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Evaluation of Micro Leakage of Two Direct Esthetic Restorations with Different Preparation Techniques

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Abstract

Objectives: In recent times, the term "minimal intervention dentistry" has coined to describe a new approach to the treatment of the disease of caries. This study was carried out to evaluate the marginal integrity of class V cavity in permanent posterior teeth prepared with different air abrasion parameters compared with classical rotary cavity preparation. **Methods:** A total number of 150 sound caries for free human posterior teeth were used in this study. Teeth were extracted for periodontal disease or orthodontic reasons and the average age of patients between 20 - 35 years. Teeth were divided according to the type of restoration into two main groups: Group I (n = 75) restored with low shrinkable posterior composite (P90) and Group II (n = 75) restored with Ketac nano ionomer (N100). Each main group was divided into five groups (n = 15), then each group was further subdivided into three subgroups (n = 5) according to the storage time (immediately, three months, and six months). All teeth would be tested at both occlusal and gingival margins of prepared class V cavity according to the method of cavity preparation. **Results:** A high significant difference was found in the mean ranks of micro-leakageat both occlusal enamel and gingival dentin walls among Groups 1 - 5 (p-value of <0.05). For main groups that restored with low shrinkable composite resin material (P90) and Ketac nano ionimer (N100), results revealed that scores of micro-leakage between (P90) or (N100) and both occlusal enamel or gingival dentin walls were significantly higher in group (AS1P1) than those in groups (B), (AS1P2), and (AS2P2) respectively. While no statistical significant difference was detected between groups (AS1P1) and (AS2P1). High scores of micro-leakage were detected at groups with six months, three months and im-

mediately storage time respectively. **Conclusion:** Low shrinkable silorane based composite yielded better results of micro-leakage scores along the occlusal enamel and gingival dentin walls when the cavity of class V was prepared with air abrasion technique with large size alumina particles under high pressure at immediate storage time as compared with Ketac N100.

Keywords

Air Abrasion, Low Shrink Composite, Nano Ionomer, Micro Leakage

1. Introduction

Minimal intervention dentistry means that it is possible to heal and re-mineralize the lesion providing it has not progressed to the stage of surface cavitation. It is not suggested that this approach is easier than traditional surgery, but it is far more conservative of tooth structure and offers far greater longevity for the dental structures [1] [2]. Alternative methods of cutting enamel and/or dentin have been assessed periodically. One of these methods is air abrasion system that is using a high speed stream of purified aluminum oxide particles propelled by air pressure. The air abrasive technique as a non-mechanical cavity preparation increases patient comfort by reducing pressure, heat, vibration, and noise occurred during the mechanical preparation of teeth with conventional rotating bur [3] [4]. Due to improvements in bonding, restorative materials, isolation, and high volume suction, the trend of air abrasion treatment has been a new concept of an alternative means of cavity preparation [5] [6] [7]. Some studies have shown that the bonding of enamel and dentin surfaces prepared with air abrasion was much better than that prepared with conventional carbide burs followed by acid etching, and others have shown the opposite [5] [6] [7] [8] [9]. With the introduction of nano-filled and low shrink types of esthetic restorative materials, it will be easier to restore cavities with more bond strength and less tooth structure loss and minimal specification of GV Black's concepts [9] [10] [11] [12] [13].

2. Materials and Methods

2.1. Study Design

A total number of 150 sound caries free human posterior teeth were used in this study. Teeth were collected from (teeth bank) of Alfarabi private collages for Dentistry & Nursing. Teeth were divided according to type of restoration into two main groups; Group I (n = 75) restored with low shrinkable posterior composite (P90) and Group II (n = 75) restored with Ketac nano ionomer (N100) [6]. Each main group was divided into five groups (n = 15) according to method of cavity preparation.

Group one (control) (G1: Bur): Using the conventional bur in preparation of class V cavity.

