Original Article

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The influence of cutting speed and feeding force in specimen preparation on the microtensile bond strength test

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Objective: The purpose of this study was to determine the effect of cutting speed and feeding force of cutting device in specimen preparation on the integrity of the non-trimmed stick-shaped microtensile specimen by observing bond strength and SEM photomicrographs.

Materials and Methods: Sixty flat middle dentin prepared from human third molars were restored with one step self-etching adhesive system (Prime& Bond Universal) and composite resin (Filtek Z350XT) following the manufacturer's instructions. After 24 hours storage in distilled water 37^{o}C, the bonded teeth were randomly divided into 6 groups, then, the bonded teeth of each group were sectioned in x and y axis according to different cutting speeds and feeding forces as follows: 300 rpm/20N, 300 rpm/40N, 300 rpm/60N, 1,000rpm/20N, 1,000 rpm/40N, and 1,000rpm/60N to obtain resin-dentin stick specimens with cross-sectional area of 1.0 mm^2. Four specimens from the center of each tooth were subjected to the microtensile bond strength test. Also, five additional specimens from 80 remaining of each group were randomly selected for surface topography observation under SEM.

Results: Bond strength of the 1000 rpm cutting speed group was significantly higher than that of the 300 rpm cutting speed group (p<0.001), whereas the feeding forces had no influence on bond strength values (p=0.952). From the SEM observation, stick specimens prepared with the 1000 rpm cutting speed showed a small defect score on the edge of the specimen in comparison with stick beams prepared with the 300 rpm cutting speed (p=0.006).

Conclusion: Within the limitation of this study, both the cutting speed and the feeding force had a significant influence on the surface integrity of the resin bonded dentin specimens for the microtensile bond strength test. The cutting speed had a significant effect on the bond strength, whereas, the feeding force was no significant effect.

Keywords: cutting speed, dentin, feeding force, microtensile bond strength, resin composite

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Introduction

Nowadays, several adhesive materials have been developed with advanced technology to improve their mechanical, chemical and biological properties. When a new material has been developed, the material should be tested in the laboratory to examine and predict the eventually clinical performance of the new materials. The results of the testing provide information for both researcher and dentist to improve the quality of the material, to choose the suitable material, and to set up a guideline or precaution of use [1].

The tensile bond strength measurement is common laboratory test for a new adhesive material was proposed by ISO/TS 11405 - Testing of adhesion to tooth structure [2]. The testing is mainly categorized into two types regarding to size of the bonded interface (*i.e.*, macrotensile bond strength test and microtensile bond strength test). The macrotensile bond strength test refers to a test with a bonded interface larger than 3 mm [3]. Larger bonded interface usually results in lower bond strength because of non-uniform stress distribution at the interface. Also, the non-uniform stress distribution leads to a cohesive failure [3, 4]. To solve the

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non-uniform stress distribution issue, in 1994, Sano and co-worker introduced the microtensile bond strength test with a smaller interface size of 1 x 1 mm [5]. Therefore, the microtensile bond strength test can achieve higher bond strength in comparison with the macrotensile bond strength test [3, 4]. Moreover, the decreased number of teeth required for the microtensile bond strength test can be advantageous to control the tooth variation [1, 6].

Due to variations in condition of substrate, specimen's preparation, test procedures, and experimental conditions of the microtensile testing, values of bond strengths reported by different experiments might be varied, so they are not comparable [7-9]. With a small size of the microtensile specimen, the cutting or trimming procedure in specimen preparation may induce a micro-crack of microspecimens that can motivate failure during bond strength test and skewing of the result data of test. In 2002, Ferrari and co-workers reported various defects on the observation of 80 prepared microtensile sticks on both resin-enamel bonded specimens and resin-dentin bonded specimen, especially micro-crack into specimens which may be affect on the bond strength [10]. Moreover, the micro-crack due to cutting process of the specimen's preparation lead a risk of the premature failure. The premature failure is a de-bonding or cracking of specimen that appeared before applying tensile force and cannot be attributed to any human manipulation error [6]. The bond strength values of premature failure were assigned as a determined value, mean value, the lowest value, and zero MPa in the statistical analysis. If there are many pre-testing failures in the experimental, it will result in distortion of the mean of data calculation. Therefore, Pre-testing failure reduction will promote the reliability of the experimental data [5, 11].

