T.C. İSTANBUL YENİ YÜZYIL UNIVERSITY
HEALTH SCIENCES INSTITUTE
DEPARTMENT OF ORTHODONTICS

Comparison of shear bond strength of orthodontic metal brackets bonded with one second LED curing system and conventional LED light curing system

MASTER OF THESIS

Ahmad Fidi Hussein ELALEM

Supervisor
Prof. Dr. Mustafa Haluk İŞERİ

ISTANBUL
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Dedication

Words are not enough to thank my Family at the first place for the unlimited support and the unforeseen conditional love.

My mother, I am grateful for your patience and tender on me, you are the reason why I exist, and without you over there, I wouldn't be able to accomplish any of my goals.

My dad, He was the biggest support of me in all the hard times. He was the one who wanted be to be better even than him, and taught me the meaning of loyalty, dignity and hardworking.

I am very grateful to my wife who supported me by leaving her family behind and coming with me to Turkey only to support me though this journey. She is the one who made my foreignness easier.

To my children: You're the reason for which I struggle in this life, wish you the best, I will always be proud of you.

Acknowledgement

However, I would like to express my deep appreciation and indebtedness to Prof. Dr. Haluk İŞERİ, Prof. Dr. İlter UZEL Prof. Dr. Gökmen KURT, Assoc. Prof. Hüseyin ÖZKAN and Assoc. Prof. Göksu Trakyalı for support as well as kind and understanding spirit during my study.

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Abbreviations

GIC: Glass ionomer cement.

RBC: Resin bonded cement.

SBS: Shear bond strength.

RBC: Resin based composites.

MPa: Mega pascal.

N: Newton.

μM: Micrometer.

Mm: Millimeter.

Sec: Second.

LED: Light-emitting diode.

LCU: Light curing unit.

APC: Adhesive pre-coated brackets.

ARI: Adhesive remnant index

SEP: Self Etching Primer

Abstract

Comparison of shear bond strength of orthodontic metal brackets bonded with one second LED curing system and conventional LED light curing system

Ahmad Fidi Hussein ELALEM

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Aim: The aim of this study is to compare the difference of shear bond strength of bonded metal brackets with using the new one second LED and conventional LED light curing systems.

Materials and Method: It is an experimental *in vitro* study. A total of 40 intact extracted premolar teeth collected and divided into two groups. Metal orthodontic brackets bonded to them using Transbond XT (light-cure adhesive, 3M Unitek, CA, USA). In groups A, curing done using conventional led light given for 20 directly through bracket face. In groups B, curing carried out using the new one second LED light curing system for 1 second (Woodpecker iLED) directly through bracket face. The shear bond strength was recorded by MPa.

Results: The shear bond strength of the Woodpecker iLED (1 second) light cure is more in value than traditional 20 seconds light cure.

Conclusions: The shear bond strength of new one second LED-curing system and conventional LED light curing system are considered acceptable, there is statistically significant difference in the shear bond strength, shear bond strength for 1.sec iLED is bigger.

Key words: Shear bond strength, 3M Transbond adhesive, Woodpecker, iLED, 1 sec. Brackets.

Özet

Bir saniye LED ve konvansiyonal LED ışık sistemlerinin ile metal ortodontik braketler üzerine makaslama bağlanım dayanımının karşılaştırılması

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Amaç: Bu çalışmanın amacı, yeni bir saniye LED ve konvansiyonel LED ışık sistemlerini kullanılarak metal ortodontik braketlerin makaslama bağlanma dayanımının karşılaştırılmasıdır.

Materyal ve metod: Çalışma deneysel bir in vitro çalışmadır. Toplam 40 adet çekilmiş, sağlam küçük azı dişi toplanmış ve bu dişlerin üzerine metal braketler yapıştırılarak iki gruba ayrılmıştır. Birinci grupta (Grup A) metal braketler, Transbond XT (ışıklı yapıştırıcı, 3M Unitek, CA, ABD) kullanılarak geleneksel LED ışık ile yapıştırılmıştır. İkinci grupta (Grup B), yapıştırma işlemi, bir saniye boyunca yeni LED ışık sistemik (Woodpecker iLED) kullanılarak gerçekleştirilmiştir. Makaslama bağlanma dayanımı MPa cinsinden kaydedilmiştir**.**

Bulgular: Çalışma sonucunda Woodpecker iLED (1 saniye) ışık cihazı, makaslama bağlanma dayanımı olarak geleneksel ışık cihazından daha yüksek değerler göstermiştir.