Group two (G2: AS1P1): Using the air abrasion in preparation of class V with

small size alumina particles (10 μm) and low pressure (15 psi).

Group three (G3: AS1P2): Using the air abrasion in preparation of class V with small size alumina particles (10 μm) and high pressure (40 psi).

Group four (G4: AS2P1): Using the air abrasion in preparation of class V with large size alumina particles (50 μm) and low pressure (15 psi).

Group five (G5: AS2P2): Using the air abrasion in preparation of class V with large size alumina particles (50 μm) and high pressure (40 psi).

Then each group was further subdivided into three subgroups (n = 5) according to storage time (immediately, three months, and six months). All teeth were tested at both occlusal and gingival margins of prepared class V cavity.

2.2. Teeth Selection

One hundred fifty sound caries free human posterior teeth were used in this study. Teeth were extracted for periodontal disease or orthodontic reasons and the average age of patient between 20 - 35 years. Teeth were free of decay, cracks and hypoplastic defect, and were hand-scaled to remove calculus and soft tissues.

3. Specimen Preparation

3.1. Conventional Cavity Preparation Using a Bur (Control Group)

A standardized class V cavity was prepared in the buccal and lingual surfaces of each tooth. The dimensions of the prepared cavity were 3 mm height (occluso-gingivally), 4 mm widths (mesiodistally), and 2 mm depth (axially). For standardization of cavity depth, a permanent mark was placed on the shaft of the bur at (2 mm) depth. After preparation, depth was checked by a graduated periodontal probe. For standardization of cavity width and height, these dimensions were cut in a matrix band* which then placed in the matrix holder** and firmly placed on each tooth prior to cavity preparation. The lower end of this window was adjusted to be 0.5 - 1 mm below the cemento-enamel junction of the tooth. By this way the cervical end of the cavity was 0.5 - 1 mm away from the cemento-enamel junction in apical direction.

3.2. Minimal Invasive Cavity Prep. Using Air Abrasion

The air abrasion unit was used according to the manufacturer's directions. Four groups of air abrasion (G2, G3, G4 and G5) with two different alumina particle sizes (10 and 50 μm) and two different pressures (15 and 40 psi.) were formed as the following:

(G2: AS1P1): small size alumina particles (10 μm) and low pressure (15 psi).

(G3: AS2P1): large size alumina particles (50 μm) and low pressure (15 psi).

(G4: AS1P2): small size alumina particles (10 μm) and high pressure (40 psi).

(G5: AS2P2): large size alumina particles (10 μm) and high pressure (40 psi).

Air abrasion was used to prepare the cavity in a micro-pulse mode at beam intensity of 2 gm/min for 15 seconds at distance of 5 mm between the nozzle and tooth surface. The diameter of tip orifice of the headpiece was measured 0.28 mm (0.011 inch) and the nozzle angulation at almost 90˚ to the tooth surface.

These factors were constant for all air abrasion groups.

4. Application of Restoration

4.1. Low Shrinkable Composite Resin (90) System

4.1.1. Self-Etch Primer

The P90 System Adhesive Self-Etch Primer rubbed to prepared cavity for 15 seconds with black micro brush, followed by gentle air dispersion and then light cured for 10 seconds with halogen device on "normal" curing mode (400 - 500 nm) according to the manufacturers' recommendations. The polymerizing light was calibrated and verified periodically to ensure constancy of light output power according to the manufacturer's instructions. Direction of light was in occlusal, proximal and buccal or lingual direction.

4.1.2. Adhesive Bond

The P90 System Adhesive Bond applied for 15 seconds with green micro brush, followed by gentle air dispersion and 10 seconds of light curing in the same way as previous self etch primer.

4.1.3. Application of Filtek P90 Composite

Placement of Filtek P90 Low Shrink Posterior restorative with shade A2 is done under full operatory light conditions using incremental technique. The composite resin was applied in three increments: the first against the gingival wall and the second against the occlusal wall. The final increment was placed flush with the contour of the tooth and covered with a transparent matrix strip (Ruwa Matrix Strips). Each increment was light cured for 40 s.

