Mean obturation time for the lateral compaction of RealSeal™ (LC/R) (12.12 minutes) and lateral compaction of gutta-percha (LC/GP) (11.30 minutes) were significantly longer than both warm vertical "continuous wave" technique (WVCW) and warm vertical compaction of injected RealSeal™ (6.63 minutes) and gutta-percha (6.32 minutes) (p=0.000, 0.000) (Appendix II, Table E, Page 183), whereas, there was no significant difference between both warm vertical compaction techniques (p=0.821) (Appendix II, Table E, Page 183). Also, there was no significant difference between both lateral compaction techniques (p=0.072) (Appendix II, Table E, Page 183).

Table 5.1 Mean times (minutes) taken for obturation

Group	Mean	Std. Deviation	N
LC/RealSeal™	12.1200*	.79586	16
LC/Gutta-percha	11.3019*	.94429	16
WC/RealSeal™	6.6344	.94134	16
WC/Gutta-percha	6.3281	.51355	16
Total	9.0961	2.77123	64

**Significantly different from other groups (p<0.01).*

5.4. Extrusion of filling materials through apical foramen

The extrusion of the filling materials for each tooth is shown in Appendix II, Table F (Page 183). The percentages for non extrusion against extrusion are shown in Table 5.2. Figure 5.1 displays the extrusion compared to non extrusion of filling materials. Two specimens obturated by lateral compaction of RealSeal™ (LC/R) showed apical extrusions, whereas for lateral compaction of gutta-percha (LC/GP), there was only one specimen. For warm vertical "continuous wave" technique (WVCW) of RealSeal™, apical extrusion occurred in five specimens, whereas for warm vertical "continuous wave" technique (WVCW) of gutta-percha, there were four apical extrusion cases. The chi-square test gave a Pearson value of 4.103 in which p-value = 0.251 (df=3). Hence, there were no significant differences between extrusion and the filling materials used and techniques utilized (p=0.251), but there were less apical extrusions from lateral compaction (LC) compared to warm vertical "continuous wave" technique (WVCW) regardless of the materials used as shown in Appendix II, Table G (Page 183).

Table 5.2 Extrusion cross tabulation

			Extrusion		Total
			No	Yes	
Group	LC/ RealSeal™	Count	14	2	16
		% within Group	87.5%	12.5%	100%
	LC/Gutta-percha	Count	15	1	16
		% within Group	93.8%	6.3%	100%
	WC/ RealSeal™	Count	11	5	16
		% within Group	68.8%	31.3%	100%
	WC/Gutta-percha	Count	12	4	16
		% within Group	75.0%	25.0%	100%
Total		Count	52	12	64
		% within Group	81.3%	18.8%	100%

No significant differences between groups (p>0.05).

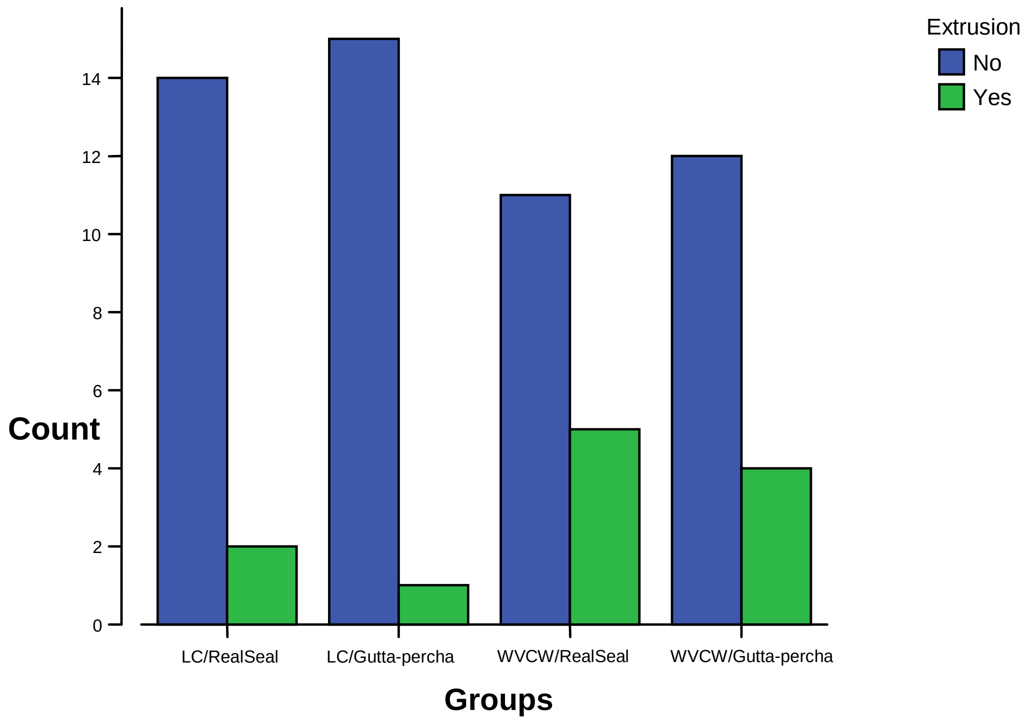


Figure 5.1 Extrusion of filling materials against no extrusion.

5.5. Percentages of canal area occupied by filling core materials (RealSeal™ and gutta-percha), sealers and voids

Appendix II, Tables H, I, J, K, L and M (Pages 184-189) show the percentages of canal area occupied by filling core materials (RealSeal™ and gutta-percha), sealers and voids at 1 mm (L1), 3 mm (L3) and 6 mm (L6) respectively.

5.5.1. First section (L1)

A. Mean percentages of canal area occupied by filling core materials, sealers and voids

Table 5.3 and Figure 5.2 show the mean percentages of canal area occupied by filling core materials (RealSeal™ and gutta-percha), sealers (RealSeal™ sealer and AH-Plus™) and voids at L1 by using both techniques (lateral compaction and warm vertical "continuous wave" techniques). For comparison of filling materials, there was higher mean percentage of RealSeal™ filling core using the lateral compaction technique (LC) compared with gutta-percha using the same technique. However, when using the warm vertical "continuous wave" technique (WVCW), only a small difference in mean was noted between both filling core materials (RealSeal™ and gutta-percha). For sealers and voids, there were also small differences in mean percentages using either lateral compaction (LC) or warm vertical "continuous wave" technique (WVCW). For comparison of obturation techniques, in either RealSeal™ or gutta-percha groups, there were small differences in mean percentages between lateral compaction (LC) and warm vertical "continuous wave of condensation" (WVCW) for filling core materials, sealers and voids.

Table 5.3 Mean percentages of filling core materials, sealers and voids using lateral compaction (LC) and warm vertical "continuous wave" techniques (WVCW) at L1

Technique	Type	Filling cores		Sealers		Voids	
		Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
LC	RealSeal™	.8700	.07254	.1193	.06604	.0121	.01122
	Gutta-percha	.7793	.11634	.1893	.11113	.0313	.03137
WVCW	RealSeal™	.8493	.06545	.1250	.06549	.0271	.02463
	Gutta-percha	.8187	.09226	.1447	.08667	.0367	.03579

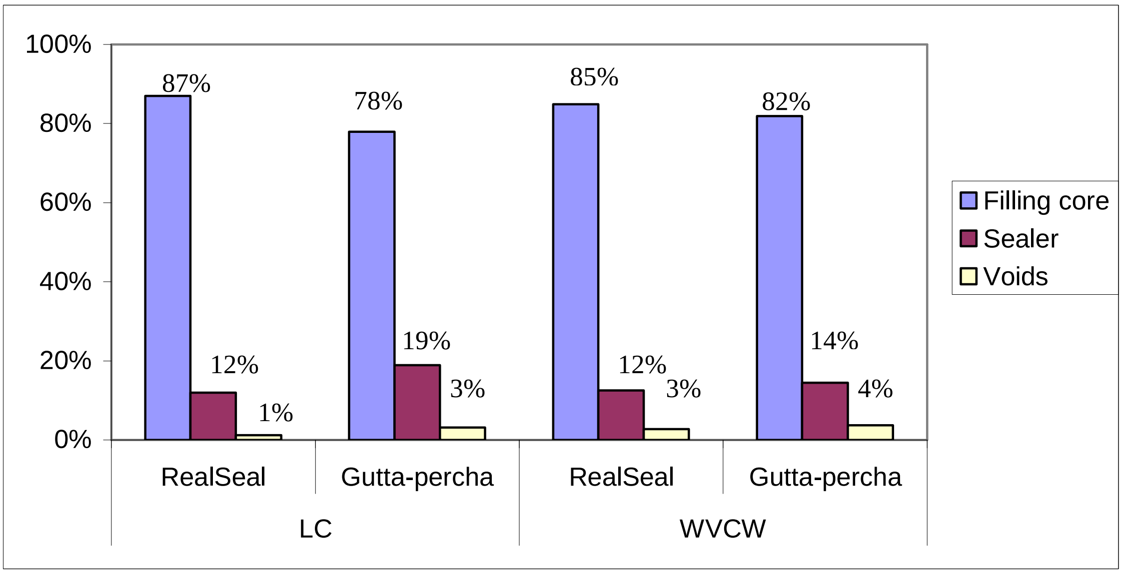


Figure 5.2 Mean percentages of filling cores (RealSeal™ and gutta-percha), sealers and voids using lateral compaction (LC) and warm vertical "continuous wave" techniques (WVCW) at L1.

B. Effect of different materials and different techniques on percentages of filling core materials, sealers and voids

Two-way analysis of variances (ANOVA) was employed to detect the effect of different materials and different techniques on percentages of filling core materials, sealers and voids at L1. The assumption of variables normally distributed and equality of variances was checked. Filling core materials (RealSeal™ and gutta-percha) and voids were normally distributed (p=0.081, 0.200, 0.068, 0.185). However, RealSeal™ sealer and AH-Plus™ were not distributed normally (p=0.007, 025) [Appendix II, Tables N and O (Page 190) and Figures A, B, C, D, E and F (Pages 191-193)]. Table 5.4 shows the effect of different materials and different techniques on percentages of filling core materials, sealers and voids at L1. For comparison of filling materials, there was significant difference between RealSeal™ and gutta-percha core materials (p=0.013). However, there were no significant differences between both groups for sealers and voids (p=0.053, 0.052). For comparison of obturation techniques, there were no significant differences between the two techniques (p=0.663, 0.367, 0.172).

Table 5.4 The effect of different materials and different techniques on percentages of filling core materials, sealers, and voids at L1

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Technique LC and WVCW	Filling cores	.002	1	.002	.191	.663	.003
	Sealers	.006	1	.006	.826	.367	.015
	Voids	.001	1	.001	1.919	.172	.034
Type RS and GP	Filling cores	.053	1	.053	6.571	**.013**	.107
	Sealers	.029	1	.029	4.010	.053	.068
	Voids	.003	1	.003	3.950	.052	.067

Since there was significant difference in mean percentage between filling core materials, independent sample *t*-test was applied. RealSeal™ core material occupied a significantly higher area compared to gutta-percha using the lateral compaction technique (LC) (p=0.019) as shown in Table 5.5. However, there was no significant difference in mean percentage for RealSeal™ core material compared to gutta-percha core material using the warm vertical "continuous wave" technique (WVCW) (p=0.315) (Table 5.6).