There are various parameters of cutting process, such as cutting mode, feeding rate, feeding force, rotational speed, and abrasive particle size of cutting blade. The cutting parameters may determine a friction force, surface fatigue, residual stress, and microcrack [12-14] which may be indirectly affect on the bond strength of the microspecimens. The result of the study of Reis and co-workers (2004) demonstrated that water storage in a week and cutting with high speed of 500 rpm produced the highest mean bond strength of the dentin specimens were bonded by Single Bond adhesive and restored with Z250 resin composite. On the other hand, when the specimens were cut immediately after composite restoration 10 min and cut at low speed of 100 rpm, the lowest mean bond strength was performed [15]. In 2005, Sadek and co-workers reported that cutting speed on specimen preparation affected microtensile bond strength of resin bonded tooth substrate, especially enamel-involved specimen. The bond strength of enamel-resin bonded specimen received 400 rpm cutting speed was significantly lower than 100, 200 rpm. Moreover, cutting with 400 rpm found more defects than another groups in SEM observation. While, they did not detect the different of the bond strength of dentin-resin bonded specimens received 100, 200, and 400 rpm [16].

Due to the effects of cutting speed in specimen's preparation on the bond strength is still not clear and the lack of information about the feeding force, this study aimed to determine the influence of cutting speed and feeding force on microtensile bond strength test of resin bonded dentin specimen preparation. The null hypothesis tested was that different cutting speeds and feeding force did not affect the microtensile bond strength of resin bonded dentin specimen preparation.

Materials and Methods

The study protocol was approved by the Faculty of Dentistry/Faculty of Pharmacy, Mahidol University Institutional Review Board. Sixty extracted non-carious human third molars were stored in 0.1% Thymol solution at 4°C according to the approved study protocol. The storage solution of extracted teeth was change to normal saline 24 hours before use.

Tooth preparation

All third molars were sectioned horizontally at coronal 1/3 of the crown to expose a middle dentin with low speed diamond saw (Isomet™, Buehler, Evanston, IL, USA) with a cutting speed of 200 rpm under water lubricant. The root below cementoenamel junction (CEJ) 2 mm was embedded in self-cured acrylic resin and paralleled to CEJ level. The exposed middle flat dentin was positioned perpendicular to the long axis of tooth and load direction. Then, 1.5 mm remained dentin thickness was monitored using radiographic examination. To create a standardized smear layer, the cutting surfaces of each tooth were polished in linear motion (10 cm stroking) by silicon carbide paper 600 grit under running water for 30 seconds.

Bonding procedure and resin composite placement

After smear layer preparation, all moist dentin surfaces were applied with 1-step self-etching adhesive system (Prime& Bond Universal™, Dentsply DeTrey, Konstanz, Germany) as the manufacturer's instruction at room temperature. Then, composite resin (Filtek™ Z350XT shade A2, 3M ESPE, MN, USA) was placed onto the dentin surface with 2 mm incremental layer until a height of 4 mm was obtained. A LED light curing unit (Bluephase N, Ivoclar Vivadent AG, Liechtenstein, Germany) was used for optimal polymerization of composite resin with 20 seconds per each layer. The light intensity of the curing unit was monitored at >1,000 mW/cm^2 before used was obtained. All bonded specimens were stored in distilled water at 37°C for 24 hours.

Specimen preparation

Sixty resin-dentin bonded teeth were randomly divided into 6 groups (10 teeth/group). Each group was assigned different combinations of cutting speed and feeding force. Specifically, all bonded teeth were first randomly divided into two groups of different cutting speeds (300 and 1,000 rpm). These two groups were then further randomly divided into three sub-groups of different feeding force loading used in the cutting procedure as follows: 20N, 40N, and 60N.

Bonded teeth were further sectioned using a diamond saw disk (Medium grit; PACE Technologies, AZ, USA) in the precision automatic cutting-off and grinding machine (ACCUTOM 50; Struers Inc., OH, USA) under water cooling. The diamond saw was routinely dressed before cutting each specimen. Blade dressing was also accomplished at low speeds (200 rpm) and at light loads (0.25 N) with low speed diamond saw until the entire blade surface passed through alumina wafer blade dressing sticks as the manufacturer's instruction [17].

For cutting procedure, the bonded tooth was fixed to the automatic cutting machine and aligned as perpendicular as possible. The cutting direction was starting from composite resin through adhesive and dentin, respectively. From the first cut, 1.0 mm thick slabs were obtained. Then, the second cut was sectioned by rotating the specimen 90 degree to the first section. A rectangular-shaped resin-dentin stick specimen with approximately 1.0 mm^2 cross-sectional area was obtained. The four resin-dentin stick specimens in the middle of each tooth specimen were collected for measurement of bond strength and eight remaining stick specimens from peripheral areas of the tooth were kept. Forty specimens per group were assigned to microtensile bond strength test. Then, five sticks from the 80 remaining stick specimens from each group were randomly selected and used for observation of surface characteristics (void, micro-crack and any defect on substrate) and integrity under a scanning electron microscope (JSM-6610LV, JEOL Ltd., Tokyo, Japan) at magnifications of 80x, 300x, and 500x. The specimens, obtained with peripheral enamel or with a less 1.5 mm remained dentin thickness, were excluded from the microtensile bond strength test. The specimens failed during the cutting process or before subjecting to the microtensile bond strength test were recorded as a pretesting failure.