Sonuç: Bir saniyelik LED ve konvansiyonal LED ışık cihazlarının makaslama bağlanma dayanımları kabul edilebilir düzeyde bulunmuştur. Ayrıca, bir saniyelik iLED ile yapıştırılan braketlerin makaslama bağlanma dayanımlarının istatistiksel olarak daha yüksek olduğunu tespit edilmiştir.

Anahtar kelimeler: Makaslama bağlanma dayanımı, 3M Transbond adhesiv, Woodpecker, iLED, bir saniyelik, braket.

1. Literature review

1.1. Introduction

Fixed orthodontic therapy requires attaching brackets on teeth, which cannot be handled without using resin-based adhesion products. With the big success of bonding resins to tooth structures including enamel the use of resin materials has widened from only restorative approaches to cementation and bonding parts to specific tooth or a group of teeth, which is the situation of bracket bonding. Visible light-cured adhesives are the main ones used for bonding orthodontic attachments, this must be the norm because visible light-cured adhesives have plenty of advantages over chemical treated adhesive materials, in addition, light-cured adhesives are easier to use and can provide well extended working time. When orthodontist use light-cured adhesives he can move the bracket all over the tooth and clean the tooth from the excess adhesive. Visible light-cured adhesive materials have better physical properties because air is not impeded as it is not one of the conditions to mix base-catalyst or powder-liquid to set up a light-cured adhesive material (1-3).

On the other hand, light-cured adhesion materials have some disadvantages and the biggest one is the required time that the adhesive material should be exposed to curing light. The main used initiator is comphoroquinone, it is a substance that is sensitive to the blue light (450 to 500nm) wave length, the peak of its activity is at 480 nm. wave length (4).

Argon lasers and plasma arc lights can obviously reduce curing time of any type of dental composite. The Argon laser produced a concentrated beam of light which have 480nm., or around, wave length, this is just perfect for the aim of taking most dental composites into action. Also, plasma arc lights reduce curing time because of much more highly intensive light than halogen light can produce (5).

For better dental practice efficiency, a lot of orthodontists use Argon lasers embedded light curing devices, plasma arc light curing devices, and other speedy curing devices, despite of all aspects of their efficiency for curing our orthodontic adhesion materials isn't well researched. Research in restorative dentistry have shown activating composites with high intensity curing lights or any kind of lasers can lead to bigger value of polymerization marginal leakage and shrinkage in other words increased microleakage (6-11), if this was proved it will be the worst disadvantage for rapid curing.

Polymerization shrinkage is very dependent on the amount of filler, the diluent, and also the percentage of monomer conversion in the resin.

Miyazaki et al. proved that shrinkage related to polymerization goes above the limits as the amount of fillers decreases (12). Least but not the last, a punch of researches have proved that restorative composites that have been cured with laser provide bond strengths similar to those of conventional halogen lights (13-14).

The interest in dental laser and intensive lights such as plasma arc and other types has been growing, to activate resin adhesives, because of their short working time (13-19).

By finishing up the polymerization procedure in no time when compared with the old fashion halogen lights, they own the act of saving noticeable time for doctors and patients (13).

Some studies have concluded that curing orthodontic composites with laser lights such as argon or plasma arc light can end up with bond strength that is very similar with that of old halogen emitters (20-23).

Anyway, more searching is needed to prove the previous foundlings, including double check whether plasma arc lights and Argon lasers lead to increase in microleakage around orthodontic attachments, if this happens the patient's prevalence of decalcification increases and this will lead to definite occurrence of decays. Furthermore, the effect of the orthodontic composites on microleakage and bond strength should be double checked (24,25).

