Microleakage under Class II restorations restored with various bulk-fill materials

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Purpose:

The aim of the present study was to evaluate microleakage around a bulk-filled Class II restoration following thermocycling.

Experimental design:

This study compared 5 materials: a dual-cured bulk fill composite (Bulk EZ, Danville), a light-cured bulk fill composite (Filtek Bulk Fill Posterior, 3M ESPE), a chemically cured bulk fill composite (Fill-Up!, Coltene), a dual-cured enhanced RMGI (Activa, Pulpdent), and conventionally placed light-cured composite (Filtek Supreme Ultra, 3M ESPE). One universal adhesive was used for all groups.

Material	Manufacturer	Classification
Bulk EZ 	Danville	Dual-cured bulk fill composite
Filtek Bulk Fill Posterior 	3M ESPE	Light-cured bulk fill composite
Fill-Up! 	Coltene	Chemically cured bulk fill composite
Activa BioACTIVE 	PulpDent	Dual-cured enhanced RMGI
Filtek Supreme Ultra 	3M ESPE	Conventional light cured composite
Scotchbond Universal 	3M ESPE	Universal adhesive (pH = 2.7)

Materials and Methods:

Specimen Preparation

Freshly extracted human molars (n=48) were used for this protocol following IRB approval. All teeth were evaluated using 20X magnification and teeth with cracks and caries were excluded from the study. Standardized outlines of Class II slot preparations were drawn on the tooth with a permanent marker by measuring (±0.5mm) a 5mm height, 4mm width and 2 mm depth. Preparations were prepared using a carbide bur under water cooling.

All restorations then received a layer of Scotchbond Universal (3M ESPE) adhesive used in the self-etch mode (for the specimens in the Fill-Up! group, a dual-cure activator will be mixed with the Scotchbond Universal for 5 seconds prior to proceeding). The adhesive layer was applied with 20 seconds of agitation. Then the solvent was evaporated with 5 seconds of gentle air. A circumferential metal matrix was placed around the tooth and secured with a Toffelmeier matrix. The adhesive was then light cured with an LED curing light (Elipar S10, 3M ESPE, output > 1000mW/cm^2) for 10 seconds from the occlusal direction only. The light tip was held above the center of the restoration at a distance 1-2 mm from the occlusal surface of the tooth.

The specimens were restored with each of the 4 bulk fill materials (shade A2) in a single 5mm increment according to manufacturer's instructions:

Bulk EZ:

- Immediately place the mixing tip at the deepest part of the preparation and fill entire preparation and sculpt to desired contour as the material self cures.
- Allow the material to self-cure for at least 60 seconds till it solidifies.
- Cure the top layer with a dental curing light for 10 seconds.

Filtek Bulk Fill Posterior:

- Place the carpule tip at the deepest part of the preparation and fill entire preparation and sculpt to desired
- Cure the top layer with a dental curing light for 20 seconds.

Fill-Up!:

- Place the syringe tip at the deepest part of the preparation and fill entire preparation (1 minute max working time) and sculpt to desired

- Cure the top layer with a dental curing light (1600 mW/cm^2) for 5 seconds

Activa:

- Dispense 1-2mm of material onto a mixing pad and discard this material.
- Place the syringe tip at the deepest part of the preparation and fill entire preparation (1 minute max working time) and sculpt to desired
- Cure the top layer with a dental curing light for 20 seconds

The positive control was restored with the conventional composite (shade A2) in two 2mm and one 1mm increments according to manufacturer's instructions:

Filtek Supreme Ultra:

- Place the carpule tip at the deepest part of the preparation and fill a 2mm increment
- Cure the first increment with a dental curing light (+1000 mW/cm^2) for 10 seconds.
- Repeat
- Place final increment and sculpt to desired shape and light cure for 10 seconds.