Microtensile bond strength test

The dimension of bonded interface was measured with digital caliper (Mitutoyo Corp., Tokyo, Japan).

Microtensile bond strength test was measured with a universal testing machine (Lloyd™ Testing Machine, Model LR 10K, Lloyd Instruments, Fareham Hanth, UK) at cross head speed of 1 mm/min. Each stick specimen was attached to a microtensile jig with a cyanoacrylate adhesive glue (Model repair II blue; Dentsply Sankin, Otawara, Japan) to keep a parallel position to the long axis of the device on the universal testing machine. Mean bond strength in megapascal unit (MPa) from bond strength of four specimens from each tooth was calculated and used as the representative bond strength of that tooth. This calculated mean bond strength was further used for statistical analysis.

Failure mode observation

Both sites (tooth/resin composite) of fractured specimens were observed under the scanning electron microscope (SEM) at magnification of 80-200. Failure mode was investigated and classified into 4 types; type 1: adhesive failure (75% to 100% failure occurred at interface of resin dentin bond), type 2: mixed failure (mixed with adhesive failure at the resin/dentin interface and cohesive failure in resin and/or dentin), type 3: cohesive failure in dentin (75% to 100% of the failure occurred in the underlying dentin), and type 4: cohesive failure in resin (75% to 100% of the failure occurred in the adhesive resin and/or overlying composite)

Surface topography and integrity observation

The five stick specimens from each group were randomly chosen to examine the surface characteristics and specimen integrity. The surface of specimen was cleaned by an ultrasonic cleaner for 10 minutes in distilled water and gently blotting dried using tissue paper. The cleaned specimens were mounted on aluminum stubs and coated with palladium by sputter coater machine (SC7620 Sputter coater, Quorum Technologies Ltd, England). Two external edges of each mounted specimen were observed to determine a defect score under the SEM at 300x magnification by placing the bonding interface at the horizontal center of the SEM image. The SEM image was captured as Figure 1. Then, the depth of the external edge defect was chosen and analyzed from the deepest defect found in that captured area by scale bar of SEM image according to Table 1. The proportion score of the defect is a percentage of total defect length over the captured length according to Table 2. The defect score was a summation of the depth score and the proportion score of defect.

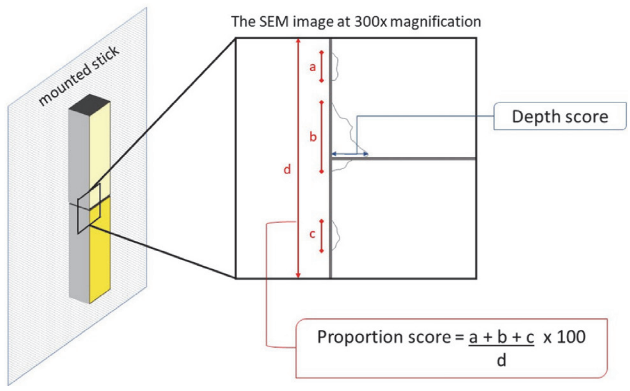

Figure 1 The drawing shows the measurement of the depth and proportion score of each external edges of mounted stick specimen in surface topography and integrity observation.

Table 1 Scoring of the depth of the deepest external edge defect.

Score	The depth of external edge defect
0	No defect appearance
1	1 – 25 microns
2	26 – 50 microns
3	51 – 100 microns
4	More than 100 microns

Table 2 Scoring of the proportion of the appearance of defect.

Score	The proportion of the appearance of defects along the edge
0	No defect appearance
1	1 – 25 % of total image length
2	26 – 50 % of total image length
3	51 – 75 % of total image length
4	76 – 100 % of total image length

Statistical analysis

The collected data was analyzed using SPSS version 18 (SPSS Inc, Chicago, USA). The normal distribution and homogeneity of variance of the microtensile bond strength were verified with a Kolmogorov–Smirnov test and Levene test. The influences of the cutting speed and feeding force were further analyzed with two-way ANOVA. The bond strength value of zero for each premature failure stick specimen was included for statistical analysis. Furthermore, the defect score and the failure pattern on both sides of the defect specimens including deboned specimens were analyzed with Non-parametric Kruskal-Wallis test and compared the specific sample pairs with Mann-Whitney U test. The level of significance was set up at p=0.05.