Understanding the basic events that happen in dental polymerization process, regardless the mode of lancing the reaction, can give the dental practitioners to compresence the enormous boosts that have been achieved among years, and will further more lead to precious data on differences among tactics manufacturers use to make their product performance as optimal as possible.

1.1.1 Polymerization

It is the chemical reaction in which low-molecular weighted monomers are remodelled into higher molecular weight chains of polymers. Polymerization is an infinite continuous reaction, it never ends.

In dentistry almost the whole chain of resin based restorative materials uses the same basic monomer family and polymerization mechanism: methacrylates and vinyl, free radical addition polymerization (26).

1.1.1.1 Vinyl-free radical methacrylate polymerization

When we say Vinyl, we mean that organic compound of an electron-rich, with carbon to carbon bond at the terminal of a monomer. In specific way, methacrylates are known by their methyl group covalently bonded to α atom of carbon. Structure of methacrylate monomer is shown in Figure 1.

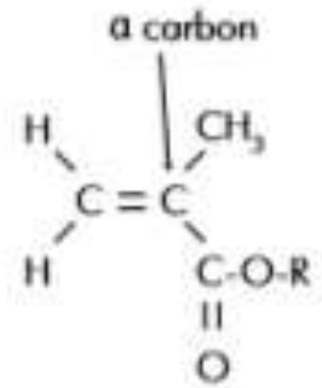


Figure 1: Chemical structure of a methacrylate-based monomer

In the figure above, for example, when “R” is changed with a methyl group we obtain methyl methacrylate, which is a material used in some temporary filling resins, by placement of a “hydroxyethyl” with methyl methacrylate we generate hydroxyethyl methacrylate (HEMA).

1.1.1.2 Creation of radicals

The methacrylate vinyl group is just like a compressed spring awaiting to be released from pressure. In the words, it has an amount of internal energy which can be used to polymerize other methacrylate groups in restorative substance and orthodontic adhesives. The proper method to release this internal energy is finding really active chemical subjects that insanely follows dense electron areas (Double bond of carbon). The ideal chemical substance for this is free radical generators. A lot of kinds of chemicals is being used for this sake, with similarity in end products; chemical compounds are activated by external energy (chemical energy, radiant energy, heat), this process can be seen in Figure 2.

Figure 2: Illustration of external energy factors acting on a radical-generating component to form free radicals

When it becomes in this form, the substance becomes a free radical, with an outer level electron actively looking for another electron to share orbital power, to make a stable molecule, covalent bond. The dentist shall get to know the suitable phase of the reaction to edit and control and he/she should know the best timing for that, and to which level polymerization reaction can continue. Number of free radicals, rate of formation of these radicals, and rate at which they are annihilated that controls the polymerization process. Thus, factors such as proportioning of component, amount of radiant energy exposure, and degree of temperature are controlled by the practitioner, and control the rate of polymerization.

1.1.1.3 Polymerization process initiation

At the moment freed radicals are created, they start to diffuse through resin to seek an area which is rich of electrons, which in methacrylate monomer is the carbon to carbon double bond. When collided, polymerization starts (Figure 3).

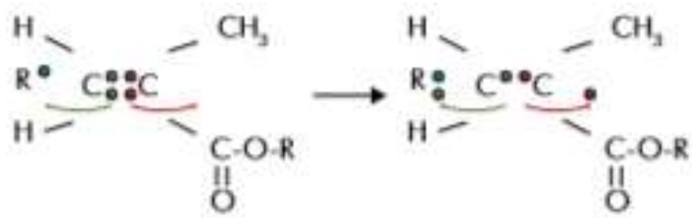


Figure 2: Initiation of polymerization

In polymerization reaction, free radicals take one electron from carbon to carbon double bond, and thus create a covalent bond between itself, and a carbon atom. More than that, we come up with an extra electron that immigrates away, leaving us with one covalent bond between carbon atoms. Extra electron that immigrated will diffuse fast in the resin to find another convenient carbon double bond to react again in the same way.