4.2. Ketac (N100) Light-Curing Nano-Ionomer Restorative

4.2.1. Priming

Ketac N100 Primer was applied to both enamel and dentinal surfaces of prepared cavity for 15 seconds with a micro brush and were kept wet with the primer for the full application time. Scrubbing the tooth surface with the primer was not necessary. The primed surface appeared shiny after drying and light curing. Using of Ketac N100 primer was mandatory as manufacturer instruction to achieving adhesion of Ketac N100 restorative to tooth structure.

4.2.2. Dispensing

Ketac N100 restorative was designed to be dispensed and mixed with equal volumes of each paste in a ratio of 1.3/1.0. Two clicks were dispensing from the clicker dispenser to provide an adequate amount of material for restorative filling applications. If the dispensed pastes appeared to be of uneven volume, the dose was discarded.

4.2.3. Mixing

According to manufacturer's instructions, both pastes mixed together for 20 seconds using a teflon spatula. Paste might appear homo-genous in less than 20 seconds.

4.2.4. Placement

- Teflon carver used for shaping and contouring Ketac N100 was wetted in the primer to prevent the glass ionomer from adhering to it.
- After placement, Ketac N100 restorative shortly became relatively firm which was aided in shaping and contouring. However, the working time did not exceed the 3 minute otherwise might resulted in diminished esthetics as mentioned by manufacturer.
- Like most resin modified glass ionomers, Ketac N100 restorative was not placed in bulk, layering of 2 mm increment was done.

4.2.5. Curing

Ketac N100 restorative was placed in 2 mm increments or less, and light cured after each increment. Light cure for each increment was done for 40 seconds. Direction of light was in occlusal, proximal and buccal or lingual direction. Distance between the light curing nozzle and the restorative material approximately zero.

5. Storage of Specimens

Teeth were stored in distilled water at 37˚C and humidity 100% in an incubator* for different storage time (immediate, three months, and six months) until time of examination. The distilled water was changed daily.

6. Sealing of Teeth

The apices of the teeth were dried with air and conditioned with dentin conditioner. Then they were filled with light cured glass ionomer cement**, in order to prevent dye penetration throughout the apical foramen. The teeth were coated with two layers of an acid-resistant protective nail varnish except for an area approximately 1 mm around the margin of the restorations.

7. Dye Immersion

After sealing of the restored teeth, they were immersed in an aqueous solution of 2% methylene blue dye solution for 24 hours at room temperature. After removal from the dye, the specimens were gently washed by tape water, and care was taken not to exert any pressure by running tap water on the window area of the stained specimen. Washing under running water was done to remove excess dye before teeth sectioning and dryness with oil free compressor air.

8. Sectioning of the Teeth

The teeth were sectioned longitudinally in buccolingually direction through the middle of the restoration using a diamond disc (Isomet saw) at low speed under cooling system

9. Sterio-Microscopic Examination

Both tooth halves were examined under stereomicroscope at ×25 magnification

and photographs of specimens were taken by a digital camera connected to the stereo-microscope. For each tooth halve the extent of micro-leakage at the occlusal and the gingival margins were evaluated. The micro-leakage was assessed by scoring the degree of dye penetration in the tooth restoration interface according to the following criteria:

Score 0 = No dye penetration.

Score 1 = Dye penetration along enamel (or cementum) wall only.

Score 2 = Dye penetration along enamel and dentin wall but not reach the axial wall.

Score 3 = Dye penetration reaching the axial wall.