The negative control was restored with the conventional composite (shade A2) in one 5mm increment according to manufacturer's instructions:

Filtek Supreme Ultra:

- Place the carpule tip at the deepest part of the preparation and fill a 5mm increment
- Cure with a dental curing light (+1000 mW/cm^2) for 10 seconds.

Note: the same curing light was used for all materials (Elipar S10, 3M ESPE, output > 1000mW/cm^2)

All specimens were finished using a red-stripe carbide finishing bur. Restoration margins were evaluated under a magnification after finishing to ensure the absence of "flash" over the margin. Teeth were sealed with two coats of acid-resistant varnish leaving a window including the restoration and 2mm of tooth structure uncoated surrounding the restoration. Restored teeth were stored in incubator in distilled water at 37ºC for 48 hours.

Fig 1. Example of Class II slot preparation

Evaluation of Microleakage

The specimens underwent 10,000 cycles of alternating 5°C and 55°C water baths with 15-second dwell times (Fig 2). After thermocycling, samples were immersed in 0.5wt% solution of Fuchsine solution for 24hours and then sectioned mesial-distally to provide 2 halves (Fig 3). Sections were investigated using a digital microscope at 25X magnification and dye penetration was quantitatively evaluated by measuring the distance of the dye penetration from the external surface. Penetration was measured from the external surface to the point where no dye can be seen at both the apical and occlusal margins (Fig 4) and reported in microns (Keyence VHX 600 Series) (Fig 5). Measurements will be taken with digital analysis software (Keyence).

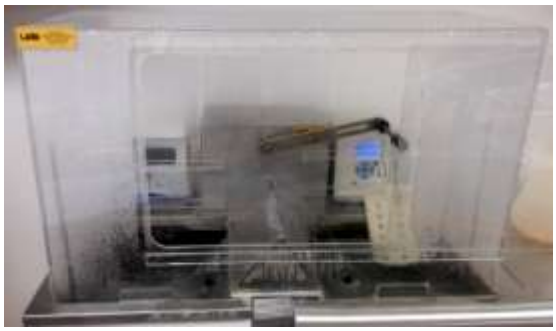


Fig 2. Thermocycling device

Fig 3. Sectioning device

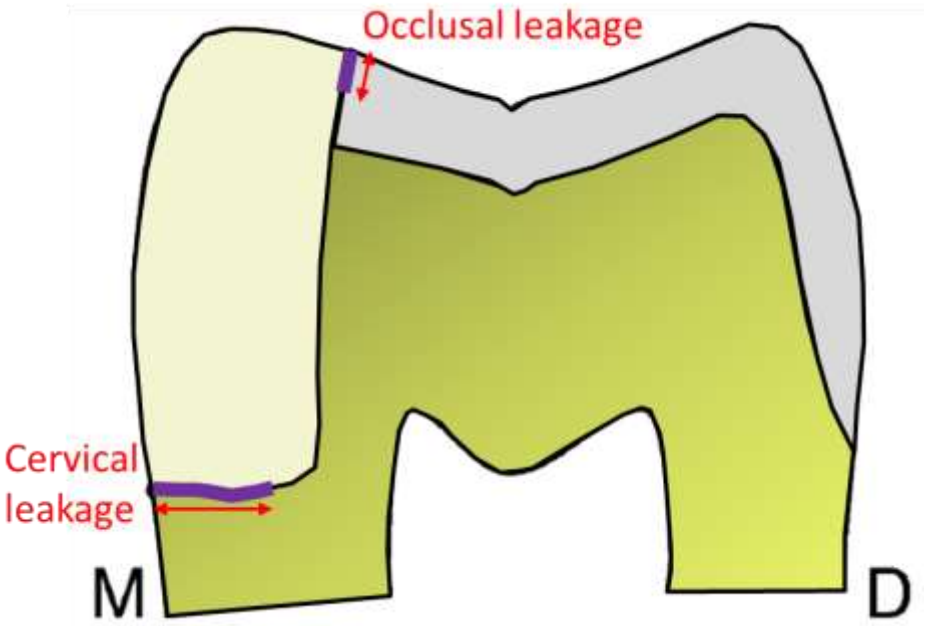


Fig 4. Diagram showing microleakage measurement areas

Fig 5. Keyence digital microscope VHX 600 Series

Results

Filtek Supreme Ultra Increments (Positive control)