Table 5.5 The effect of different materials on the mean percentages of filling core materials using lateral compaction technique (LC) at L1

Area	RealSeal™ (n=14) Mean (SD)	Gutta-percha (n=15) Mean (SD)	*t*-test* (df)	p value
Filling cores	.87 (.073)	.78 (.116)	2.50 (27)[a]	.019

**Independent sample t-test was applied. a. Equal variances assumed (Levene's test, p=0.065).*

Table 5.6 The effect of different materials on the mean percentages of filling core materials using warm vertical "continuous wave" technique (WVCW) at L1

Area	RealSeal™ (n=14) Mean (SD)	Gutta-percha (n=15) Mean (SD)	*t*-test* (df)	p value
Filling cores	.85 (.065)	.82 (.092)	1.02 (27)[a]	.315

**Independent sample t-test was applied. a. Equal variances assumed (Levene's test, p=0.402).*

5.5.2. Second section (L3)

A. Mean percentages of canal area occupied by filling core materials, sealers and voids

Table 5.7 and Figure 5.3 show the mean percentages of canal area occupied by filling core materials (RealSeal™ and gutta-percha), sealers and voids at L3 by using both techniques (lateral compaction and warm vertical compaction techniques). For comparison of filling materials, there was smaller mean percentage of gutta-percha in lateral compaction (LC) compared with RealSeal™ core material using the same technique, but greater mean percentages of sealer and voids in gutta-percha than in RealSeal™ group. Whereas, when using the warm vertical "continuous wave" technique (WVCW), only a small difference in mean percentages was noted between filling core materials, sealers and voids. For comparison of obturation techniques, there was smaller mean percentage of gutta-percha but greater mean percentage of sealer in lateral compaction (LC) compared with warm vertical compaction (WVCW and WVCI). Whereas, comparison of both techniques showed smaller differences in mean percentages for RealSeal™ core material and sealer.

Table 5.7 Mean percentages of filling core materials, sealers and voids using lateral compaction (LC) and warm vertical compaction techniques (WVCW and WVC1) at L3

Technique	Type	Filling cores		Sealers		Voids	
		Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
LC	RealSeal™	.8893	.04743	.0973	.04267	.0120	.01082
	Gutta-percha	.7900	.08367	.1733	.07566	.0387	.03681
WC	RealSeal™	.9027	.04096	.0773	.03807	.0200	.01512
	Gutta-percha	.8753	.05604	.1033	.05367	.0200	.01648

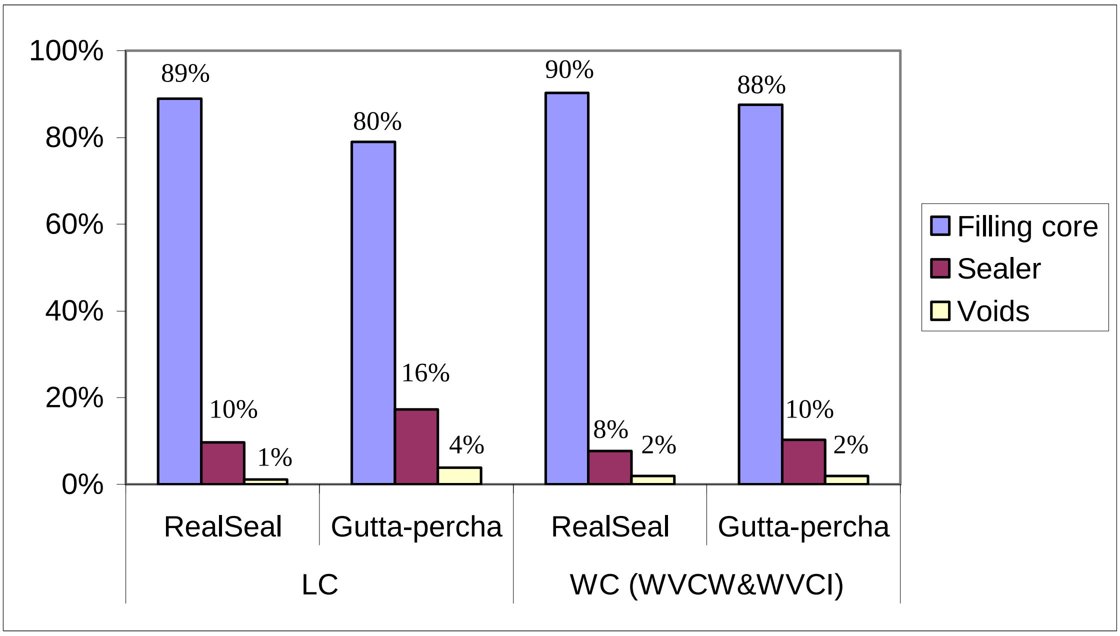


Figure 5.3 Mean percentages of filling cores (RealSeal™ and gutta-percha), sealers and voids using lateral compaction (LC) and warm vertical compaction techniques (WVCW and WVC1) at L3.

B. Effect of different materials and different techniques on percentages of filling core materials, sealers, and voids

Two-way analysis of variances (ANOVA) was employed to detect the effect of different materials and different techniques on percentages of filling core materials, sealers and voids at L3. The assumption of variables normally distributed and equality of variances was checked. Filling core materials (RealSeal™ and gutta-percha) and voids were normally distributed (p=0.081, 0.200, 0.068, 0.185). However, RealSeal™ sealer and AH-Plus™ were not distributed normally (p=0.007, 025) [Appendix II, Tables N and O (Page 190) and Figures A, B, C, D, E and F (Pages 191-193)]. Table 5.8 shows the effect of different materials and different techniques on percentages of filling core materials, sealers and voids at L3. For comparison of filling materials, there were significant differences between both groups for filling core materials, sealers and voids (p=0.000, 0.001, 0.029). For comparison of obturation techniques, there were significant differences between both techniques for filling core material and sealer (p=0.003, 0.003).

Table 5.8 The effect of different materials and different techniques on percentages of filling core materials, sealers, and voids at L3

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Technique LC and WC	Filling cores	.037	1	.037	9.616	**.003**	.144
	Sealers	.030	1	.030	9.858	**.003**	.147
	Voids	.000	1	.000	.803	.374	.014
Type RS and GP	Filling cores	.060	1	.060	15.848	**.000**	.218
	Sealers	.039	1	.039	12.662	**.001**	.182
	Voids	.003	1	.003	5.020	**.029**	.081

Since there were significant differences for filling materials and obturation techniques, independent sample ***t***-test and Mann-Whitney U test were applied. For comparison of filling materials, using the lateral compaction technique, there were significant differences between RealSeal™ and gutta-percha for filling core materials, sealers and voids (p=0.000, 0.021, 0.002) (Tables 5.9 and 5.10). However, in warm vertical compaction (WVCW and WVCI), there were no significant differences between RealSeal™ and gutta-percha for filling core materials, sealers and voids (p=0.138, 1.00, 0.138) (Tables 5.11 and 5.12). For comparison of obturation techniques, there was significant difference between lateral compaction and warm vertical compaction of gutta-percha (WVCW and WVCI) for gutta-percha core material and sealer (p=0.003, 0.007) (Table 5.13). However, there was no significant difference between lateral compaction (LC) and warm vertical compaction of RealSeal™ (WVCW and WVCI) for core material and sealer (p=0.417, 0.186) (Table 5.14).

Table 5.9 The effect of different materials on the mean percentages of filling core materials and voids using lateral compaction technique (LC) at L3

Area	RealSeal™ (n=15) Mean (SD)	Gutta-percha (n=14) Mean (SD)	*t*-test* (df)	P value
Filling cores	.89 (.047)	.80 (.068)	3.98 (27)[a]	.000
Voids	.01 (.011)	.04 (.038)	-2.58 (14.95)[c]	.021

Independent sample* ***t*-*test was applied.* *a. Equal variances assumed (Levene's test, p=0.172).*
c. Equal variances not assumed (Levene's test, p=0.017).

Table 5.10 The effect of different materials on the mean percentages of sealers using lateral compaction technique (LC) at L3

Area	RealSeal™ (n=15) Mean Rank (SR)	Gutta-percha (n=14) Mean Rank (SR)	*U*-test* (Z)	P value
Sealers	10.37 (155.50)	19.96 (279.50)	35.50 (-3.04)	.002

**Mann-Whitney U test was applied.*

Table 5.11 The effect of different materials on the mean percentages of filling core materials and voids using warm vertical compaction technique (WVCW and WVCI) at L3

Area	RealSeal™ (n=15) Mean (SD)	Gutta-percha (n=15) Mean (SD)	*t*-test* (df)	P value
Filling cores	.90 (.041)	.88 (.056)	1.53 (28)[a]	.138
Voids	.02 (.015)	.02 (.016)	.000 (28)[c]	1.00

**Independent sample t-test was applied. a. Equal variances assumed (Levene's test, p=0.485).*
c. Equal variances assumed (Levene's test, p=0.457).

Table 5.12 The effect of different materials on the mean percentages of sealers using warm vertical compaction technique (WVCW and WVCI) at L3

Area	RealSeal™ (n=15) Mean Rank (SR)	Gutta-percha (n=15) Mean Rank (SR)	*U*-test* (Z)	P value
Sealers	13.13 (197)	17.87 (268)	77 (-1.49)	.138

**Mann-Whitney U test was applied.*

Table 5.13 The effect of different techniques on the mean percentages of gutta-percha core material and sealer at L3

Area	Lateral compaction (n=14) Mean (SD)	Warm compaction (n=15) Mean (SD)	*t*-test* (df)	P value
Gutta-percha	.80 (.068)	.88 (.056)	-3.28(28)[a]	.003
Sealer	.16 (.055)	.10 (.054)	2.92 (28)[b]	.007

**Independent sample t-test was applied. a. Equal variances assumed (Levene's test, p=.213).*
b. Equal variances assumed (Levene's test, p=.340).

Table 5.14 The effect of different techniques on the mean percentages of RealSeal™ core material and sealer at L3

Area	Lateral compaction (n=15) Mean (SD)	Warm compaction (n=15) Mean (SD)	*t*-test* (df)	P value
RealSeal™	.89 (.047)	.90 (.041)	-.82 (28)[a]	.417
Sealer	.10 (.043)	.08 (.038)	1.35 (28)[b]	.186

**Independent sample t-test was applied. a. Equal variances assumed (Levene's test, p=.909).*
b. Equal variances assumed (Levene's test, p=.805).