Results

The mean and standard deviation values of the microtensile bond strengths of six study groups with varied settings of cutting speed and feeding force are summarized in Table 3, including prevalence of the premature failures. The statistical analysis demonstrated that the cutting speed had a significant effect on the microtensile bond strength (p=0.001). Whereas, the feeding force had no a significant influence on the bond strength (p=0.952). Study group with the lowest mean value of bond strength was the 300 rpm/20N group (20.78 ± 9.33 MPa). The highest bond strength in this experimental (32.43 ± 12.93 MPa) was found in 1000 rpm/20N group.

Since there was no significant difference among feeding force settings, the study results were combined into two groups regarding to cutting speed. The mean and standard deviation values of the microtensile bond strengths of the two combined groups are reported in Table 4. The mean and standard deviation values of bond strengths of 300 rpm and 1000 rpm cutting speed groups were 21.20 ± 7.96 and 31.11 ± 12.08 MPa, respectively. The independent T- test was further used to analyze a significant difference between 300 rpm group and 1,000 rpm group, at 95% confident interval. The microtensile bond strength of the 1,000 rpm group was significantly higher than that of the 300 rpm group (p<0.001). Moreover, there was no the incidence of premature failure in the 1,000 rpm group, whereas seven premature failure specimens occurred in the 300 rpm group.

Table 4 Means microtensile bond strength and standard deviations (mean ± S.D.) in MPa of each group. The number of premature debonding specimen was presented in parentheses. (n=30/groups)

Cutting speed	
300 rpm	1000 rpm
21.20 ± 7.96 ^{A} (7)	31.11 ± 12.08 ^{B} (0)

(rpm: revolutions per minute, MPa: megapascal)

Table 3 Mean and standard deviation (mean ± S.D.) of microtensile bond strength (MPa) of six study groups with varied settings of cutting speed and feeding force. The number of premature debonding specimens is presented in parentheses. (n=10/group)

Feeding force (N)	Cutting speed	
	300 rpm	1000 rpm
20	20.78 ± 9.33 (4)	32.43 ± 12.93 (0)
40	21.06 ± 5.36 (2)	30.10 ± 11.56 (0)
60	21.76 ± 9.38 (1)	30.79 ± 12.90 (0)

(rpm: revolutions per minute, N: newton, MPa: megapascal)

The failure mode analysis is revealed in Figure 2. From Mann-Whitney U test at 95% confident interval analysis, the distribution of the failure pattern of the 300 rpm group was not significantly different from the 1,000 rpm group (p=0.07). In both groups, the adhesive failure was prominent. However, the increasing of mixed failure and cohesive failure in dentin was observed in the 1,000 rpm group. The cohesive failure in resin did not detected in 300 rpm group. The representative images of each of the failure mode (debonded specimens on both resin composite and dentin fracture site) are showed in Figure 3.

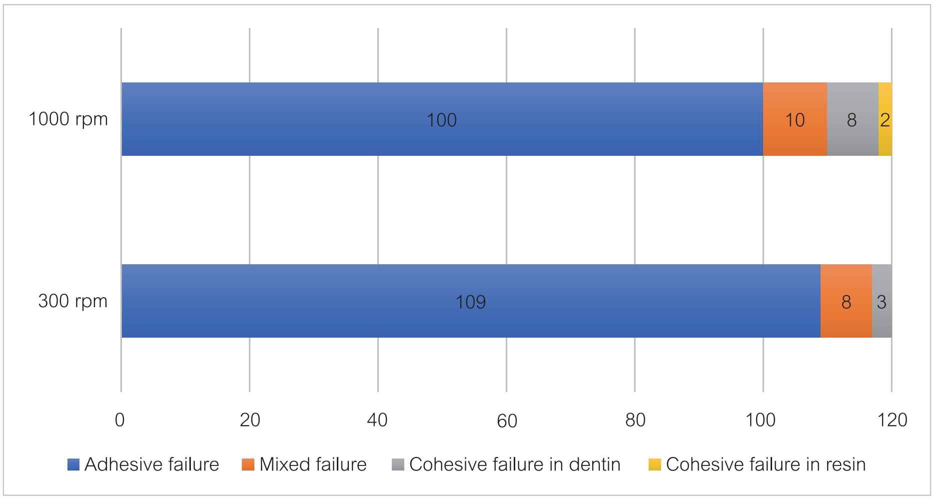

Figure 2 A number of failure modes of specimens in the two cutting speed groups (300 rpm and 1000 rpm) are represented with numbers on the plot. The failure modes are classified into four types and represented in different colors: adhesive (blue), mixed (orange), cohesive in dentin (gray) and cohesive in resin (yellow).

