CHAPTER V

DISCUSSION

The discussion of this research will be presented in two parts as follows:

1. **Discussion of the results of the study**
2. **Discussion of the materials and methods of the study**

1. Discussion of the results of the study

Originally, self-etching adhesive systems were introduced for the use in operative dentistry bonding procedures. The shear bond strength values of brackets bonded using self-etching adhesive systems were significantly lower than those using total-etching adhesive systems,[8] although some investigators found that the shear bond strength values of brackets bonded using self-etching adhesive systems were not significantly different from those bonded by total-etching adhesive systems.[3,6,37,38,48]

The results of this study indicate that the shear bond strength values of the total-etching adhesive system were significantly higher than those of the two-step self-etching system and the one-step self-etching system. However, the shear bond strength values of the two-step self-etching adhesive system were not significantly different from those of the one-step self-etching adhesive system. The higher shear bond strength of the total-etching adhesive system can be explained by the fact that

etching with total-etching adhesive systems dissolves hydroxyapatite crystals, and enhances the penetration of resin into the etched enamel.[35]

In an attempt to save chair time during bonding, precoated adhesive brackets have been offered to provide for uniform thickness of adhesive, decrease the number of steps in the bonding procedure and reduce the risk of bracket contamination. The adhesion between the adhesive and the bracket base in precoated brackets is more effective than that in the conventional procedure in which the clinician has to apply the adhesive to the bracket. However, reports of the shear bond strength of precoated bracket are controversial. Previous studies have indicated that a modified precoated adhesive composition produced a decrease in shear bond strength.[51,81,82] Bishara *et al*.[51] indicated that precoated Victory Series metal brackets (3M Unitek) had significantly lower shear bond strength values than uncoated Victory Series metal brackets do. On the other hand, precoated Transcend 6000 ceramic brackets (3M Unitek) had similar shear bond strength values to uncoated Transcend 6000 ceramic brackets. The results of this study were different from those of previous studies. In this study, the shear bond strength values of precoated Clarity ceramic brackets had significantly higher shear bond strength values than those of uncoated Clarity ceramic brackets. The adhesive system of Bishara *et al*.[51] was total-etching adhesive system with Transbond XT™. However, the surface area and bracket base of the ceramic brackets used by Bishara *et al.*[51] were different from those used in this study. The de-bonding force needed with ceramic brackets is dependent on the bracket retention mechanism, the method of enamel conditioning, the composition of the adhesive, and the method of debonding.[71]

The requirements for orthodontic bonding systems are resistance to the forces during orthodontic mechanotherapy, to the stresses exerted by the archwires, to the forces of mastication, and to patient abuse as well as allowance for control of tooth movement in all three planes of space. However, excessively high bond strength values are undesirable because of the increased de-bonding forces needed, resulting in possible damage to enamel. Some studies have suggested bond strength values ranging from 2.8 to 10 MPa as being adequate for clinical use.[20,49,50] Retief[49] demonstrated that maximum bond strength of an orthodontic bracket should be less than the breaking strength of enamel, which is about 14 MPa. However, that was an *in-vitro* value in ideal substrate conditions and would probably be less in *in-vivo* conditions.[52] In this present study, the highest bond strength value of the total-etching adhesive system with precoated ceramic brackets was 11.08 MPa and the bond strength values of all groups were less than 14 MPa. Furthermore, no enamel fracture was detected in any group.

Bracket failure at the bracket/adhesive interface is advantageous, because it leaves the enamel surface relatively intact. However, considerable chair time is needed to remove the residual adhesive with the possibility of damaging the enamel surface during the cleaning process.[83] Conversely, when brackets fail at the enamel/adhesive interface, less residual adhesive remains, but the enamel surface can be damaged when failure occurs in this mode. The cohesive failure of the Clarity ceramic brackets were mostly located at the wings of the bracket. This was expected because the point of force application is at the tie wings of the brackets. A higher frequency of cohesive ceramic fractures was mostly found in the monocrystalline brackets.[84]

This present study indicated more residual adhesives on enamel surfaces bonded with the total-etching adhesive system than those bonded with the self-etching adhesive systems as similar as previous studies.[5,43,47] This may be indicative of a reduced etch pattern and of reduction in the quality of the micromechanical bond of self-etching adhesive systems.[85] Less residual adhesive need less chair-side time spent in adhesive removal after debonding.

So the use of one-step self-etching systems with precoated ceramic bracket offer uniform adhesive thickness and may reduce in the chair-side time for bonding procedures and for removing adhesive remnant on tooth surface with adequate bond strength. Furthermore, some characteristics of APC Plus Clarity™ ceramic bracket may provide high favor for clinical use. This system improves tolerance to humidity in comparison with Transbond XT™ or other systems and releases fluoride to prevent decalcification of the enamel surrounding the brackets.

2. Discussion of the materials and methods of the study

In this present study, the maxillary premolar teeth extracted for orthodontic reasons were selected because: 1) the most common tooth type for research is human premolar teeth[86], and 2) they were easy to collect. The teeth were used within 6 months after extraction because the likelihood of dehydration is increased after six months and dehydration might have affected bond strength. The storage medium prior to bonding was 0.1% thymol solution to prevent contamination.