5.5.3. Third section (L6)

A. Mean percentages of canal area occupied by filling core materials, sealers and voids

Table 5.15 and Figure 5.4 show the mean percentages of canal area occupied by filling core materials (RealSeal™ and gutta-percha), sealers and voids at L6 by using both techniques (lateral compaction technique and warm vertical compaction of injected materials). For comparison of filling materials, there were small differences in mean percentages between both groups for filling core materials, sealers and voids using lateral compaction (LC). Also, when using warm vertical compaction of injected materials (WVCI), small differences in mean percentages were noted between both groups for filling core materials, sealers and voids. For comparison of obturation techniques, in either RealSeal™ or gutta-percha groups, there was a smaller mean percentage of filling core materials but greater mean percentages of sealers and voids in lateral compaction (LC) compared with warm vertical compaction of injected materials (WVCI).

Table 5.15 Mean percentages of filling core materials, sealers and voids using lateral compaction and warm vertical compaction of injected materials (WVCI) at L6

Technique	Type	Filling cores Mean	Filling cores Std. Deviation	Sealers Mean	Sealers Std. Deviation	Voids Mean	Voids Std. Deviation
LC	RealSeal™	.9027	.03973	.0813	.03944	.0153	.00640
	Gutta-percha	.9073	.04026	.0727	.03575	.0193	.01033
WVCI	RealSeal™	.9679	.01477	.0271	.01069	.0057	.00646
	Gutta-percha	.9547	.02532	.0393	.02344	.0073	.00704

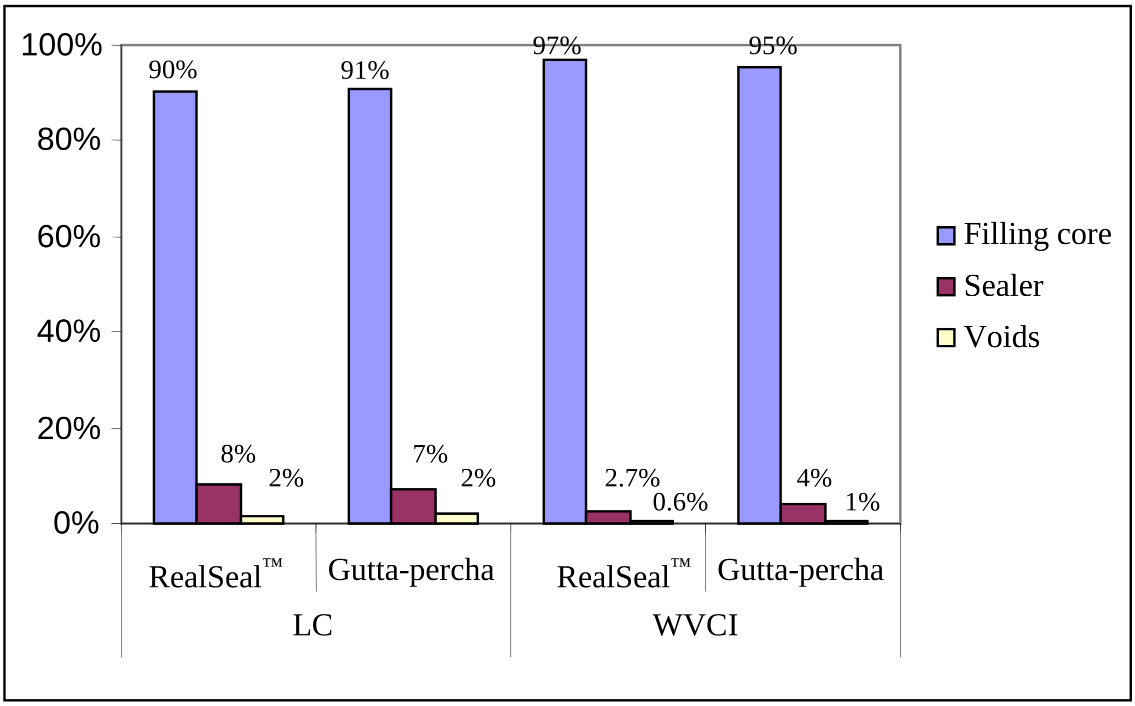


Figure 5.4 Mean percentages of filling cores (RealSeal™ and gutta-percha), sealers and voids using lateral compaction and warm vertical compaction of injected materials (WVCI) at L6.

B. Effect of different materials and different techniques on percentages of filling core materials, sealers, and voids

Two-way analysis of variances (ANOVA) was employed to detect the effect of different materials and different techniques on percentages of filling core materials, sealers and voids at L6. The assumption of variables normally distributed and equality of variances was checked. Filling core materials (RealSeal™ and gutta-percha) and voids were normally distributed (p=0.081, 0.200, 0.068, 0.185). However, RealSeal™ sealer and AH-Plus™ were not distributed normally (p=0.007, 025) [Appendix II, Tables N and O (Page 190) and Figures A, B, C, D, E and F (Pages 191-193)]. Table 5.16 shows the effect of different materials and different techniques on percentages of filling core materials, sealers and voids at L6. For comparison of filling materials, there was no significant difference between groups for filling core materials, sealers and voids (p=0.626, 0.841, 0.164). For comparison of obturation techniques, there was significant difference between lateral compaction (LC) and warm vertical compaction of injected materials (WVCI) for filling core materials, sealers and voids (p=0.000, 0.000, 0.000).

Table 5.16 The effect of different materials and different techniques on percentages of filling core materials, sealers, and voids at L6

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Technique LC and WVCI	Filling cores	.046	1	.046	44.981	**.000**	.445
	Sealers	.028	1	.028	31.076	**.000**	.357
	Voids	.002	1	.002	29.133	**.000**	.342
Type RS and GP	Filling cores	.000	1	.000	.241	.626	.004
	Sealers	.003	1	.003	.041	.841	.001
	Voids	.000	1	.000	1.990	.164	.034

Since there were significant differences for obturation techniques, independent sample ***t***-test was applied. There were significant differences in mean percentages between lateral compaction (LC) and warm vertical compaction of injected RealSeal™ (WVCI) for RealSeal™ core material, sealer and voids at L6 (p=0.000, 0.000, 0.000) (Table 5.17). There were also significant differences between lateral compaction (LC) and warm vertical compaction of injected gutta-percha (WVCI) for gutta-percha core material, sealer and voids at L6 (p=0.001, 0.005, 0.001) (Table 5.18).

Table 5.17 The effect of different techniques on the mean percentages of RealSeal™ core material, sealer and voids at L6

Area	LC (n=15) Mean (SD)	WVCI (n=14) Mean (SD)	*t*-test (df)	P value
RealSeal™	.90 (.040)	.97 (.015)	-5.93 (18.03)[a]	.000
Sealer	.08 (.040)	.03 (.011)	5.12 (16.18)[b]	.000
Voids	.02 (.006)	.01 (.006)	4.03 (27)[c]	.000

*Independent sample **t**-test was applied. a. Equal variances not assumed (Levene's test, p=0.015). b. Equal variances not assumed (Levene's test, p=0.039). c. Equal variances assumed (Levene's test, p=0.979).*

Table 5.18 The effect of different techniques on the mean percentages of gutta-percha core material, sealer and voids at L6

Area	LC (n=15) Mean (SD)	WVCI (n=14) Mean (SD)	*t*-test (df)	P value
Gutta-percha	.91 (.040)	.95 (.025)	-3.86 (28)[a]	.001
Sealer	.07 (.036)	.04 (.023)	3.02 (28)[b]	.005
Voids	.02 (.010)	.01 (.007)	3.72 (28)[c]	.001

*Independent sample **t**-test was applied. a. Equal variances assumed (Levene's test, p=0.139). b. Equal variances assumed (Levene's test, p=0.143). c. Equal variances assumed (Levene's test, p=0.398).*

5.6. Quality of the obturation

5.6.1. Root canal shapes

Root canals had different shapes at each cross-section. At 1 mm (L1) most canals were round in shape (≥75%) after preparation; however, some canals were ovoid/irregular in cross-section (≤25%) (Table 5.19). At 3 mm (L3), approximately half of the canals were round and the other half were ovoid/irregular (Table 5.20). The third section at 6 mm (L6) had a greater number of ovoid/irregular shapes (≥65%) than round (Table 5.21).

5.6.2. Lateral compaction of RealSeal™ (LC/R)

The photomicrographs (Figure 5.5) show cross-sections at L1, L3 and L6 of lateral compaction of RealSeal™. The RealSeal™ appeared to be rough and homogenous in the best cross-sections, whereas in the poorest one (Specimen No. 14, L1), the RealSeal™ appeared as an irregular, coalescent mass with voids and pooled sealer around the perimeter of the root canal due to the failure of the bonding to the canal wall. Sometimes, long gaps were present between RealSeal™ core materials and sealer. No sealer was evident between the filling cores. The majority of voids were associated with the long areas of sealer. It was obvious that the area of sealer decreased coronally, while that of RealSeal™ core material increased.

5.6.3. Lateral compaction of gutta-percha (LC/GP)

The photomicrographs (Figure 5.6) show cross-sections at L1, L3 and L6 of lateral compaction of gutta-percha. The gutta-percha mass appeared to be smooth and homogenous at the best cross-sections, whereas the poorest cross-section (Specimen No. 5, L1) showed an irregularly shaped coalescent mass with voids and pools of sealer at the perimeter of the canal. Some filling core materials were attached to each other with obvious sealer between the filling cores. Voids and sealer were seen along canal walls in most cross-sections. The majority of voids were associated with larger quantities of sealer. It was obvious that the area of sealer decreased coronally, while that of gutta-percha core material increased.

5.6.4. Warm vertical compaction of RealSeal™ (WC/R)

The photomicrographs (Figure 5.7) show cross-sections at L1 of WVCW, at L3 of WC (WVCW and WVCI) and L6 of WVCI of RealSeal™. The best cross-sections at L1, L3 and L6 produced close adaptation like mono-block to the canal wall. RealSeal™ had a rough and homogenous view in most specimens. However, the poorest cross-section (Specimen No. 9, L1), failed to bond to the canal wall and showed the single core without enough compaction particularly at L1. There was better adaptation and bonding to the canal wall at L3 and L6.

5.6.5. Warm vertical compaction of gutta-percha (WC/GP)

The photomicrographs (Figure 5.8) show cross-sections at L1 of WVCW, at L3 of WC (WVCW and WVCI) and L6 of WVCI of gutta-percha. The best cross-sections at L1 demonstrated close adaptation of the master gutta-percha core material to the canal wall. For the poorest cross-section (Specimen No. 12, L1), the warm gutta-percha failed to adapt to the canal wall and showed the single core without enough compaction. This was associated with large areas of sealer and voids at the periphery of the filling core. There was a distinct difference between L1 and other levels. At L3 and L6, it was observed that gutta-percha had a smooth and homogenous view in most specimens. However, in some cross-sections at L3 (Specimen No. 15, L3), the filling core did not blend with the backfilling. There was close adaptation between the gutta-percha mass and canal wall. Sealer lining the canal wall was not frequently observed.

