CHAPTER V

DISCUSSION

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

5.1 DISCUSSION OF THE METHODS OF THE STUDY

5.2 DISCUSSION OF THE RESULTS OF THE STUDY

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In the clinical situation, although brackets are finally removed after orthodontic treatment, they are in the oral cavity for several years, and it is necessary to evaluate the durability of the adhesive. Storage in water for 24 hours is normally sufficient to distinguish materials that can and cannot withstand a wet environment. Thermocycling between 5°C and 55C° is usually used as an accelerated aging test. Thermocycling is required to test the bond strength of brackets to ceramics, because of artificial aging and the various thermal expansion coefficients of metal, resin, and ceramic materials.[14,22] In this study, thermal cycling with 1000 repetitions between 5ºC and 55ºC was performed.

In this study, freehand application of orthodontic brackets with an undetermined amount of pressure was used. This method has been used in the majority of protocols on force application and in clinical practice.

Shear bond strength testing after orthodontic bonding has been the standard method of measuring the strength of bonds between brackets and various surfaces.[13,18,22] It has been reported that the direction of the de-bonding force significantly influences shear bond strength values; standardization of this parameter is required for orthodontic shear bond strength testing.[21] Although, in many in laboratory studies, high bond strength were obtained, in clinical situation failures of de-bonding are still being reported at a considerable rate.[5] Many variables, such as porcelain type, bracket base designs, testing device, method and direction of de-bonding, and crosshead speed may affect the data in these investigations. Therefore, evaluations of bonding agents should be made by considering both laboratory tests and clinical trials.

5.2 DISCUSSION OF THE RESULTS OF THE STUDY

The bonding of orthodontic brackets to enamel has been well-documented in the orthodontic literature but with the increasing demand for adult orthodontic treatment, clinicians need to acquire more knowledge about bonding to non-enamel surfaces. In clinical practice, the bond must be strong enough to withstand orthodontic and chewing forces. It has been suggested by Reynolds[39] that clinically adequate bond strength for a metal orthodontic bracket to enamel is 6 to 8 MPa. The mean shear bond strength values of metal brackets to ceramic surfaces in this study showed bond strengths which were all greater than those required for minimal orthodontics forces and, therefore, can be considered sufficient for clinical application.

In this study Hydrofluoric acid (HF acid) was used because its efficiency in improving the bond strength of brackets bonded to ceramics has been widely accepted.[4,7,8,13-16] When the porcelain surface was treated with HF acid, uniformly distributed pores and shallow irregularities were observed.[1] Karan[14] reported that

9.6% HF acid etching is effective in the removal of the crystalline phase and the glass matrix, and then creates a retentive surface. Wolf's study[17] reported that a HF acid etching time longer than 60 seconds increased cohesive failures in porcelain when de-bonding. For this reason, the etching time in this study was reduced to 60 seconds.

In this study, Group I, where the porcelain surfaces were etched with HF acid alone, showed the lowest, but acceptable, mean shear bond strength. Although the bond strength obtained with HF acid etching was satisfactory, there are some disadvantages to using HF acid. Extreme care should be taken during intraoral application of HF acid because contact between the acid and soft tissues can cause severe tissue irritation, thus requiring bonding separately from other teeth, with careful isolation of the working area.[1,18]

It has been previously proved that phosphoric acid is relatively ineffective for providing mechanical retention on ceramics.[17] The effect of phosphoric acid is to neutralize the alkalinity of the adsorbed water layer, which is present on all ceramic restorations in the mouth, and, thereby, enhance the chemical activity of any silane primer subsequently applied.[17]

Silane provides a chemical link between dental porcelain and composite resin, and the organic portion of the molecule increases the wettability of the porcelain surface, thereby providing a closer micromechanical bond.[2] The chemical action of the silane coupler performs two functions; the hydrolysable group of the coupler reacts with the inorganic dental porcelain, whereas its organofunctional group reacts with the resin and enhances adhesion.[24]

However disagreement exists concerning the effectiveness of organophosphoric acid with silane application. The issue of bond reliability using organosilanes has been of concern. Some studies show that application of silane only did not give sufficient bond strength to withstand occlusion force and that silane coating should be combined with surface roughening or HF acid etching.[4,7,9,13,15,16,22-25] However in this study, the use of silanes without HF acid etching (Group II: Phosporic acid, silane, System™1+) demonstrates acceptable mean shear bond strength. This finding confirms the option for using silane to improve bond strength to porcelain—a conclusion that is in keeping with the findings of other authors. [2,10,17-21]

Although HF acid etching with silane application (Group III) resulted in increased bond strength, that value was not significantly different from that of the group subjected to organophosphoric acid and silane (Group II).