The time between bonding and testing varied widely. The bond strength values were less five minutes after bonding than they were 24 hours after bonding. The 5-minute values were 60 to 70 percent of the 24-hour values. This suggested that timing

between bonding and testing was probably not critical, provided that this period was not less than 24 hours. The time between bonding and testing in this present study were 48 hours.

Clean tooth surfaces have high surface energy, which is amenable to bonding,[87] but fluoride on the surface can lower the surface energy of the adherent, and this decreases the spreadability of the adhesive. In this study, all teeth were cleaned with non-fluoridated pumice before bonding brackets. This pretreatment cleansing removes organic material, including acquired pellicle. Burgess *et al.*[26] has reported that the bond failure rates in a self-etching adhesive system with the omission of pumice prophylaxis were higher than those of a total-etching adhesive system. So pretreatment with pumice might be necessary for maximum efficacy of self-etching adhesive systems. Pandis and Eliades[88] have suggested that a clean surface is more important for self-etching adhesive systems than for total-etching systems because the chalky appearance (of enamel resulting from total-etching adhesive systems) indicative of a well-prepared surface is not clinically visible when using self-etching adhesive systems.

The phosphoric acid solution was used in this present study, because this etchant is routinely used in the orthodontics clinic in Chiang Mai University. Transbond XT™ was used because it is similar to the adhesive paste of the APC Plus bracket. However, APC Plus contains less Bisphenol glycidyl methacrylate than Transbond XT™ and may enhance handling characteristics, package stability and fluoride releasing.[62]

Traditionally, orthodontic bonding systems have been evaluated by means of *in vitro* shear bond strength tests using a Instron® universal testing machine (Instron

Corp, Canton, Mass). The Instron® universal testing machine which serves as the gold standard, is a stable and rigid device capable of producing pure shear de-bonding forces. Pickett *et al.*[89] reported that the de-bonding forces measured *in vivo* were significantly lower than those measured *in vitro*. It would be preferable to record actual *in vivo* measurements to assess bond strength, since the bracket-bonding systems being tested are in different environments. Possible reasons for the lower bond strength values recorded *in vivo* are the length of time the appliance is in the oral environment (exposing the bonded brackets to acid and saliva), patient abuse and masticatory forces. All may contribute to a decrease of bond strength. Additionally, the technique commonly used for de-bonding in clinic is to apply force bilaterally at the bracket-adhesive interface with de-bonding pliers or ligature cutters. On the other hand, shear forces from a universal testing machine apply unilateral load at the bracket-adhesive interface.[71]

Studies of thermocycling are controversial. Elekdag-Turk. *et al.*[90] found that the mean shear bond strength values of self-etching adhesive systems were decreased with 2000 and 5000 thermal cycles. However, the mean shear bond strength values of total-etching adhesive systems were not significantly different among 0, 2000, and 5000 thermal cycles. They concluded that self-etching adhesive systems provided clinically acceptable bond strength values. Saito *et al.*[91] reported that there were no significant differences in mean shear bond strength values between phosphoric acid etching and Megabond self-etching primer in the absence of thermocycling. The mean shear bond strength values with phosphoric acid etching were significantly decreased after 2000 and 5000 thermal cycles. However, the Megabond self-etching primer

showed no significant difference in mean shear bond strength values after thermocycling.

There are many different thermocycling standardization protocols. This present study performed thermocycling between 5˚C and 55˚C for 1,000 cycles, as prescribed by Zachrisson *et al.*[92] The exposure to each bath was 30 seconds, and the transfer time between the two baths was 10 seconds. De-bonding was performed at room temperature, as prescribed by International Organization for standardization.[93]

The debonding forces in this study were applied in gingivo-occlusal direction, until the bracket dislodged from tooth surface. The reason for this was that the width from bracket base to bracket wing at gingival end was wider than that at occlusal end. The wings of ceramic brackets might not be fractured from de-bonding part of universal testing machine. The de-bonding forces are applied parallel to the bracket base because shear bond strength is significantly higher when there is a deviation of force direction toward the enamel surface. Shear bond strength is decreased significantly when a force direction away from the enamel surface is used.[94] However, de-bonding methods used in *in vitro* studies are different from those used *in vivo*. The Clarity bracket was designed with a de-bonding slot on the base. So, in clinical de-bonding methods, the bracket is de-bonded to collapse the bracket under mild pressure from Howe pliers or Weingart pliers.[15]

Shear bond strength may vary as a result of differences in etching patterns of enamel, irregularities in the surface enamel or intra-operator variability.[89]

Limitation of this study

The enamel surfaces of the premolars used in the study were not flat. The de-bonding plate of the universal testing machine should, ideally, be placed parallel to

the bracket bases and the enamel surface. Incisors, having flatter surfaces, might have permitted better placement of the de-bonding plate of the universal testing machine parallel to the bracket bases and enamel surface. However, premolars were readily available.