Table 5.19 Shapes of root canals at L1

Shape	technique	Material	Number
Round	LC	RealSeal™	11
		Gutta-percha	10
Irregular	LC	RealSeal™	3
		Gutta-percha	5
Round	WC	RealSeal™	11
		Gutta-percha	12
Irregular	WC	RealSeal™	3
		Gutta-percha	3

Table 5.20 Shapes of root canals at L3

Shape	technique	Material	Number
Round	LC	RealSeal™	7
		Gutta-percha	6
Irregular	LC	RealSeal™	8
		Gutta-percha	8
Round	WC	RealSeal™	8
		Gutta-percha	7
Irregular	WC	RealSeal™	7
		Gutta-percha	8

Table 5.21 Shapes of root canals at L6

Shape	technique	Material	Number
Round	LC	RealSeal™	5
		Gutta-percha	6
Irregular	LC	RealSeal™	10
		Gutta-percha	9
Round	WC	RealSeal™	6
		Gutta-percha	5
Irregular	WC	RealSeal™	8
		Gutta-percha	10

Figure 5.5 Photomicrographs of specimens utilizing LC/R at L1, L3 and L6 Specimen number 1 to 8

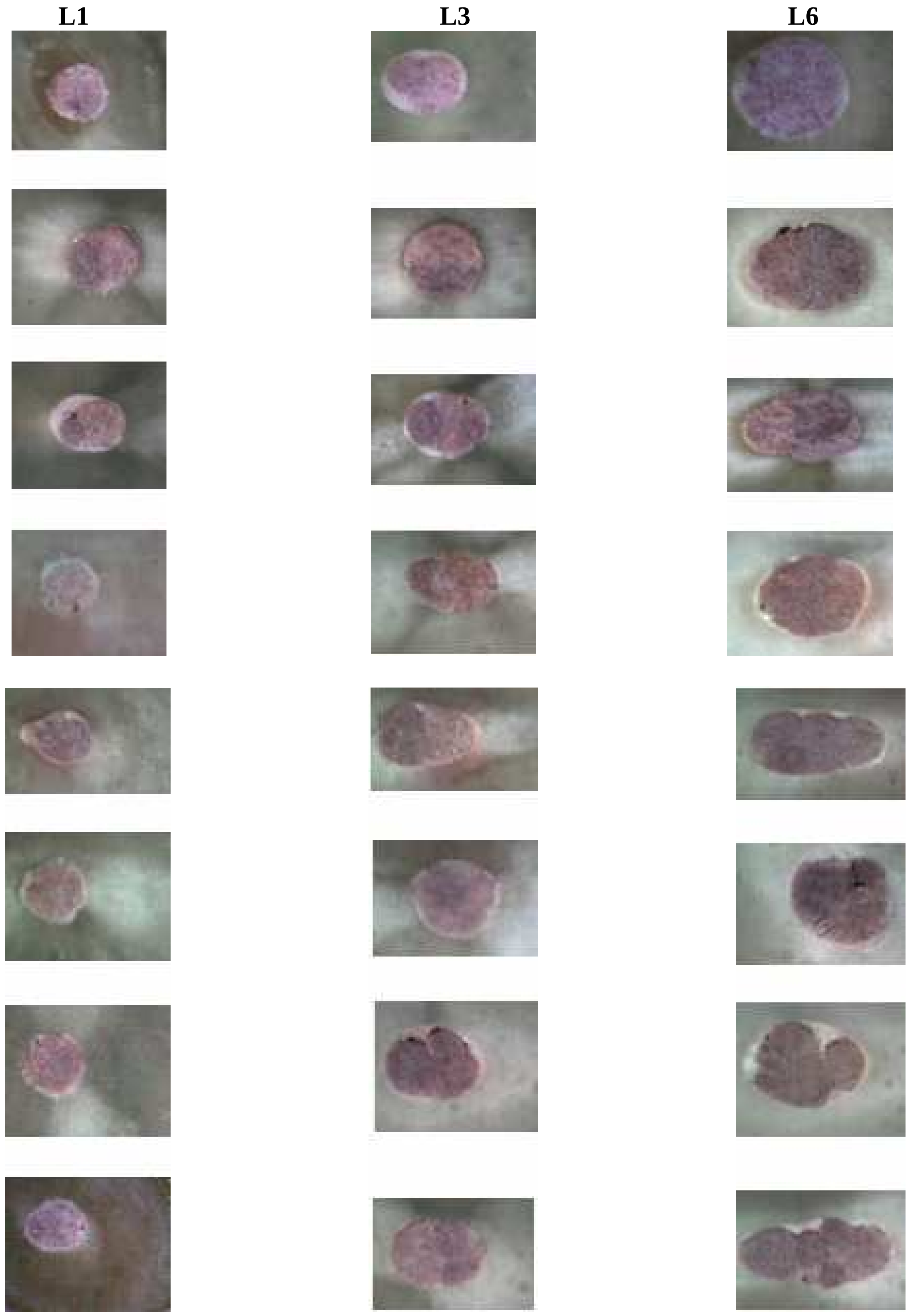


Figure 5.5 Continued ….
Specimen number 9 to 15

L1 **L3** **L6**

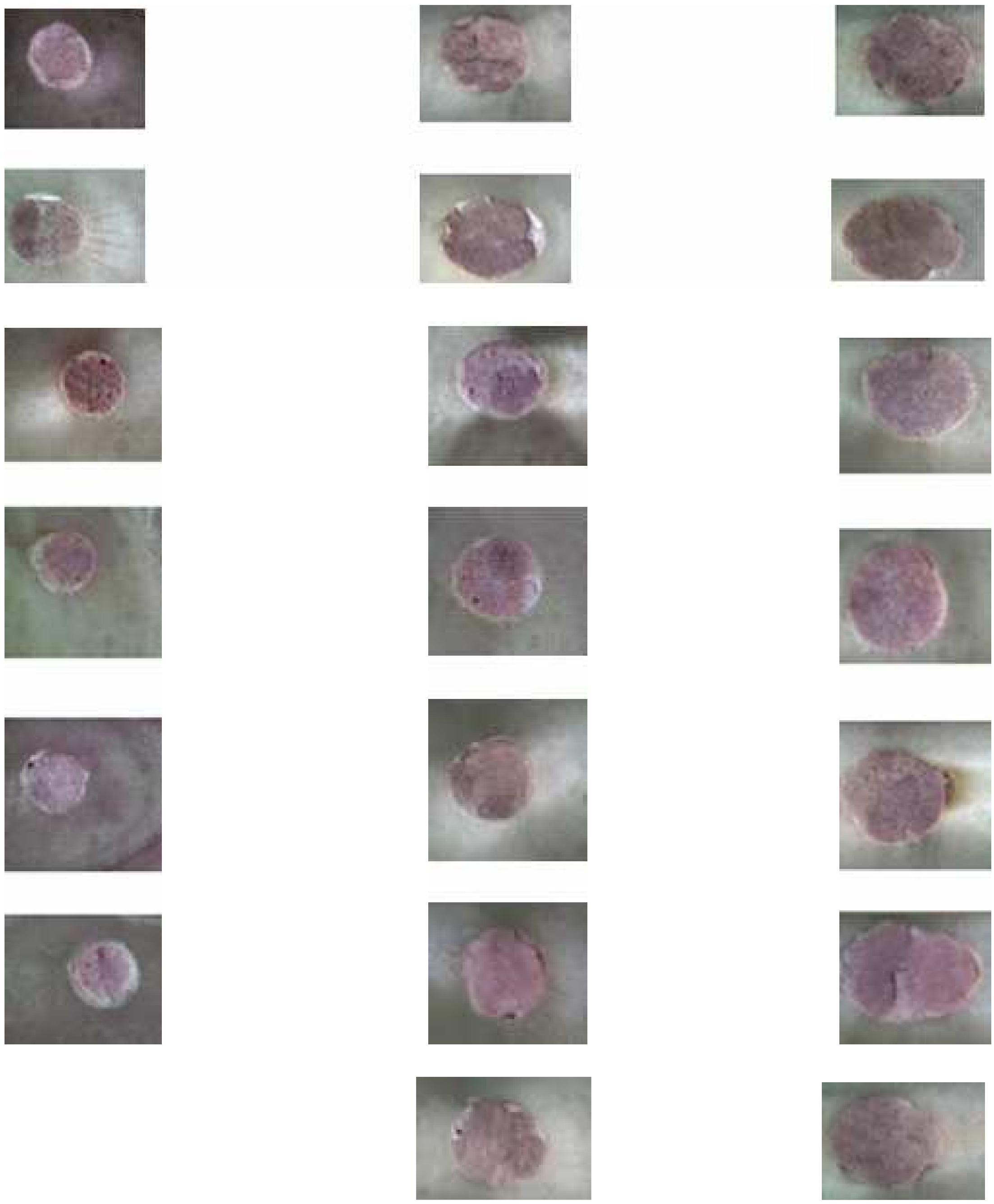


Figure 5.6 Photomicrographs of specimens utilizing LC/GP at L1, L3 and L6. Specimen number 1 to 8