1.1.1.4 Chain propagation

The first free radical looks for electron dense monomer kinds, reacts with them to make covalent bonds (building a network of polymers), and a new free radical end is also gets built in every monomer that joins the party. This is shown in Figure 4. This way, our polymer chain grows by connecting monomers one by one. Over the, the consumption rate jumps up, auto-acceleration is the specific spike that represents the enormous increase of monomer consumption. As much as monomers added to the polymer group the viscosity of resin raises, and finally diffusion rates calm down until there is no more monomer to add.

1.1.1.5 Termination

A lot of reasons can cause halting the polymerization process. Monomer concentration falls down as the reaction goes ahead, and the radical chains become harder to diffuse as they grow in length. Anyway, the easier scenario is when the last pair of monomers bond together. This action is presented when two chains form covalent bond between each other, which means no more chains at all.

1.1.2 Dental photocuring

1.1.2.1 Photo initiators and electromagnetic spectrum

Light contains photons, these photons have the talent to make free radicals active, by dealing with photoinitiator molecules. Electromagnetic energy is sinusoidal, and can go as fast as the light is. Because the speed is constant, sinusoidal waves traversing a set distance do so using a specific number of complete waves to accomplish that. Frequency is defined as the number of waves that can be done every second. Wave length is the length of each cycle (length of each wave). There is a relationship between wave length and electromagnetic frequency and energy levels; this relation is shown in Figure 4.

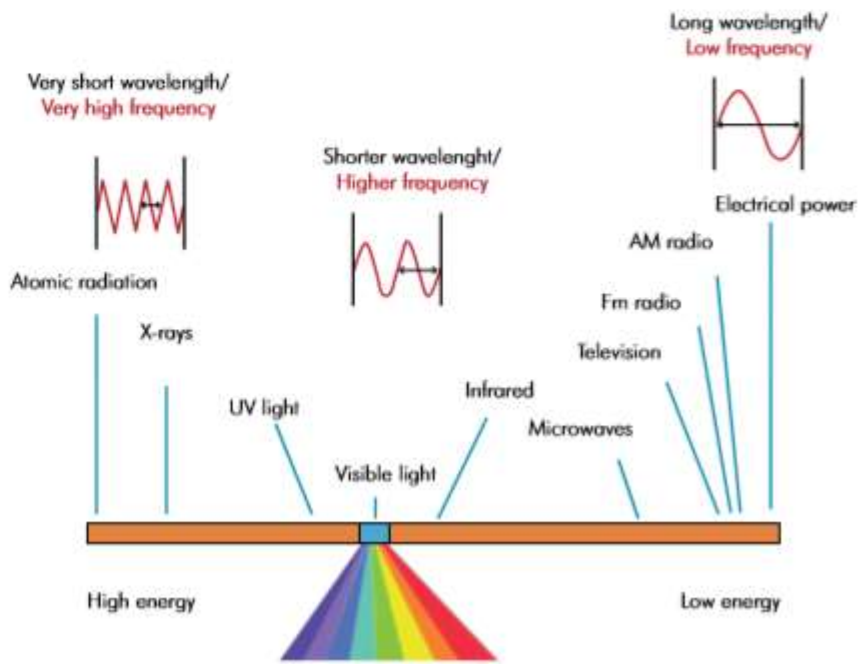


Figure 3: Electromagnetic spectrum with correlated trends in frequency and wavelength

1.1.2.2. UV curing

The use of UV light to activate polymerization is not originally done by dental researchers, it was already used in printing industry. In the last years of 70's, the prime UV-cured restorative material was developed by LD Caulk company. It deployed urethane methacrylate base, the photo initiator was initiated by exposing it to electromagnetic radiation at wave length 365 nm. it was available in many forms for sealants and fillings, direct and esthetic materials were sent to the market (NUVA, Dentsply/ Caulk, Milford, DE). Of course, this variety of products made it possible for this system to last for years, but problems such as the lack in incremental thickness adding when more than 1 mm. and the must to shoot each increment for 60 seconds, made it hard to adapt with this system. After all, the aim of providing the practitioner with a set-on-command direct and esthetic material was achieved. Light curing apparatus of that times was UV source that, consumed power continuously even in standby mode, which means UV bulb will reach the end of its age very early, plus it is dangerous and can cause cataract to practitioners and it altered the oral flora wherever it was used. Nowadays, radiation limits for dental photocuring were set to be within visible light spectrum (380 nm and 700 nm) (27).