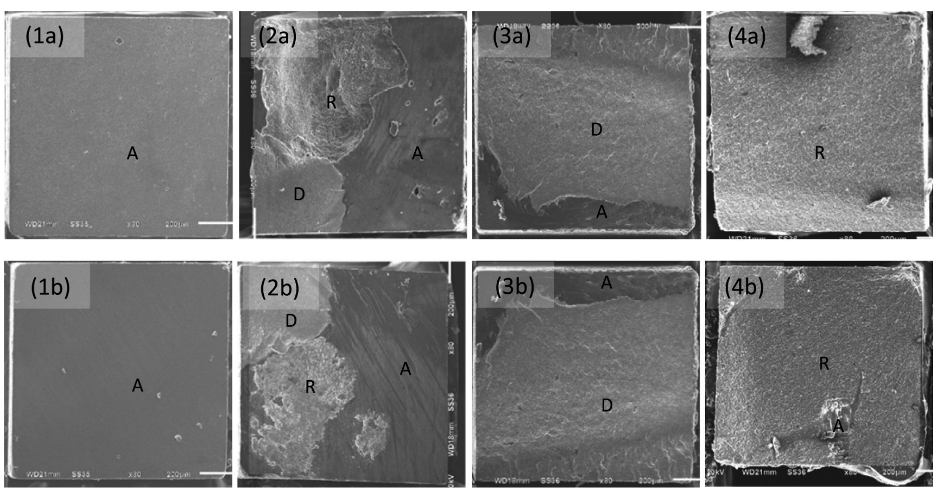

Figure 3 Representative images of each failure mode (1a) debonded specimens on resin composite fracture site of adhesive failure, (1b) debonded specimens on dentin fracture site of adhesive failure, (2a) debonded specimens on resin composite fracture site of mixed failure, (2b) debonded specimens on dentin fracture site of mixed failure, (3a) debonded specimens on resin composite fracture site of cohesive failure in dentin, (3b) debonded specimens on dentin fracture site of cohesive failure in dentin, (4a) debonded specimens on resin composite fracture site of cohesive failure in resin, (4b) debonded specimens on dentin fracture site of cohesive failure in resin. (A=adhesive, R=composite resin, D=dentin).

According to surface topography observation, frequency of the defect score of the two cutting speed groups are shown in Figure 4. All studied specimens had defects from the lowest defect score of two to the highest defect score of seven. The highest defect score (score 7) specimens of both 300 rpm and 1000 rpm groups were found at 60 N feeding force. No defect-free specimen was found in this study. The means rank of defect scores of six groups were significantly different regarding to non-parametric Kruskal-Wallis test at 95% confident interval ~~analysis~~ (p=0.005). The means rank of the defect score of all groups were not statistically significant differences regarding to Mann-Whitney U test at 95% confident interval ~~analysis~~ (p>0.05), except the mean rank of 300rpm/60N group showed significantly different regarding to Mann-Whitney U test at 95% confident interval ~~analysis~~ (p<0.05). The prominent defect score of the 300 and 1000 rpm group was score 6 and score 3, respectively. The representative images of the depth of external edge defect and the proportion of the appearance of defects along the edge of the specimen together with their scores are presented in Figure 5 and 6, respectively.