L1 **L3** **L6**

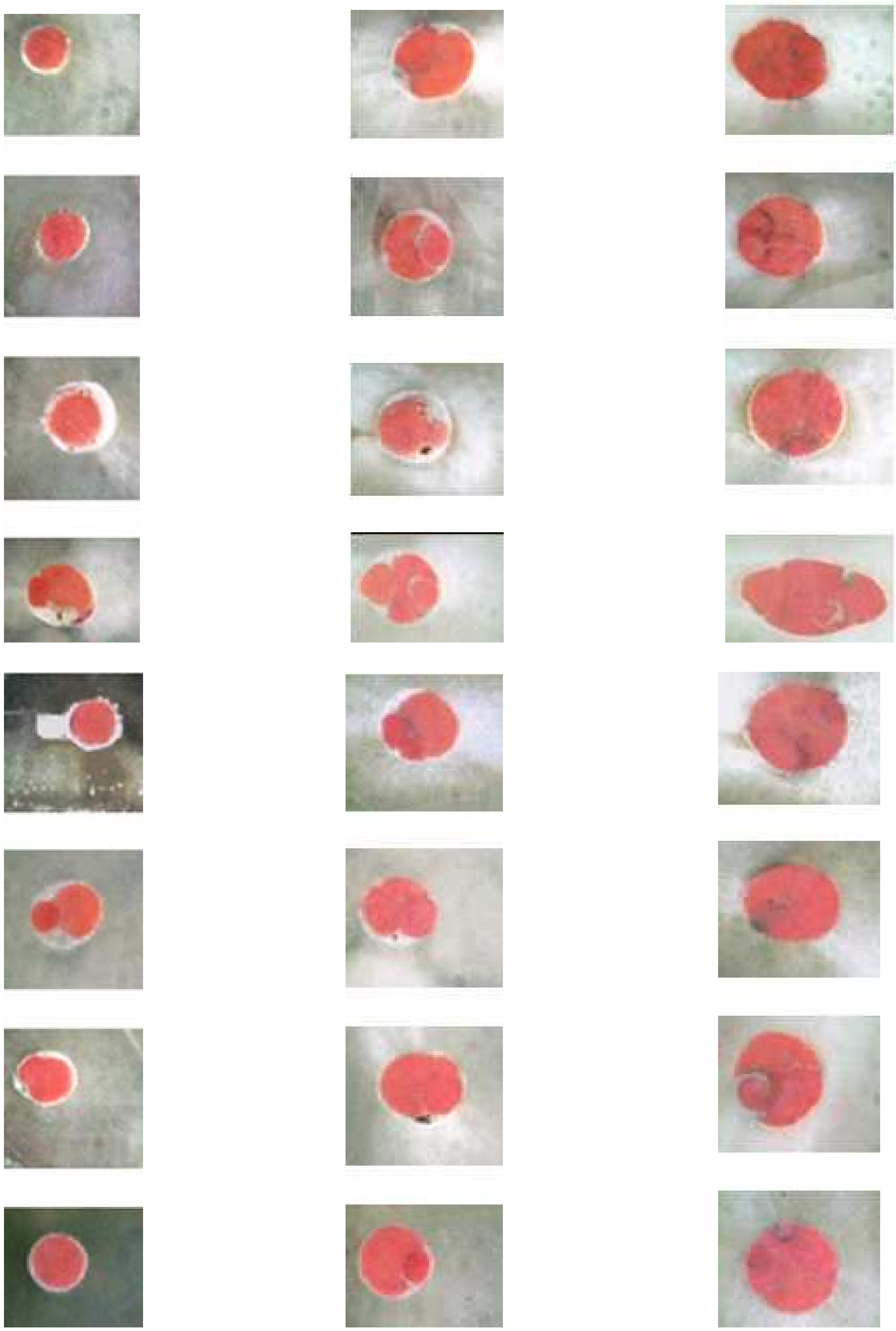


Figure 5.6 Continued ….
Specimen number 9 to 15

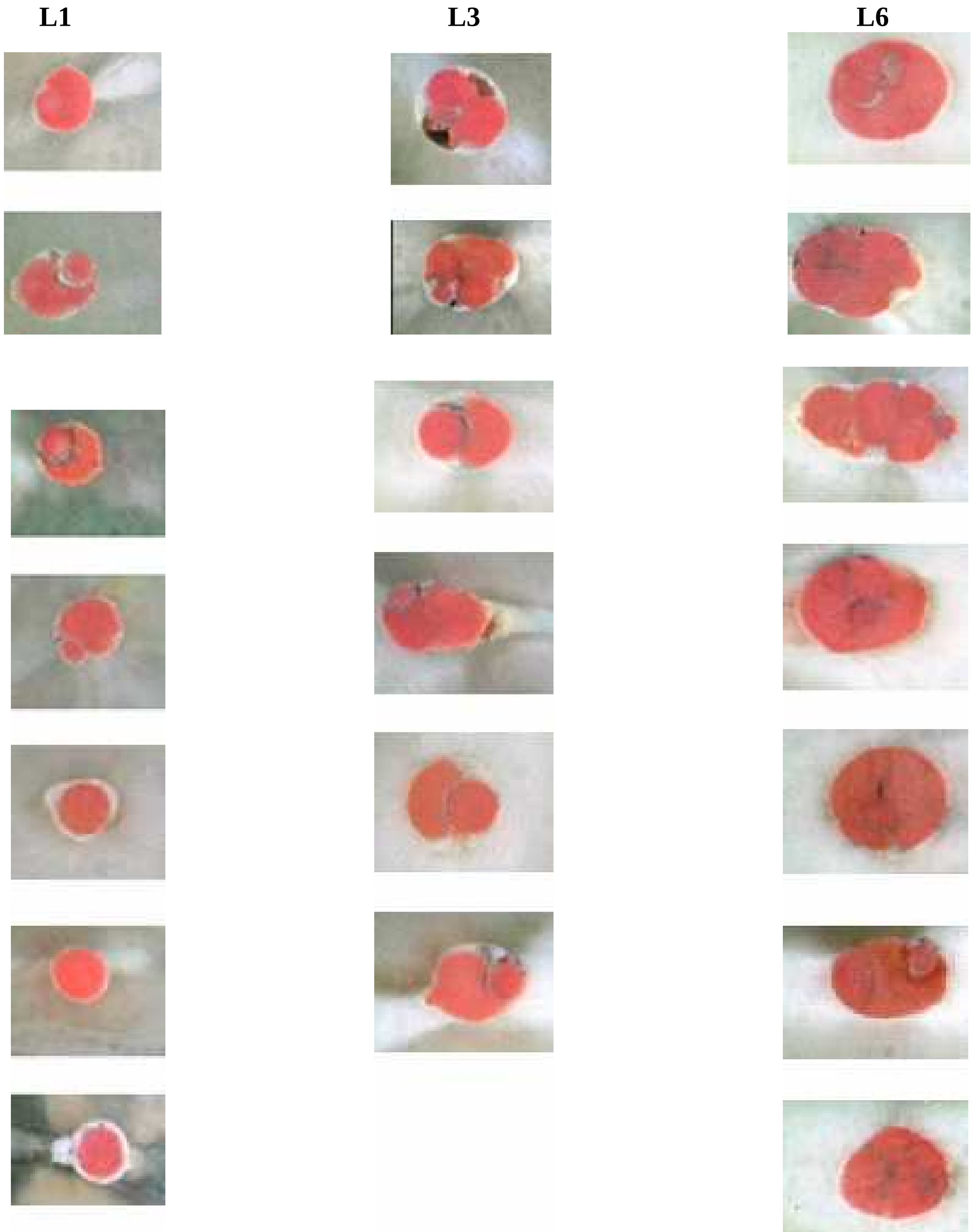


Figure 5.7 Photomicrographs of specimens utilizing WC/R at L1, L3 and L6. Specimen number 1 to 8