	Occlusal			Cervical		
	Original	**M.L**	**% M.L**	**Original**	**M.L**	**%M.L**
1	4.92	0	0.00%	1.71	0	0.00%
2	4.39	0	0.00%	1.69	1.19	70.41%
3	4.61	0	0.00%	1.7	0	0.00%
4	4.24	0	0.00%	1.65	0	0.00%
5	4.79	0	0.00%	1.66	1.66	100.00%
6	4.59	0	0.00%	1.54	1.54	100.00%
7	4.8	0	0.00%	1.8	0	0.00%
8	4.33	0	0.00%	1.81	0	0.00%
MEAN			0.00%			33.80%
STD DEV			0.00%			38.03%

Filtek Supreme Ultra in bulk (Negative control)

	Occlusal			Cervical		
	Original	**M.L**	**% M.L**	**Original**	**M.L**	**%M.L**
1	4.64	0	0.00%	1.67	0.85	50.90%
2	4.5	1.4	31.11%	2	2	100.00%
3	4.52	0	0.00%	1.86	0.76	40.86%
4	5.22	1.85	35.44%	1.81	0.71	39.23%
5	4.26	4.26	100.00%	1.96	1.96	100.00%
6	4.21	0	0.00%	1.24	1.24	100.00%
7	4.48	0	0.00%	2.1	2.1	100.00%
8	4.51	0.91	20.18%	1.68	0.88	52.38%
MEAN			23.34%			72.92%
STD DEV			34.38%			29.28%

Bulk EZ

	Occlusal			Cervical		
	Original	**M.L**	**% M.L**	**Original**	**M.L**	**%M.L**
1	4.9	0	0.00%	1.64	0	0.00%
2	4.75	0	0.00%	1.73	0	0.00%
3	4.53	0	0.00%	1.57	0	0.00%
4	4.67	0	0.00%	1.77	0	0.00%
5	4.62	0	0.00%	1.6	0	0.00%

6	4.63	0	0.00%	1.78	0	0.00%
7	4.61	0	0.00%	1.82	0	0.00%
8	4.57	0	0.00%	1.87	0	0.00%
MEAN			0.00%			0.00%
STD DEV			0.00%			0.00%

Filtek Bulk Fill Posterior

	Occlusal			**Cervical**		
	Original	**M.L**	**% M.L**	**Original**	**M.L**	**%M.L**
1	5.8	0	0.00%	2.42	0	0.00%
2	6.25	0	0.00%	1.82	0	0.00%
3	5.53	0	0.00%	2.24	0.95	42.41%
4	5.25	0	0.00%	1.82	0	0.00%
5	5.95	0	0.00%	1.89	0	0.00%
6	5.61	0	0.00%	1.93	0	0.00%
7	5.21	0	0.00%	2.53	0	0.00%
8	5.48	0	0.00%	2.37	1.34	56.54%
MEAN			0.00%			12.37%
STD DEV			0.00%			23.21%