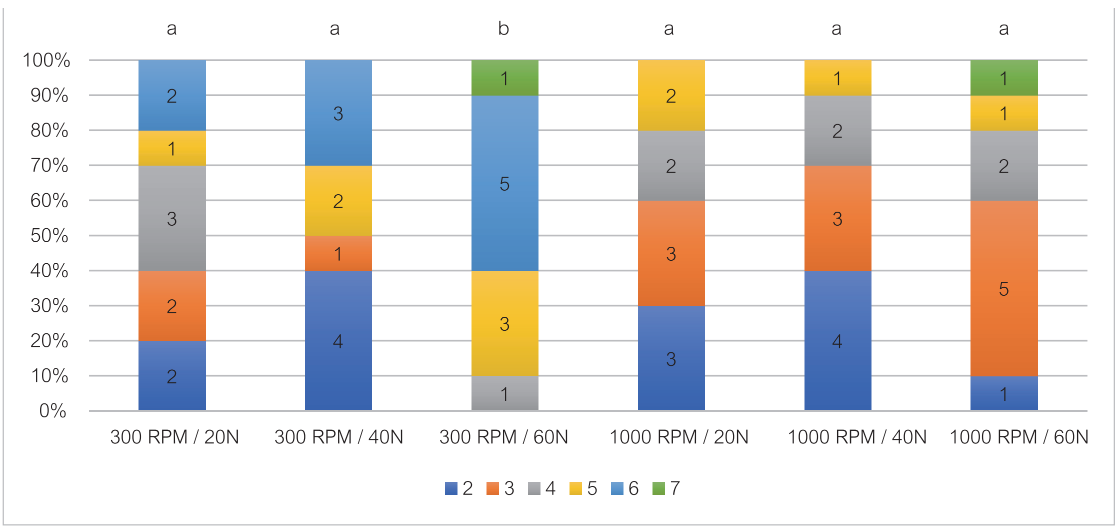

Figure 4 Frequency of the defect score in the two cutting speed groups (300 rpm and 1000 rpm). Each color represents different defect scores from 2 to 7.

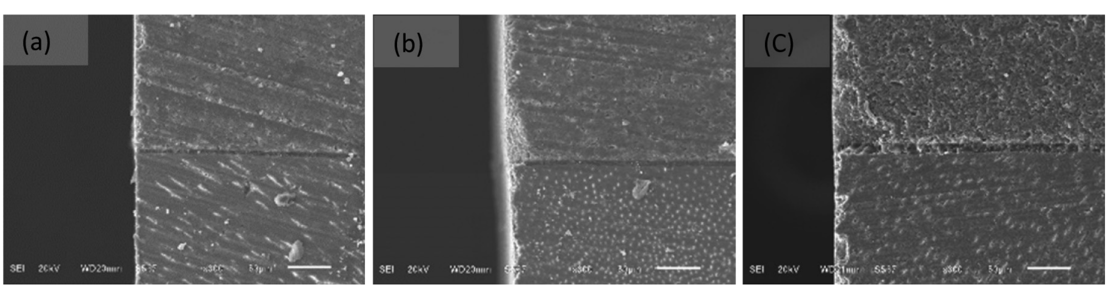

Figure 5 The score of the depth of external edge defect at 300X magnification; (a) score 1:1 – 25 microns, (b) score 2: 26 – 50 microns and (c) score 3: 51 – 100 microns.

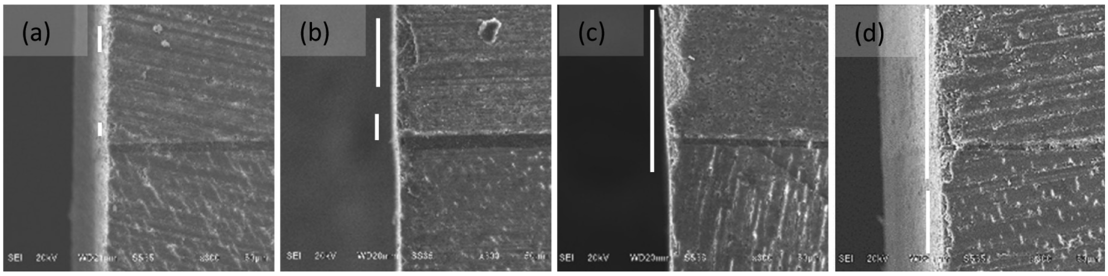

Figure 6 The score of the proportion of the defects along the edge of the specimen was observed under the SEM at 300X magnification by placing the bonding interface at the center of the image; (a) score 1(1-25%), (b) score 2 (1=26-50%), (c) score 3 (51-75%) and (d) score 4 (76-100%).

Discussion

According to the result of this study, the influence of the cutting speed parameter in specimen preparation to the microtensile bond strength value was found, and thus the null hypothesis regarding to cutting speed was rejected. While, the feeding force parameter did not influence the microtensile bond strength results, thus the null hypothesis regarding to feeding force was accepted.

The results of laboratory testing aim to predict the eventual clinical performance of the material. Therefore, the results from in vitro test methods have to provide reliable data [5]. The microtensile testing is a versatile method that is normally used for adhesive testing. Recently, the international standardized test protocols for the bond strength evaluation of specimens were discussed in various reports [18]. There are various factors that affect microtensile bond strength such as substrate's properties, storage condition of specimen, specimen preparation procedure, design testing measurement, and data analysis [7-9]. Armstrong and co-worker (2017) presented the guidelines performing for microtensile bond strength testing of resin composite bonded dentin structure, but some detail in the specimen preparation didn't be reported, especially cutting parameter in specimen preparation [11].