L1 **L3** **L6**

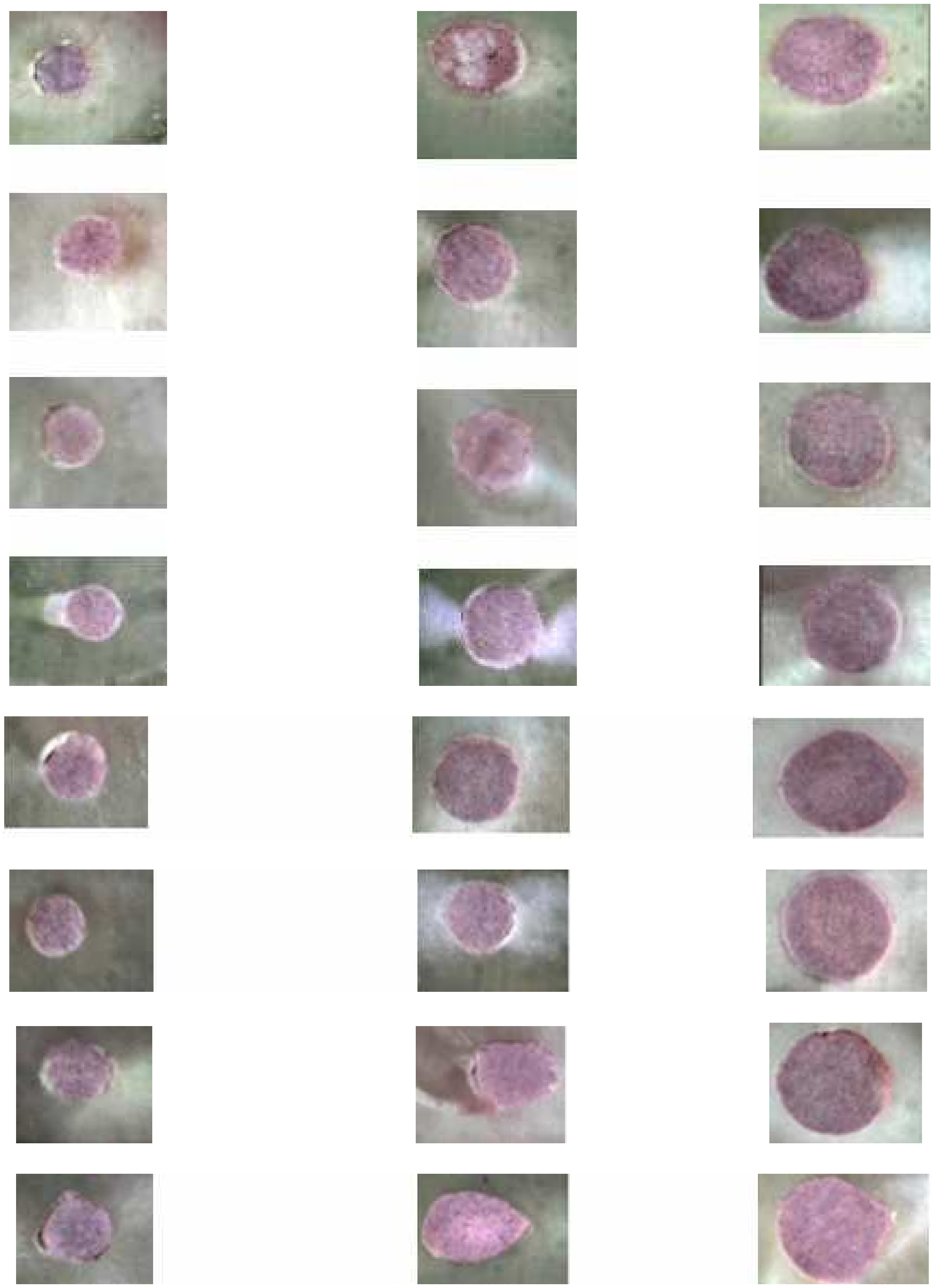


Figure 5.7 Continued ….
Specimen number 9 to 15

L1 **L3** **L6**

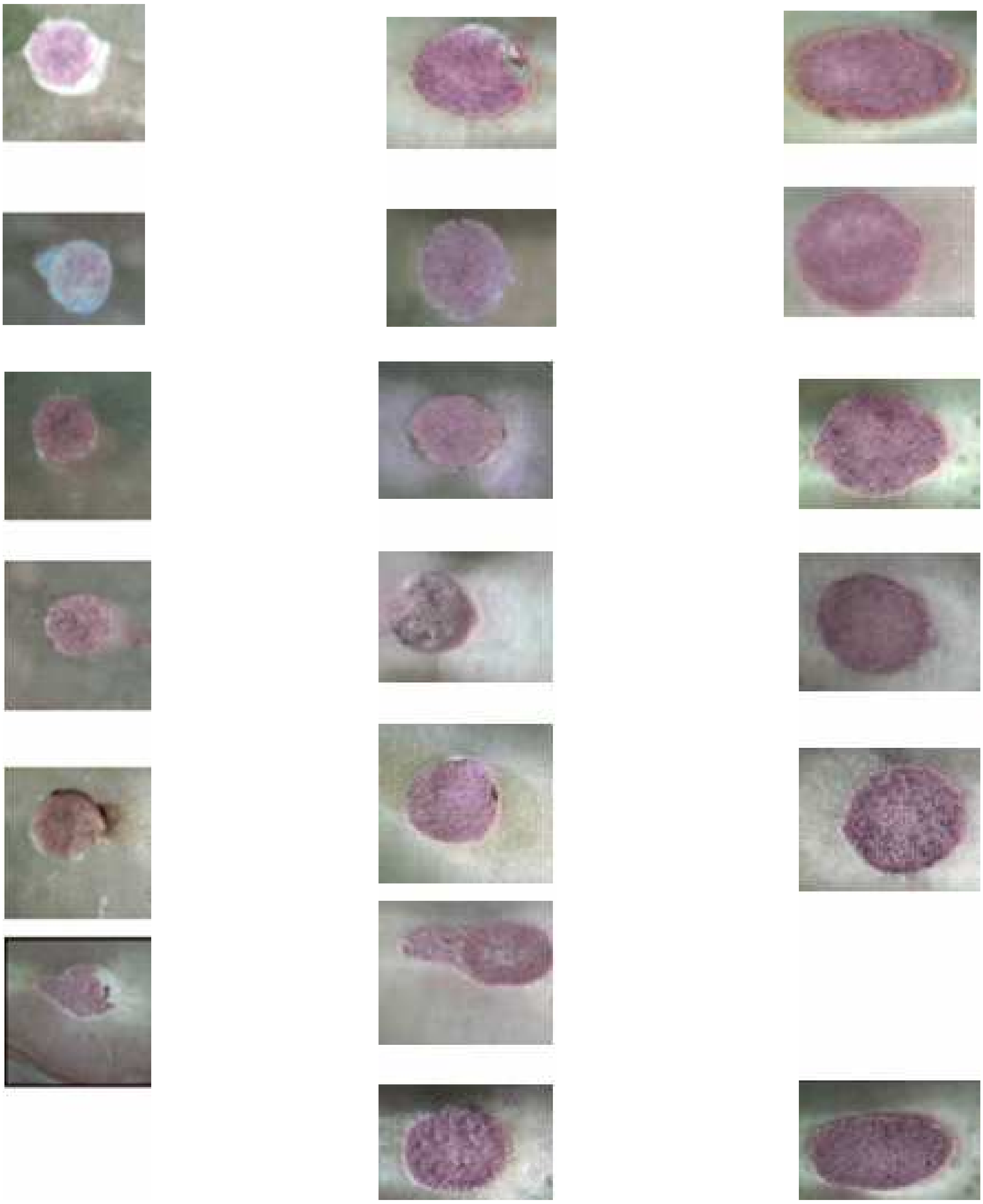


Figure 5.8 Photomicrographs of specimens utilizing WC/GP at L1, L3 and L6. Specimen number 1 to 8

L1 **L3** **L6**

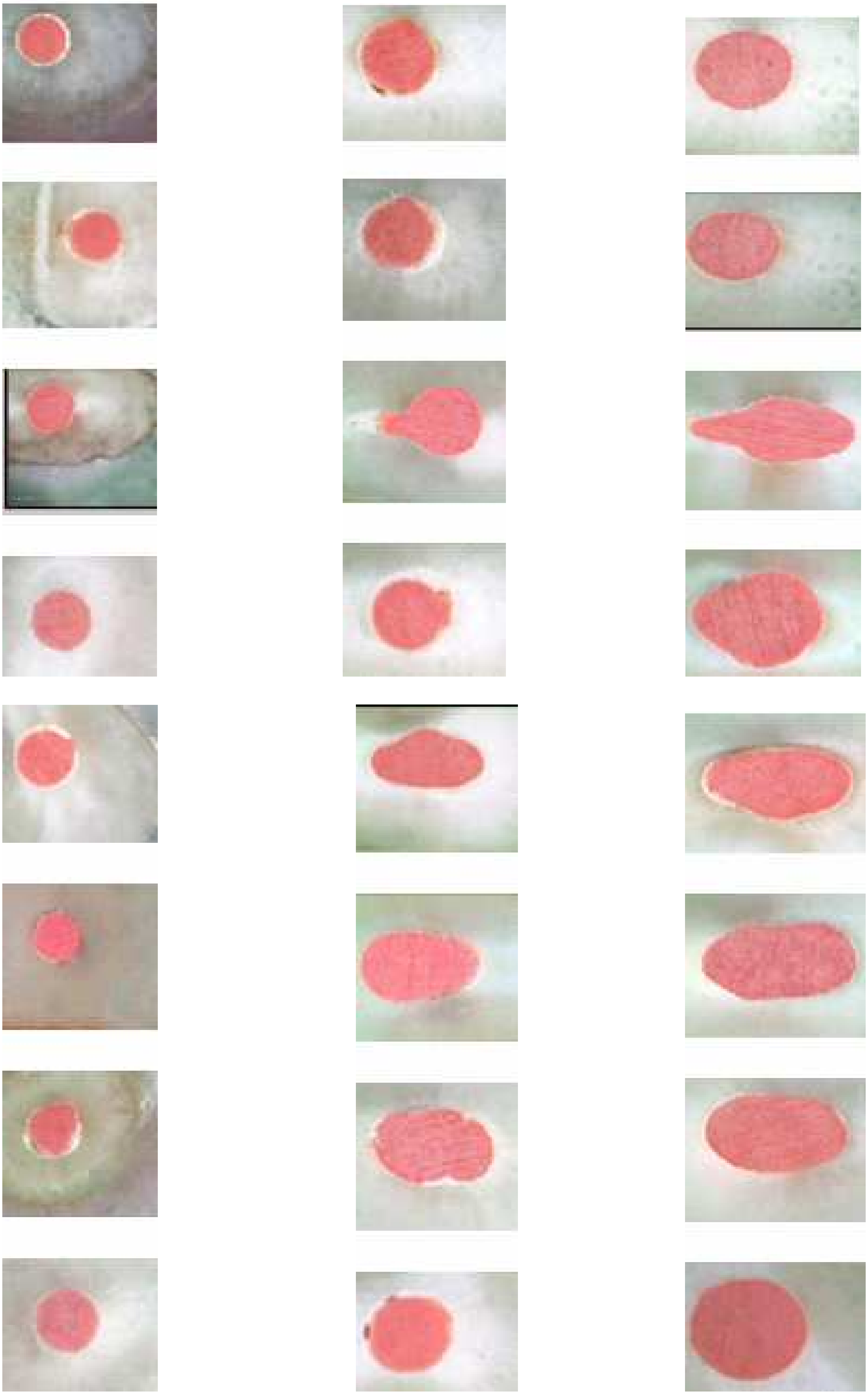
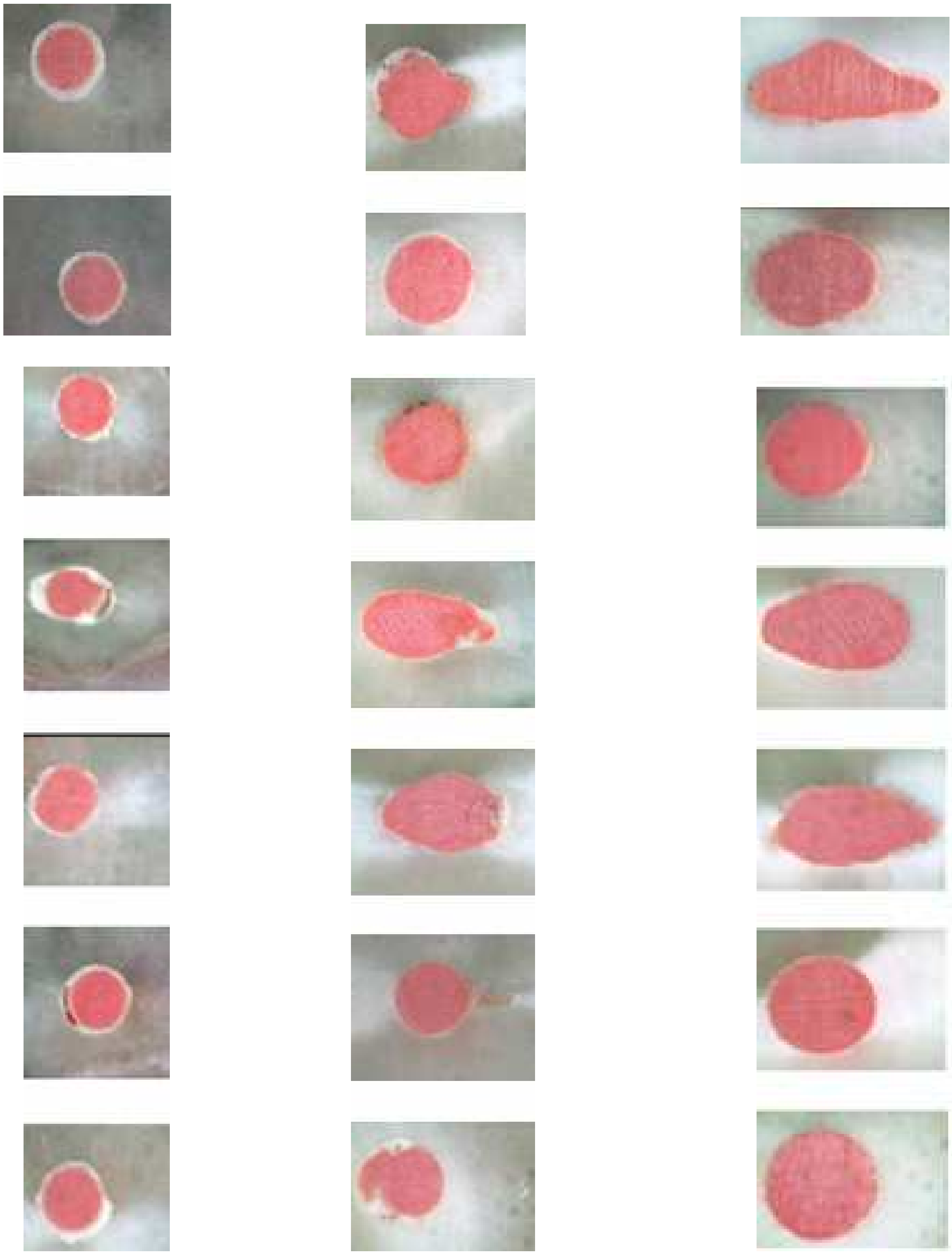


Figure 5.8 Continued ….
Specimen number 9 to 15

L1 L3 L6



5.7. Reliability test

Data on the reliability test in this study is available in Appendix II, Table P (Page 194). Appendix II, Table Q (Page 195) shows the mean for selected specimens. Appendix II, Table R (Page 195) shows the correlation between two measurements. Appendix II, Table S (Page 195) does not show any significant difference between the first and second measurements. The reliability test shows that there was correlation between the first and second measurements. Variations in the canal area occupied by filling core materials (RealSeal™ and gutta-percha), sealers and voids were negligible. Therefore, reproducibility of the evaluation method was acceptable.