10. Data Collection and Analysis

The data of marginal adaptation were analyzed using SPSS pc+ version 16.0 statistical software. Two-way analysis of variance was used to compare the mean values of marginal gaps for both occlusal enamel and gingival dentin margins across groups 1 - 5. Student's t-test for two independent samples was used to compare the mean values of marginal gaps for each group. A non-parametric Kruskal-Wallis test and post Hoc paired comparison were done to compare the mean rank of microleakage across groups 1 - 5. When comparing micro-leakage of occlusal enamel to that of gingival dentin walls for each group, Fisher's exact test was used. The test was used to compare the distribution of qualitative variables across the two micro-leakage scores of 0 and 1 (no and slight micro-leakage) and 2 & 3 (moderate to severe micro-leakage). Spearman rank correlation was used to quantify the correlation between marginal adaptation and micro-leakage values of occlusal enamel and gingival dentin margins. A p-value of <0.05 was considered as statistically significant.

10.1. Results

A high significant difference was found in the mean ranks of micro-leakage at both occlusal enamel and gingival dentin walls among Groups 1 - 5 (p-value of <0.05). For main groups that restored with low shrinkable composite resin material (P90) and Ketac nano ionimer (N100), Results revealed that scores of micro-leakage between (P90) or (N100) and both occlusal enamel or gingival dentin walls were significantly higher in group (AS1P1) than those in groups (B), (AS1P2), and (AS2P2) respectively. While no statistical significant difference was detected between groups (AS1P1) and (AS2P1). High scores of micro-leakage were detected at groups with six months, three months and immediately storage time respectively.

As seen in Figures 1-5 by Sterio-microscopic examination and revealed in Table 1 and clarify in bar charts in Figure 6 & Figure 7.

10.2. Discussion

The longer the storage time, the poor the marginal adaptation and the high score micro-leakage was observed in the results of present study. This was in agreement

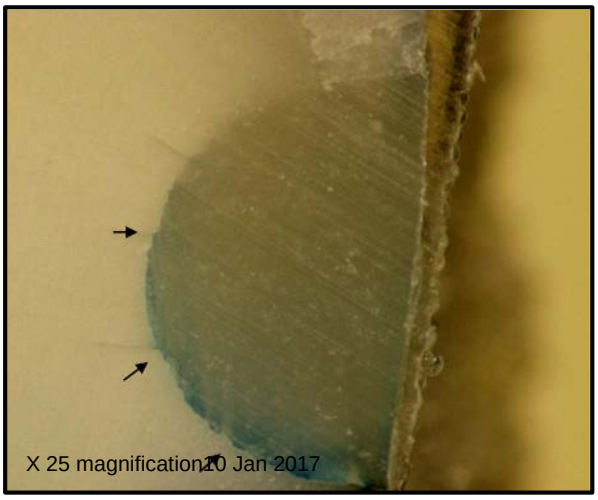

Figure 1. Micro-leakage at occlusal enamel wall (score 0) and gingival dentin wall (score 3) in group BUR restored with P90 at three months storage time.

Figure 2. Micro-leakage at occlusal enamel wall (score 2) and gingival dentin wall (score 1) in group AS2P2 restored with P90 at six months storage time.

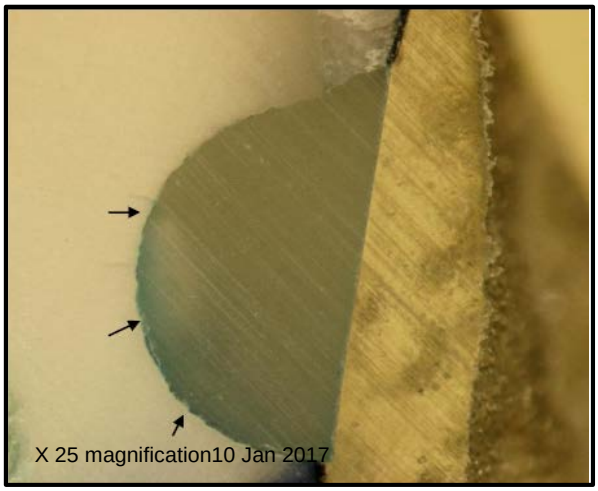

Figure 3. Micro-leakage at occlusal enamel wall (score 0) and gingival dentin wall (score 3) in group AS1P1 restored with N100 at immediate storage time.