Due to small sizes of microtensile specimen, the cutting procedure in specimen preparation may influence bond strength and surface integrity of the specimen. No defect-free microtensile specimen was found in this experiment. According to the report of Ferrari and co-workers, all microtensile specimen sticks had defects after specimen preparation such as microcrack, gaps, or voids [10]. The effect of the specimen preparation procedure may lead to the failure of microtensile stick before loading which is called "a premature failure". The premature failure influences the reliability of experimental data [5, 6]. In this study, the interesting area that was chosen to analyze was the captured SEM image at 300x magnification by placing the bonding interface at the horizontal center. Both quality and quantity of defects or flaws were analyzed in terms of the horizontally deepest defect and the percentage of defect length in the focus area. For the microtensile bond strength measurement, the tensile stress was applied to create a crack to propagate through the resin/dentin interface of the sample and separate it into two parts. The microcrack or defects in the neighborhood of the interface may generate the stress concentration and initiate the fracture by a crack propagation. The crack propagation occurred at and through out of the adhesive layer may reply to the cohesive failure in adhesive resin [19]. The cohesive failure may affect the reliability of the bond strength of the experimental. Regarding to these reasons, the surface topography observation at the neighborhood areas of adhesive layer of microspecimens is designed in the attempt to check the specimen's defects of the microspecimens preparation before bond strength testing. Due to the SEM process, the microspecimens that were prepared for the SEM observation can't use for the further bond strength test. Thus, five specimens from remaining surrounding-specimens from each group were randomly chosen to examine under the SEM. The edge of the rectangular resin-dentin microspecimen occurring by the two different direction of the cutting were observed and analyzed as a defect score.

A cutting wheel (blade) is an abrasive machining which is one type of material removal process. Its removal principle is by using the action of a multitude of small abrasive particles, usually in form of bonded wheel blade [20]. Each of the abrasive particles operates as a miniature cutting tool. When the abrasive grain penetrates into specimen, there are three types of abrasive grain actions that consist of cutting, plowing, and rubbering [21, 22]. These actions produce the energy which spreads around the interacting surface. For this reason, the cutting process may lead to a small vibration, friction, elastic stresses, microcrack, and residual stress of specimen [12, 14, 23]. Moreover, friction force of interaction substrate's surface in relative motion may produce surface fatigue at the specimen's surface. The elastic stress, which is a result of the force at the contact points between the abrasive particles and the specimen's surface, gives rise to plastic deformations. With an abrasive grain moving, the material substrate is subjected to compression followed by tension force. After the abrasive load is removed, residual stresses occur on the surface of specimen [23]. Moreover, the repeated applications of elastic stress on the contacting areas produce more surface fatigue [24]. This situation is a cyclic process and contributes to crack propagation in crack-sensitive materials [12, 25]. The specimen in this study consisted of three parts: dentin, adhesive, and resin composite. The adhesive part is the lowest of modulus of elasticity in comparison with resin composite and dentin structures [26-28]. Therefore, the adhesive layer, which is the weakest part of specimen, tends to be harmed by force.

As mentioned earlier, the cutting parameters (cutting speed and feeding force) may determine the effect of cutting process in specimen preparation on microtensile stick integrity [13, 22, 29]. From Ries and co- worker's study, the cutting speed (100, 300, 500 rpm) in specimen's preparation may affect the microtensile bond strength of the resin bonded dentin specimens [15]. The study of Sadek and co-worker demonstrated the microtensile bond strength of the resin-enamel specimen prepared with the 400 rpm cutting speed was lower than the specimen prepared with the 100, 200 rpm cutting speed. Moreover, the specimens prepared with the 400 rpm cutting speed shown more defect than 100, 200 rpm in the SEM observation. Due to no international standard protocol of the cutting parameter for the specimen's preparation of the microtensile testing [2, 11], the specimens of previous studies were prepared with various cutting conditions and cutting machines such as Labcut 1010 machine (Extec, Enfield, CT, USA), ISOMET™ Low speed Saw, Isomet 1000 (Buehler; Lake Bluff, IL, USA) [15, 16, 30, 31]. Technically, the maximum cutting speed is usually limited by the cutting machine manufacturer's instruction. The 300 rpm is a maximum cutting speed of the ISOMET™ Low speed Saw, while the 1000 rpm is the highest cutting speed of the Isomet 1000. Therefore, the Accutom-50 which has a wide range of cutting speed from 300 up to 5000 rpm was used for testing with 300 and 1000 rpm because it was suitable for this study.