5.8. Scanning electron microscopy

One specimen from each group was randomly selected and examined under a field-emission gun scanning electron microscope (FESEM). In the experimental groups, the results revealed excellent coupling of RealSeal™ core material to RealSeal™ sealer and showed good adaptation for RealSeal™ filling material. Also, no gap was observed along the filling-root dentine interface at different magnifications (200×, 600×, 1000× and 4000×) (Figures 5.9, 5.10, 5.11 and 5.12). However, fissures and gaps were observed at the filling-root dentine interface in the gutta-percha specimens. The widest gap observed for lateral compaction of gutta-percha (LC/GP) was about 4 µm wide at high magnification (4000×). However, for warm vertical compaction of gutta-percha (WC/GP) it was about 3 µm wide at the same magnification. Resin tags were visible at the filling-root dentine interface in the experimental groups. However, in the control groups, such tags were not observed. Generally, RealSeal™ filling material provided a more consistent adaptation compared with gutta-percha at the examined regions (1 mm-6 mm from the apex) of the filling-dentine interface. Gutta-percha and AH-Plus™, on the other hand, failed to produce a complete adaptation and there was evidence of a space at the tooth-filling interface.

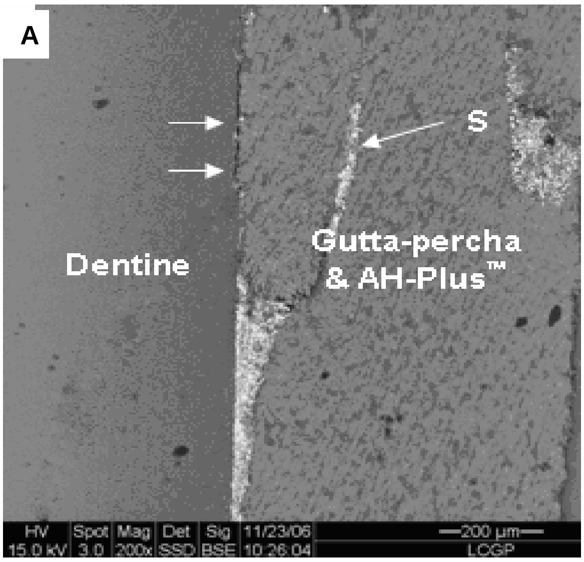


Fig 5.9(A) Low power SEM (200×) micrograph of a longitudinal section of a root filled with GP using LC, taken at a level between 1 and 6 mm from the apex. The gap (arrow) is evident at the sealer-dentine interface. The sealer (S) is evident between filling cores.

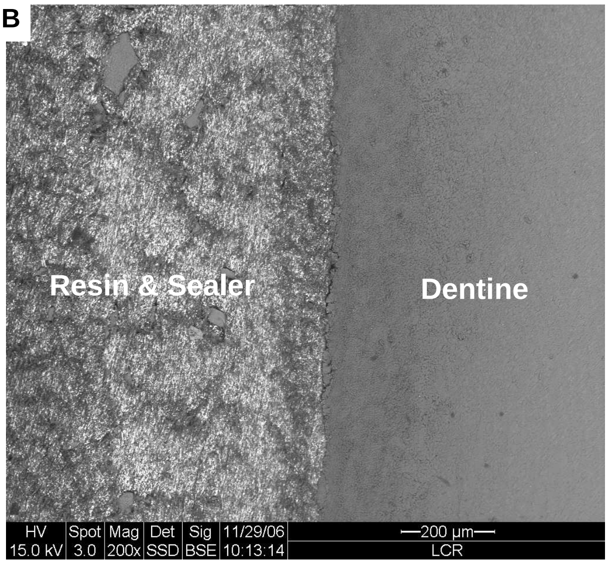


Fig 5.9(B) Low power (200×) micrograph of a longitudinal section of a root filled with resin utilizing LC, taken at a level between 1 and 6 mm from the apex. No gap is evident between the resin filling material and dentine.

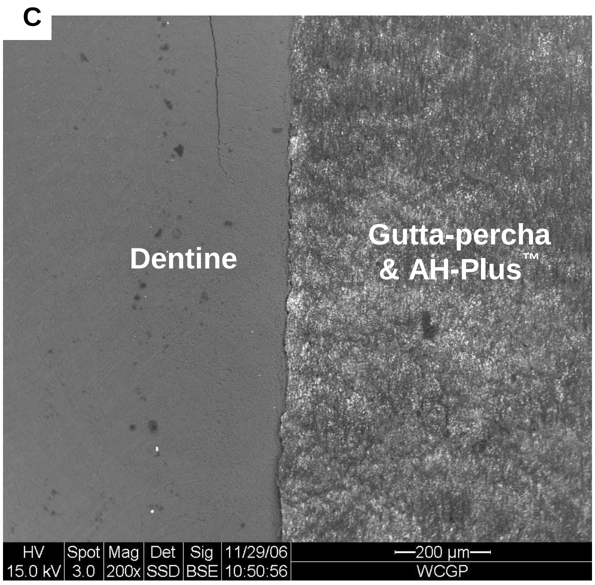


Fig 5.9(C) Low power SEM (200×) micrograph of a longitudinal section of a root filled with GP using WC, taken at a level between 1 and 6 mm from the apex.

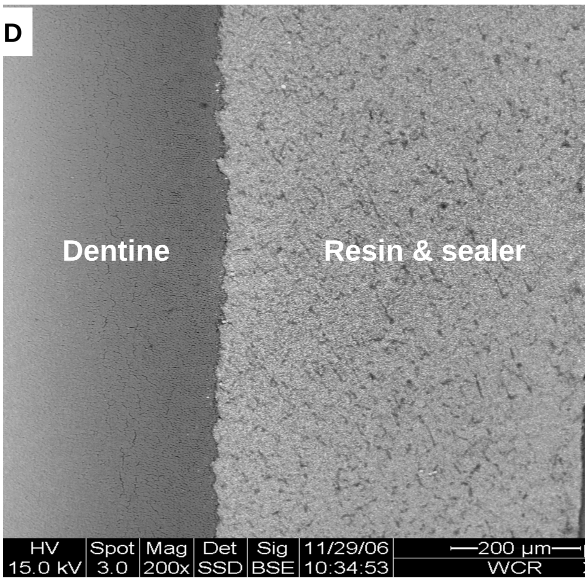


Fig 5.9(D) Low power (200×) micrograph of a longitudinal section of a root filled with resin utilizing WC, taken at a level between 1 and 6 mm from the apex. No gap is evident between the resin filling system and dentine.

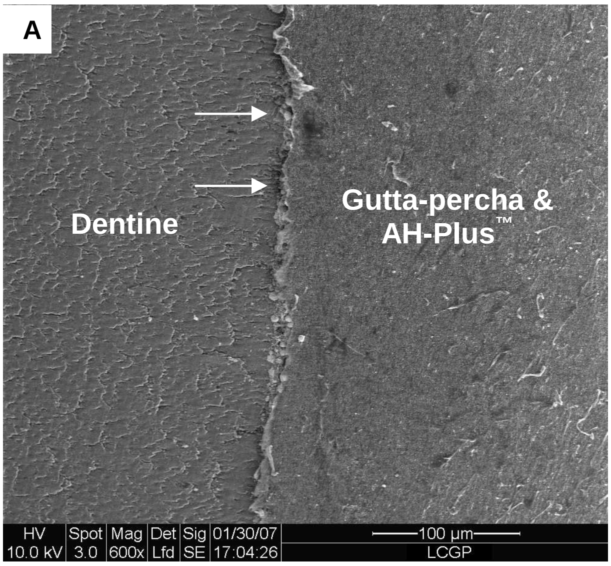


Fig 5.10(A) Medium power SEM (600×) micrograph of a longitudinal section of a root filled with GP using LC, taken at a level approximately 4 mm from the apex. The gap (arrow) is evident at the sealer-dentine interface.

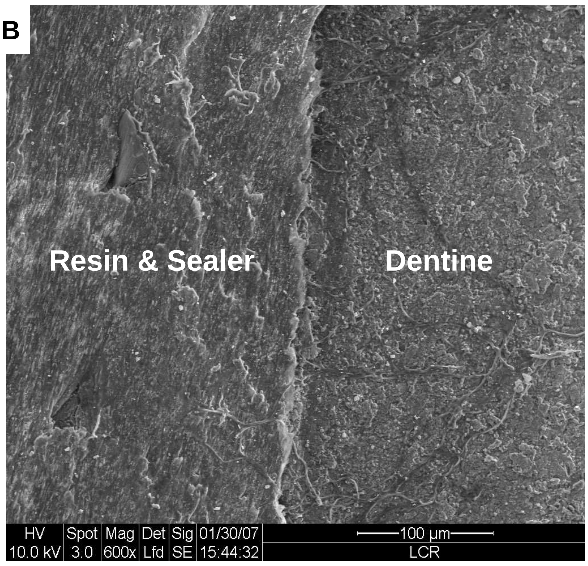


Fig 5.10(B) Medium power (600×) micrograph of a longitudinal section of a root filled with resin using LC, taken at a level approximately 4 mm from the apex. No gap is evident between the resin filling and resin tags are shown between the filling and dentine.

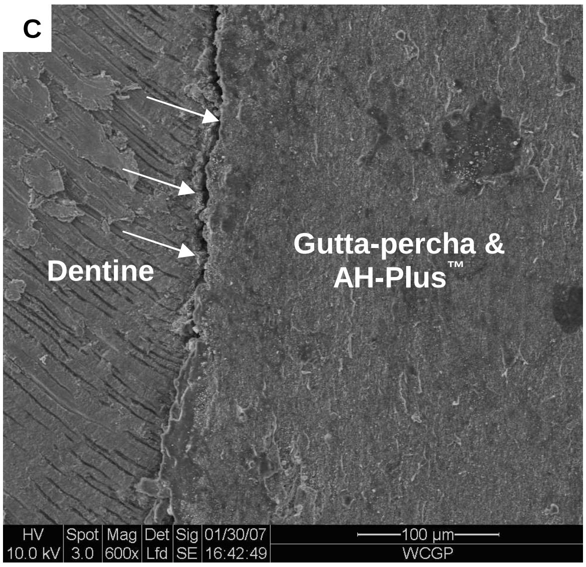


Fig 5.10(C) Medium power SEM (600×) micrograph of a longitudinal section of a root filled with GP using WC, taken at a level approximately 4 mm from the apex. A uniform gap (arrow) is shown at the sealer-dentine interface.

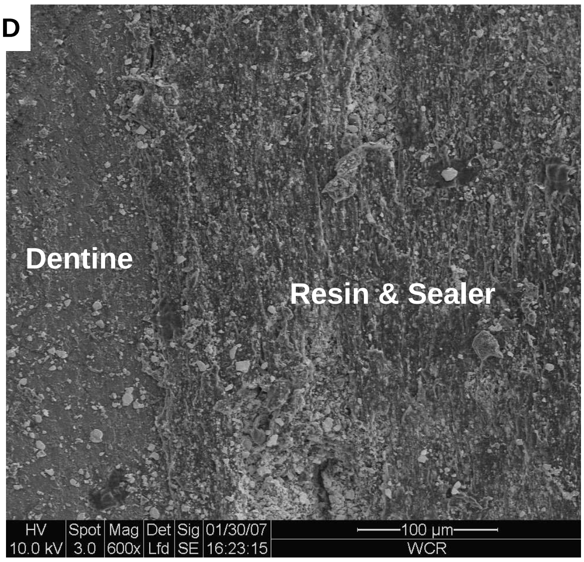


Fig 5.10(D) Medium power (600×) micrograph of a longitudinal section of a root filled with resin using WC, taken at a level approximately 4 mm from the apex. No gap is evident between the resin filling and dentin. The resin core is closely adapted to sealer.