Activa

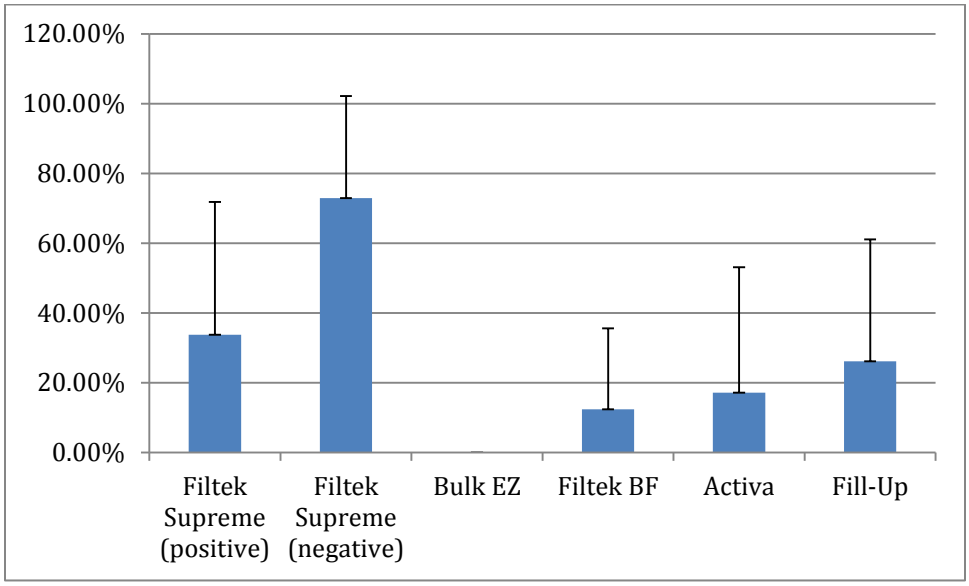
	Occlusal			**Cervical**		
	Original	**M.L**	**% M.L**	**Original**	**M.L**	**%M.L**
1	5.13	0	0.00%	1.8	0	0.00%
2	4.93	0	0.00%	1.72	0.64	37.21%
3	4.32	0	0.00%	1.56	1.56	100.00%
4	4.61	0	0.00%	1.34	0	0.00%
5	4.99	0	0.00%	1.93	0	0.00%
6	4.95	0	0.00%	1.5	0	0.00%
7	4.72	0	0.00%	1.59	0	0.00%
8	5.02	0	0.00%	1.51	0	0.00%
MEAN			0.00%			17.15%
STD DEV			0.00%			35.92%

Fill-Up!

	Occlusal			**Cervical**		
	Original	**M.L**	**% M.L**	**Original**	**M.L**	**%M.L**
1	4.64	0	0.00%	1.64	0	0.00%
2	4.38	0	0.00%	1.76	0	0.00%
3	5.02	0	0.00%	1.77	0	0.00%

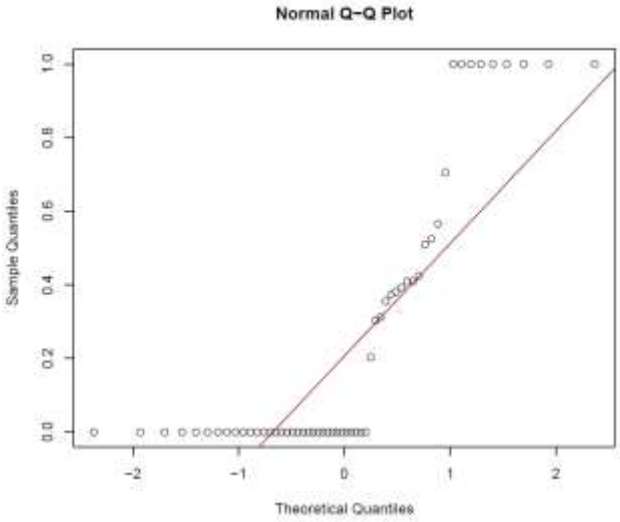
4	4.72	0	0.00%	1.68	0.64	38.10%
5	4.95	0	0.00%	1.73	1.73	100.00%
6	4.39	0	0.00%	1.86	0.76	40.86%
7	5.18	0	0.00%	2.21	0	0.00%
8	4.29	0	0.00%	1.82	0.55	30.22%
MEAN			0.00%			26.15%
STD DEV			0.00%			34.98%

Percentage of cervical margin with microleakage



Statistical Analysis

Data was analyzed for normality and it was determined that a non-parametric analysis would be necessary.