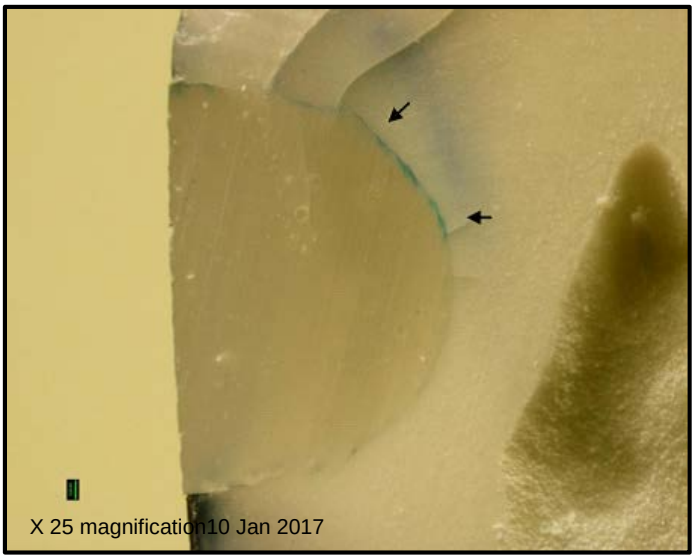

Figure 4. Micro-leakage at occlusal enamel wall (score 3) and gingival dentin wall (score 1) in group AS1P2 restored with N100 at three months storage time.

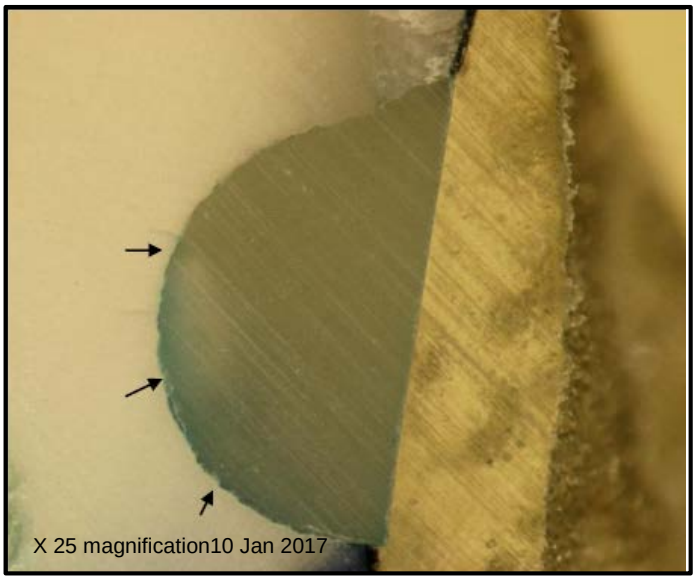

Figure 5. Micro-leakage at occlusal enamel wall (score 0) and gingival dentin wall (score 3) in group AS1P1 restored with N100 at immediate storage time.

Table 1. Micro-leakage scores of the tested composite material (P90) in both occlusal enamel & gingival dentin at different storage times (immediately, three months, and six months).

P90 at all storage times In both occlusal enamel & gingival dentin walls																				
	AS1P1				AS2P1				BUR				AS1P2				AS2P2			
Score St. time	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Occlusal enamel	-	6	7	2	3	6	5	1	6	3	3	3	7	4	4	-	11	3	1	-
Gingival dentin	-	6	6	3	1	7	5	2	2	7	3	3	3	6	5	1	8	5	2	-