The cutting speed in this study was reported in rpm units which stands for revolutions per minute. In other words, it's a measure of the number of completed cutting blade rotations in one minute around a fixed axis. The rpm is different from the measurement in surface speed (m/min) which express the relative velocity speed between the abrasive grain and the working surface of the specimen [32]. For this study, each group was operated with the same cutting blade with 4 inches diameter, the surface speed of 300 rpm groups are lower than 1,000 rpm groups. From the result of this study, the cutting speed parameter was observed to had an influence on specimen cutting process. Sandak and coworkers reported that the vibration of the circular saw blade was reduced from high to low amplitude of machine vision detector until reaching at a critical rotational speed. At a critical rotation speed, the cutting blade has a tendency to dramatically increase its vibration amplitude and leads to the self-excited vibrations of the cutting blade [33]. The operating speed of a cutting wheel should not be set greater than 50% of the maximum speed to prevent burst a cutting blade [21]. The diamond saw disk with a medium size of diamond abrasive particles were selected for this study. The diamond abrasive particle has appropriate cutting performance for resin boned dentin specimen preparation [17]. The diamond saw disk has a limitation of maximum speed at 15,280 rpm. We operated the experiment with cutting speeds (300, 1,000 rpm) that were less than half of the maximum speed of cutting blade, Therefore, the vibration of the cutting blade was determined from the rotation speed without a phenomenon of self-excited vibration of the cutting blade. The high speed of cutting blade may alleviate any inherent vibration that cause a harmful effect on prepared microtensile specimen [22]. Which corresponds to this study, the low cutting speed group (300 rpm) demonstrated higher defect score compared with the high cutting speed group (1,000 rpm). The existence of defect in the microspecimen may affect bond strength. Also, the low speed in cutting procedure may induce thermal damage on the working area [29]. The specimen of this study consisted of three layers (dentin, adhesive, and composite resin), which composed of different coefficients of thermal expansion property. A rapid thermal change of three layers of specimen from cutting procedure may induce either a microcrack formation or propagation on the specimen. The increasing of wheel speed may influence to reduce a guiding force on the working area regardless of other speed parameters. Moreover, the process of cutting with the abrasive wheel may cause clogging of the cutting debris leading to friction-force generating on the working surface. The increase in speed with lubrication has been reported to affect material removal efficiency of cutting wheel by reducing the rate of debris clogging [29]. As mentioned, the low cutting speed tend to more generate the specific energy, stress and microcrack defect on the microspecimen than the high cutting speed. So, the mean bond strength of the 300 rpm group was significantly lower than the 1,000 rpm group.

Regarding to the feeding force, an insufficient force and less cutting efficiency of blade can result in rubbing and no material removal which raised a number of cyclic cutting failure situation and stress consumption of the specimen, whereas the excess force can cause worse defect and breakage of both the cutting tool and the specimen before bond strength testing [22]. Due to the lack of the information about the effect of feeding force on the micro specimen's surface integrity and bond strength, the three pre-set of feeding force scale of the Accutom-50 of low (20N), medium (40N), and high (60N) feeding force were assigned in this study. Therefore, there was no significant difference among assigned feeding forces with both cutting speeds on the dentin bond strength. The different among three used feeding force (20N, 40N, and 60N) might not be enough to have the impact on bond strength of specimens. The highest defect score in this study is score 7 resulted from 60N force group of both cutting speeds. However, the negative result from excessive feeding force that may generate high temperature and stress on the specimen lead to defect or microcrack propagation during the cutting process has been reported [22]. This may lead to high defect score observation in high feeding force with low cutting speed group.

The cutting rate of blade may be automatically reduced because of smear layer deposition between abrasive particles on blade surface. Therefore, the debris cleansing by blade dressing is recommended to promote effective of cutting process and reduce blade broken. Blade dressing is a process of smear layer removal by blade cutting into Periodic dressing stick that consist of ceramic abrasive in soft matrix. The study of Pace Technologies Company reported that the cutting time that low concentration diamond blade is used to cut on silicon nitride specimen increased after 3 times using [17]. In this study, the diamond saw was routinely dressed before cutting each specimen.

As mentioned above, it is clearly that the benefits from increasing of cutting speed is an improvement of cutting efficiency. However, increasing wheel speed without changing other cutting parameters may reduce the efficiency removal rate and be harmful to specimen [29]. Besides, rather various factors are not considered and included in this study such as the mechanical properties of specimens, the adhesive condition, type of microspecimen (stick specimen, dumbbell specimen, hourglass specimen), trimming process, and the cutting initiation location on multilayer-specimen. These factors may influence a specimen result in different ways.

Conclusion

Within the limitation of this study, no defect-free microtensile specimen was found in this experiment. The cutting procedure in specimen preparation influenced the bond strength and surface integrity of the resin bonded dentin microtensile specimens. The high cutting speed group resulted in significantly higher bond strength values compared to the low cutting speed. The low cutting speed group had more defect score than the high cutting speed group. The difference feeding force was no significant influence on the resin-dentin bond strength, whereas may affect the surface integrity of the microtensile specimen in this study.

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Conflicts of Interest: None
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