Percentage of marginal microleakage (stain penetration divided by the depth of the preparation) was compared between different materials using a Kruskal-Wallis test.

Wilcoxon Scores (Rank Sums) for Variable microleakage
Classified by Variable Group

Group	N	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
Filtek BF	8	191.00	228.0	37.992480	23.87500
Filtek (pos)	8	236.00	228.0	37.992480	29.50000
Activa	8	192.00	228.0	37.992480	24.00000
Bulk EZ	8	136.00	228.0	37.992480	17.00000
Fill-Up!	8	235.50	228.0	37.992480	29.43750
Filtek (neg)	8	378.50	228.0	37.992480	47.31250

Average scores were used for ties.

Kruskal-Wallis Test

Chi-Square	20.1309
DF	5
Pr > Chi-Square	0.0026

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  Kruskal-Wallis rank sum test

data: microleakage and group
Kruskal-Wallis chi-squared = 20.1309, df = 5, p-value = 0.0026
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A Dunn's test with Bonferroni correction was used for post-hoc comparisons.

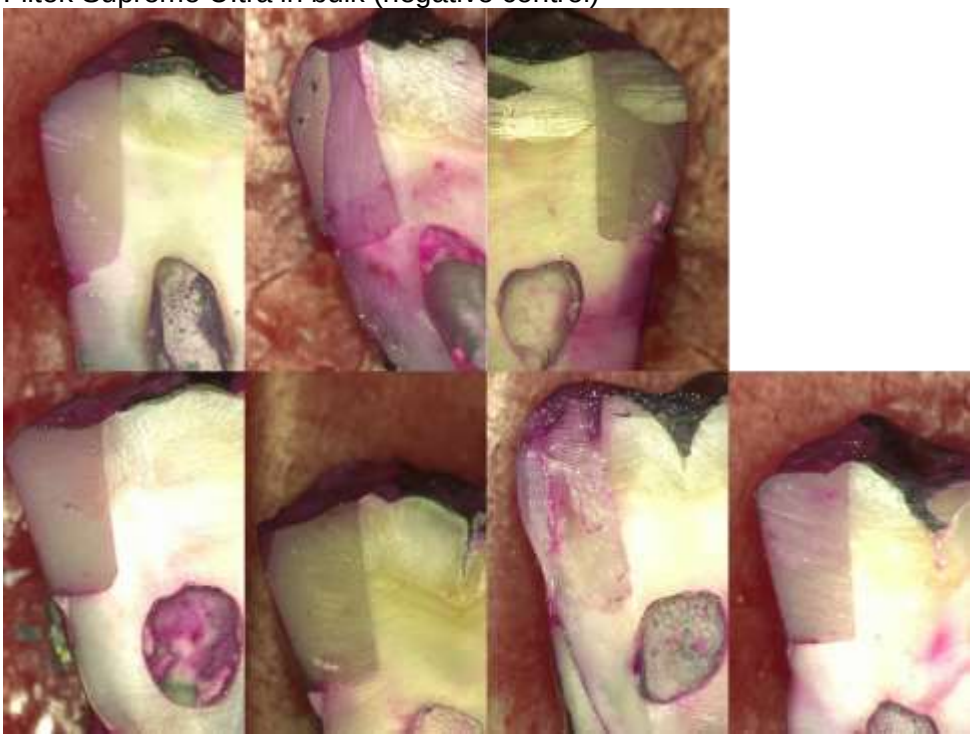
Comparison of microleakage by group
(Bonferroni)

Col Mean- / Row Mean	Filtek BF	Filtek (pos)	Activa	Bulk EZ	Fill-Up!
Filtek (pos)	-0.775401 1.0000				
Activa	-0.017231 1.0000	0.758170 1.0000			
Bulk EZ	0.947712 1.0000	1.723113 0.8911	0.964943 1.0000		
Fill-Up!	-0.766785 1.0000	0.008615 1.0000	-0.749554 1.0000	-1.714498 0.9076	
Filtek (neg)	-3.230838 0.0130	-2.455437 0.1477	-3.213607 0.0138	-4.178550 0.0003	-2.464052 0.1442