There are some factors that might affect bond strength when silane is used. Operating techniques must be such that solutions and bonding surfaces do not become contaminated, because water can greatly interrupt the ability of the silane to react to the porcelain surface. It must be ensured that fresh solutions are being used and that the manufacturer's recommendations for the storage conditions for the silane are followed. Furthermore, the resin must be able to set undisturbed to eliminate weakening of resin during curing.[3]

In this study, two adhesive resin products, System™1+ and Super-Bond C&B were used. System™1+ is a diacrylate resin, based on the acrylic modified epoxy resin, bis-GMA. Super-Bond C&B, a 4-methacryloxyethyl trimellitate anhydride (4-META)/methyl methacrylate (MMA) adhesive resin cement that has been used for bonding orthodontic brackets and has earned a reputation for strong bonding.[33] The 4-META functions as a coupling agent, promoting adhesion to composite resins, enamel, dental alloys and ceramic powders.[34,35]

The groups in which the brackets were bonded with Super-Bond C&B showed significantly higher mean shear bond strength than did those in which System™1+ only when each adhesive was used with HF acid and silane surface preparation. There is no significant different when each adhesive was used with phosphosic acid and silane surface preparation. Although Super-Bond C&B showed markedly high shear bond strength, more destruction of porcelain surfaces also occurred. Moreover, another drawback of Super-Bond C&B is that the application (brush dip technique) was more complicated than that for commonly-used adhesive resin.

After completion of orthodontic treatment, the porcelain restorations generally remain in the mouth after de-bonding. Therefore, an important requirement in bracket bonding to porcelain is that there should be no damage to the ceramic surface after de-bonding. In Group I of this study, adhesive failures were most frequently seen between the porcelain and composite resin. This type of adhesive failure demonstrated that the bond strength between the composite and the bracket and the cohesive strength of the composite were stronger than the bond strength between the composite and the porcelain.

In general, increased bond strength between the adhesive resin and porcelain surface resulted in failures within the resin or resin/ bracket base so that some resin was left on the bracket or the ceramic surfaces. The residual composite on porcelain surface can then be removed with an adhesive removal tool or a slow speed finishing bur.[24] Removal of the composite resin may result in some damage to the porcelain surface. Using the adjustment kit and polishing paste was found to be effective to smooth the porcelain surfaces after de-bonding.[40]

Cohesive failure in the ceramic material could indicate that the bond between the adhesive resin and the ceramic was stronger than the ceramic itself. On de-bonding, the different conditioning/adhesive combinations showed different percentages of damaged porcelain surfaces. Some previous studies found more fracture sites within the porcelain when silane agent was used.[11,21,41] In the present study, all of the groups had specimens with porcelain surface fractures or cracks, except for Group I (no silane application). In this study, the higher the mean shear bond strength values were, the greater the incidence of porcelain fracture. The group with the highest bond strength (Group V) had the most specimens with porcelain fracture. Other factors that may influence cohesive failure in the ceramic are the bonding agent, the ceramic type, and the type of porcelain surface treatment.[8,12]

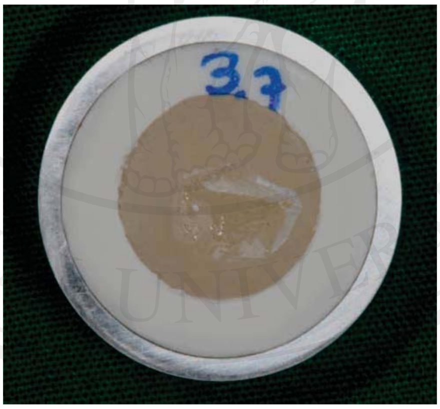

Figure 5.1 Porcelain specimen with surface fracture

However, some assemblies fractured at lower levels of strength. This can probably be explained by the presence of voids and surface cracks, occurring during the process of fabrication of the porcelain, but not detectable under clinical inspection.[20] Cracked surfaces, even those of microscopic size, can act as stress concentrators leading to dental porcelain fractures. The concentrated stress can easily exceed the strength of the porcelain body and, as the depth of the crack increases, a brittle fracture occurs rapidly. Clinically, the dentition can be divided into anterior and posterior parts. When bonding brackets to anterior teeth, where esthetics is of major concern, an appropriate adhesive system with shear bond strength in the optimal range should be chosen in order to minimize potential damage to the porcelain surface after de-bonding. Posterior teeth, on the other hand, have a slightly less esthetic concern, and greater forces may need. In the latter cases, a high shear bond strength combination may be chosen.[8]

Even though the incidence of cohesive porcelain fractures has been found to be excessively high in laboratory testing,[8,10] the incidence of porcelain damage in clinical practice while de-bonding brackets has been stated to be very low, or not to occur at all.[5] The reason for this discrepancy might be that clinically, proper and safe de-bonding techniques are used, with adequate peeling forces, which are different from the techniques and forces used in shear testing in the laboratory.[8,12] The shear force is thought to be a risk factor for porcelain destruction,[41,42] and, therefore, bracket removal by applying tensile forces is desirable. The suggested method for de-bonding orthodontic brackets from a porcelain surface, is to use a ligature cutter applied on the mesial and distal aspects of the bracket base, and then twisting it gently to break the bond.[21] Another approach used for bracket removal is to squeeze the mesial and distal bracket tie wings together, thus distorting the bracket. However, the possibility of porcelain fractures cannot be excluded. Therefore, orthodontists should inform patients about this risk and that they may need a new prosthesis.

In the present study, all of the groups had specimens with porcelain surface fractures, except for Group I (HF acid + System™1+). Although smoothness of the porcelain can be obtained by polishing systems,[18,42] cracks and fractures of the porcelain surface cannot be restored, resulting in the need for fabrication of a new prosthesis. Therefore, to avoid the risk of destroying prostheses during bracket removal, the use of appropriate removal procedures and the use of adhesive system with less risk of porcelain destruction are necessary.