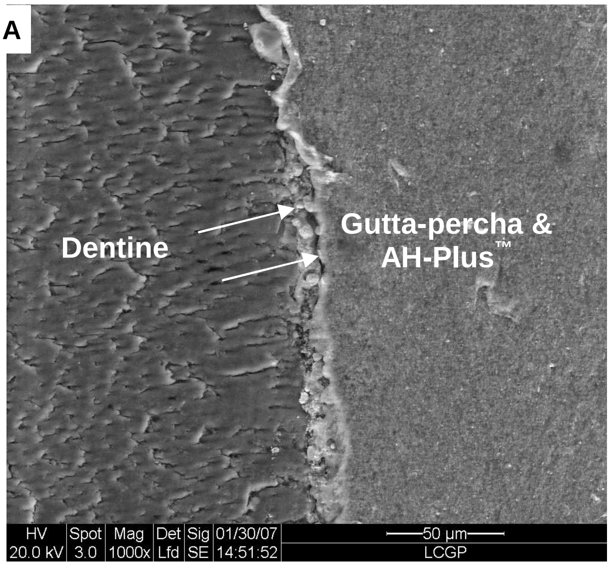


Fig 5.11(A) High power SEM (1000×) micrograph of a longitudinal section of a root filled with GP using LC. The gap (arrow) is evident at the sealer-dentine interface.

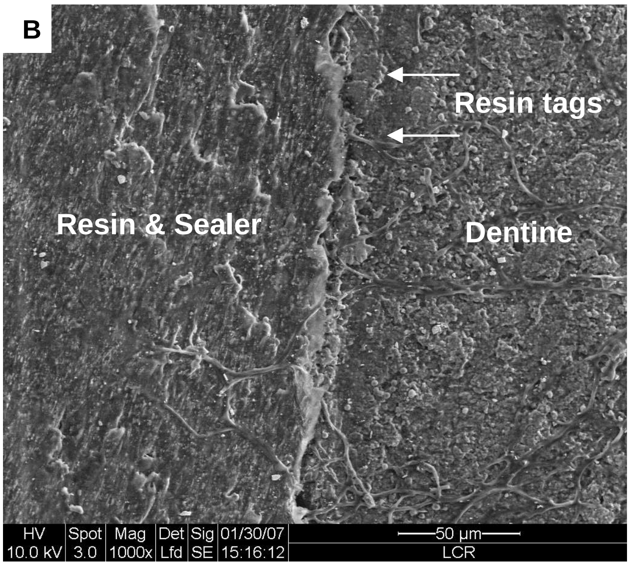


Fig 5.11(B) High power (1000×) micrograph of a longitudinal section of a root filled with resin using LC. No gap is evident between the resin system and dentine. Also resin tags (arrow) are observed between dentine and the filling system.

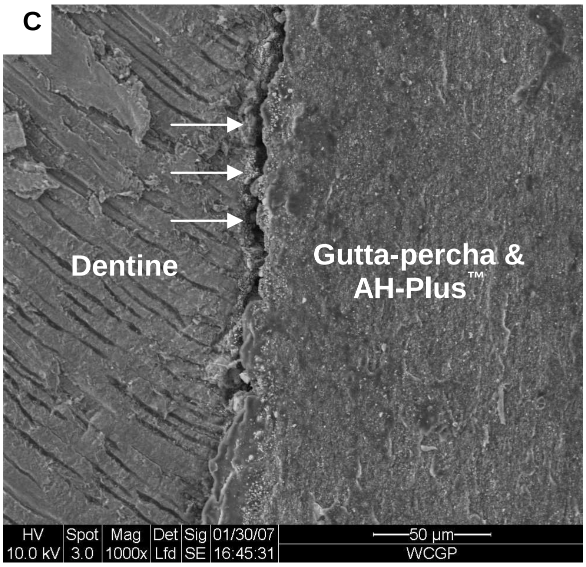


Fig 5.11(C) High power SEM (1000×) micrograph of a longitudinal section of a root filled with GP using WC. A gap (arrow) is evident at the sealer-dentine interface.

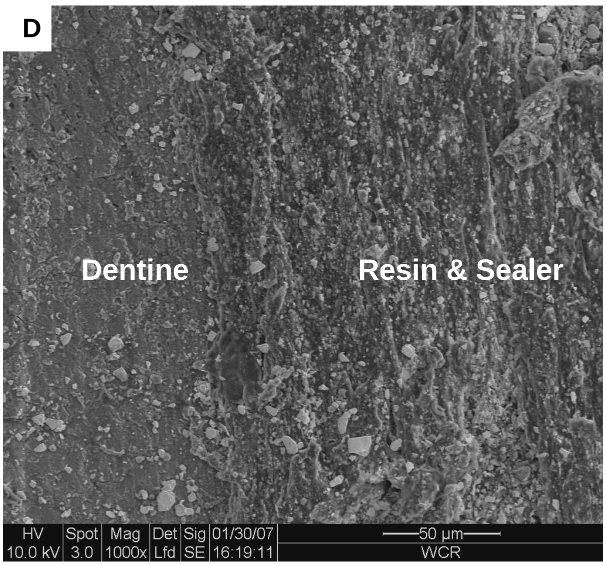


Fig 5.11(D) High power (1000×) micrograph of a longitudinal section of a root filled with resin using WC. No gap is evident between the resin system and dentine. The resin core is closely adapted to sealer.

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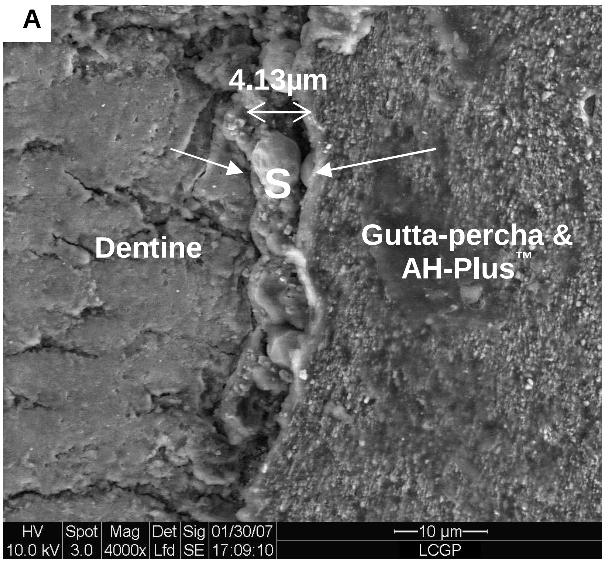

Fig 5.12(A) High power SEM (4000×) micrograph of a longitudinal section of a root filled with GP using LC. The gap is approximately 4.13 µm in width between GP and dentine. Also separation of the sealer from dentine and from the filling core is shown (arrow).

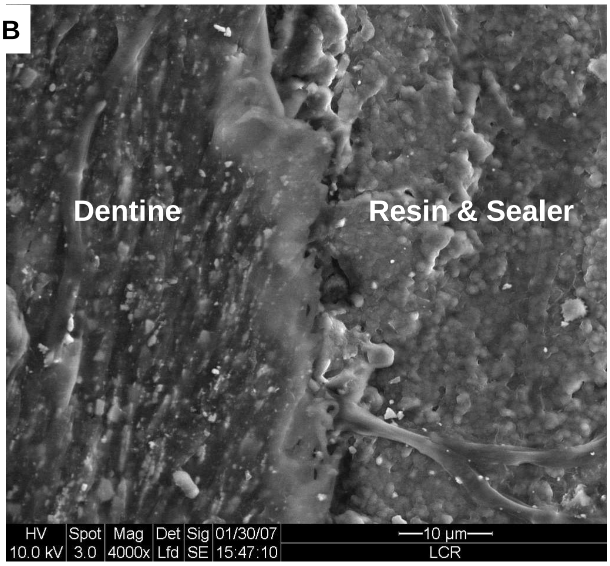

Fig 5.12(B) High power (4000×) micrograph of a longitudinal section of a root filled with resin using LC. The resin filling is closely adapted to the sealer and resin tags have penetrated into the dentine from the resin system.

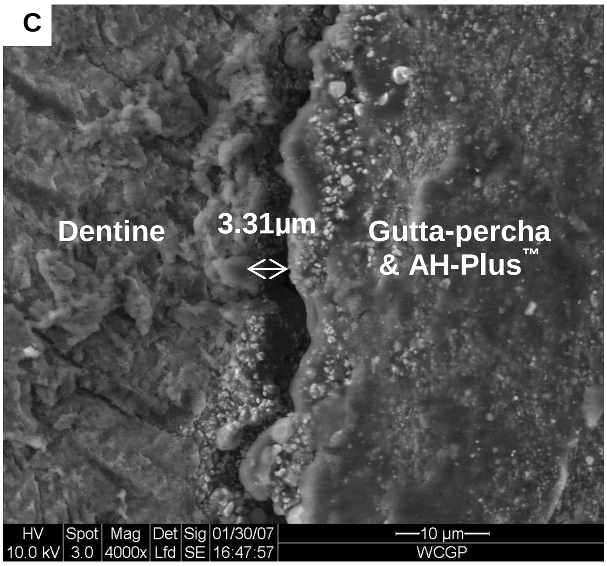

Fig 5.12(C) High power SEM (4000×) micrograph of a longitudinal section of a root filled with GP using WC. The gap is approximately 3.31 µm in width between GP and dentine.

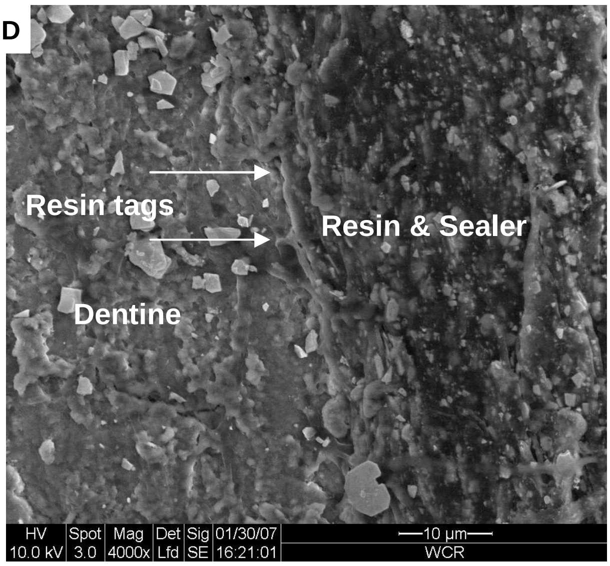

Fig 5.12(D) High power (4000×) micrograph of a longitudinal section of a root filled with resin using WC. A monoblock is formed between the resin and sealer. Also resin tags (arrow) are observed between the resin system and dentine.