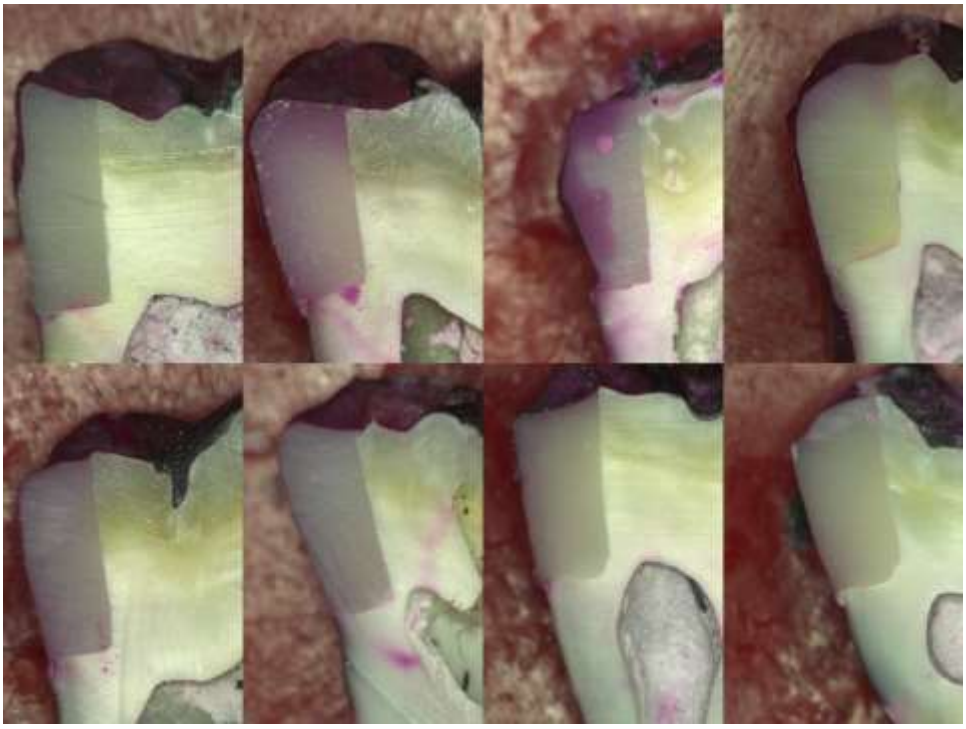
Images

Filtek Supreme Ultra Increments (positive control)

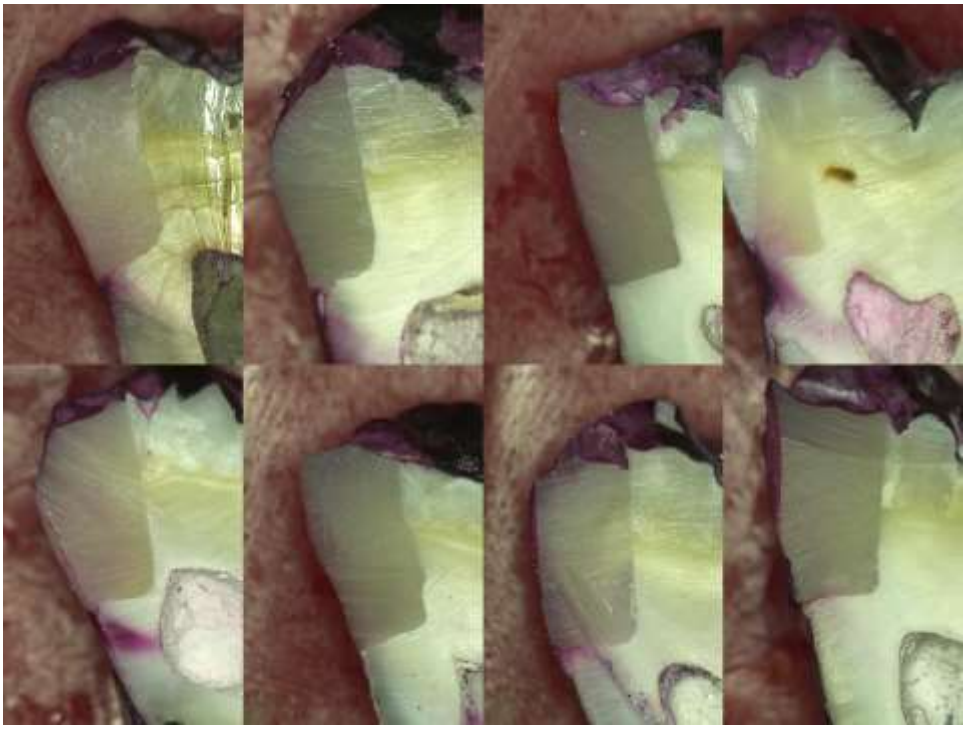
Filtek Supreme Ultra in bulk (negative control)