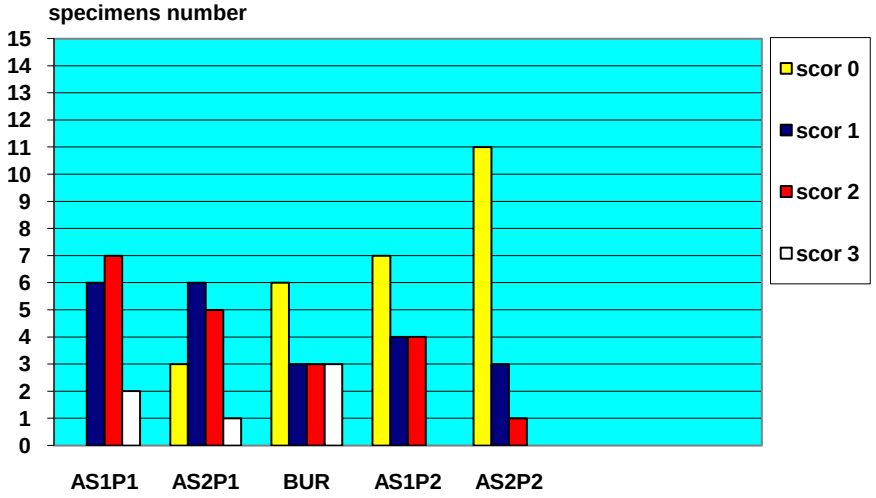

Figure 6. Showing comparison between micro-leakage scores of the tested material (P90), after different cavity treatments at different storage times at occlusal enamel walls (p-value of <0.05).

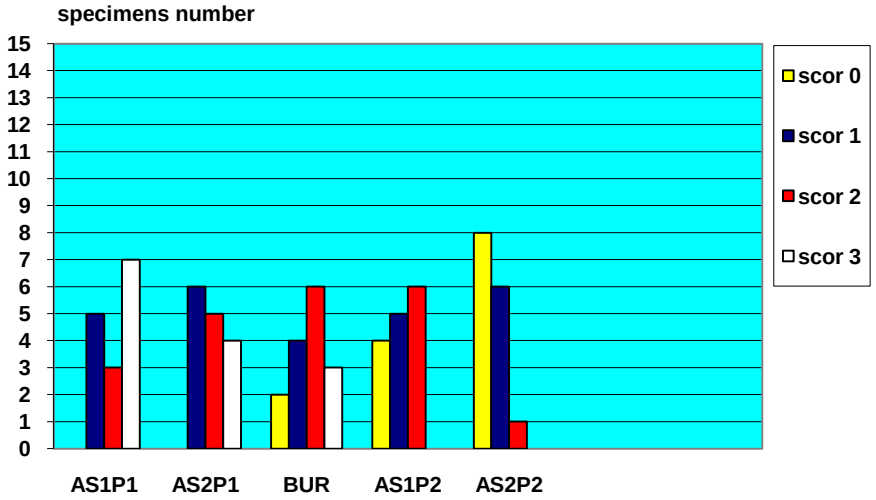

Figure 7. Showing comparison between micro-leakage scores of the tested material (N100), after different methods of cavity preparation in different storage times at occlusal enamel walls (p-value of <0.05).

of the study of Giacobbi and Vandewalle 2012, that found that 24 hours micro-tensile bond strengths were significantly greater than the 6 and 12 months bond strengths [14].

In the present study, The superior marginal integrity of high pressure air abrasion over bur my explained by the results of the study of Boyde 1984, using SEM that revealed that the smear layer formed was removed and enamel showed a mild surface etching [15]. Also, dentin was subjected to rapid erosion by air abrasion and the smear layer was removed. He suggested that these effects would improve the retention of plastic restorative materials e.g. (resin composite) even in minimal cavity preparations, to both enamel and dentin. This is agreed with the results of Obster *et al.* 1999 that showed that the air-abraded group treated with high pressure stream produced significantly higher bond strength than

group treated with low pressure stream and then acid etched group prepared with conventional bur [16].