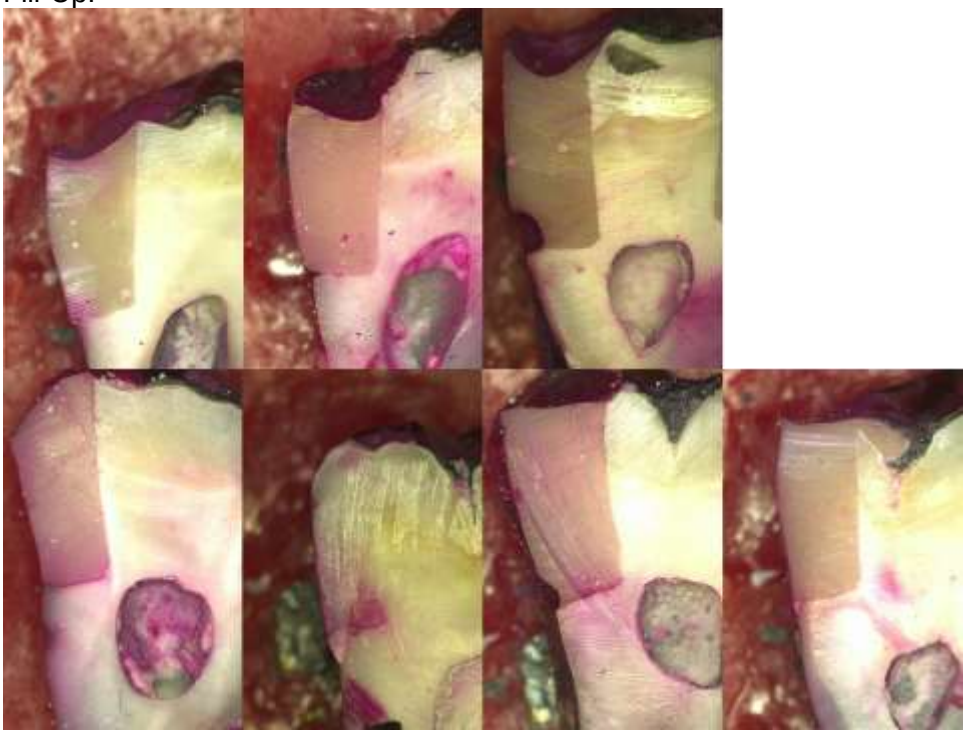
Bulk EZ



Filtek Bulk Fill Posterior



Fill-Up!



Activa

Conclusions

Some bulk-fill materials allow less microleakage than conventional composites when placed in bulk. Significantly less microleakage was produced with Bulk EZ ($p<.01$), Filtek Bulk-fill ($p=.01$), and Activa ($p=.01$) than Filtek Supreme Ultra placed in bulk.