In the present study, using of self etch primer in both restorative material after air abrasion was more effective. This was in agreement of study of Scott *et al.* 1989; they found that air-abrasion treatment followed by enamel etching gave the highest mean shear bond strength values [17]. And also in agreement of Berry and Ward 1995, Results of their study showed that bond strength of composite to air-abraded enamel followed by enamel etching were significantly higher than to air-abraded enamel only [18]. In relation to dentinal surface, the results of the study of Katamish 1996 showed that the highest bond strength values were obtained when dentin was treated with both an air-abrasive unit followed by dentin conditioning [19].

On the other hand, Laurell *et al.* 1993 found that there was no significant difference in the shear bond strength of resin composite to enamel when treated using acid etching or air abraded using KCP 2000 [20]. But air abrasion treatment of dentin significantly increased the shear bond strength of resin composite whether the primer was used or not.

These different in results may be due to different in the chemistry of etching materials (either etch & rinse or self etch primer) or due to different in air abrasion parameters e.g. size of alumina particles or degree of pressure stream or nozzle distance.

Results of the present study revealed that alumina particle size had no significant effect on marginal integrity especially with low pressure air abrasion technique that showed the lowest values. This is augmented by the results of Keen *et al.* 1994 that revealed that alumina particles size had no significant effect on shear bond strength of composite, while high pressure improved the bond strength [21]. But these results were in disagreement with the results of Roeder *et al.* 1995 that revealed that the size of alumina particles had significant effect on the bond strength of composite to both enamel and dentin [9]. Also Berry and Ward 1995, in their study stated that there was no significant difference between any combinations of the tip diameter, powder flow rate or air pressure whatever high or low [18]. These differences in results may be due to differences in air abrasion parameters e.g. time of air abrasion exposure or nozzle distance or size of alumina particles or degree of pressure stream.

Results of the present study showed superior marginal adaptation for main group restored with low shrinkable siloran based composite (P90) when comparing to the main group that restored with ketac nano ionomer (N100). This may be due to less polymerization shrinkage of low shrinkable siloran based composite (P90) that improved bonding of resin material to cavity walls especially to enamel walls. Results of the present study are in agreement with the study of Ernst *et al.* 2004, that reveal that Filtek Silorane restorative generated the lowest polymerization stress among all composites tested (11 types) [22]. In addition, Filtek Silorane restorative was the only material which maintained the same low-stress value observed after longer storage time and did not continue to

build up stress. Also, Watts *et al.* 2003, found that Filtek Silorane restorative shows significantly lower polymerization stress than the 15 types methacrylate composites tested (e.g.; Grandio, tetric evoceram) [23]. This is agreed with results of Burgess and Cakir 2010 that revealed that Filtek LS had the lowest polymerization shrinkage values among other low shrink composite materials [24].

On the other-hand, Results of the study of Boaro *et al.* 2010 revealed that not all low-shrinkage composites demonstrated reduced polymerization shrinkage [25]. Among the materials considered as "low-shrinkage" by the respective manufacturers, Although LS (P90) presented low post-gel shrinkage, Polymerization stress showed a strong correlation with post-gel shrinkage except for LS, which presented high stress. These differences in results may be due to variation in testing technique or chemistry of materials used or type of adhesives.

11. Conclusions

Based on the results of the present study and under the limitation used in this study, the following conclusions are drawn:

1) None of the restorative materials used in this study was capable to completely seal the cavity margins.

2) The Filtek P90 low shrinkage silorane based composite yielded better results of marginal integrity along the occlusal enamel and gingival dentin walls when the cavity of class V was prepared with air abrasion technique with large size alumina particles under high pressure at immediate storage time as compared with ketac N100 nano ionomer system.

3) For tooth\restoration interface of class V cavity preparation, the part of the cavity placed in occlusal enamel above the cervical line had better results than the gingival dentin part placed below the cervical line in relation to marginal integrity either prepared using air abrasion technique or classical bur preparation.

4) The shorter the storage time, the better results of marginal integrity of tooth\restoration interface.

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