1.1.2.3 Visible light curing

There is an obvious relationship between wavelength in nanometers and visible light spectrum. Photons absorption at a specific wave length can commence the conversion of normal light into hidden energy, this energy will be used in the right time to form free radicals. The absorption of photons means depleting their power and deploying it to raise outer level electron from its orbit to a higher energy layer, which is abnormal for atoms and is called the excited state of an electron. Photo initiators are not all the same, there are different types of them. Some of them react to an amine which continue to form a free radical (Type II initiator), and thus encourage polymerization to happen, or photoinitiators can just break into free radicals, in this case they will need assistant compounds to start the polymerization (Type I photo initiators). When the excited state of an electron fails to bring up radical formation to the table, this outer electron comes back to its lower energy state by giving away heat and lower length photons. In other words, the electron will come back to its original situation before the absorption. In light cure systems, free radicals creation depends on and only on the availability of photons within restorative material locally (in depth) to commence polymerization reaction. This is not similar at all to chemical setting, in which depth was not important at all as the whole reaction happens everywhere in the bulk at a time.

1.1.2.4 Dental visible light photoinitiators

The use of photoinitiators in the dental field have aroused from its being used in other industries. In the present days, a lot of different kinds of photo initiator types are being used in resin based, light-cure systems (33). The common photo initiator is camphorquinone (1,7,7-trimethylbicyclo [2.2.1] heptane-2,3-dione) Type 2 initiator system (Figure 5), was well set for dental visible-light setting by a research that was done by Imperial Chemical Industries (29). It contains a donor proton between a tertiary amine molecule, this happens while the Camphorquinone is in its excited state. When the donor proton is transferred, it forms free radical type of polymerization in the methacrylate resin product. Type 1 systems are more effective and photon-efficient than Type 2 systems that depend on CQ (30).

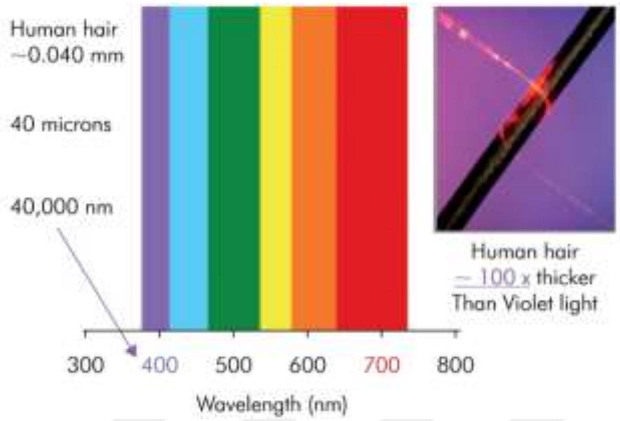


Figure 4: correlation of wavelength and human perception of color, as well as perspective of the physical wavelength of violet light

The color of CQ is canary yellow, and only a very small amount of it is effectively used in photocuring of dental systems. Because of this, restorations which contain CQ have yellow or yellowish shade. With the big demand on bleaching in the 90s of the past century, and the sake of light restorative colors to obtain restoration color that is very similar or has the same color of the light enamel-teeth, it became a big challenge for dental materials manufacturing companies to either exchange CQ completely, or to lessen the concentration of CQ and add a combining synergistic photoinitiator (31).

Later on, it became possible to produce bonding and composite systems that are CQ free systems, they were called “alternative photoinitiators”. Type I initiators which were used in these products, had a sufficient quantum yields as high absorbability (32,33). As a successful product of this group we mention Lucirin ® TPO (2,4,6-Trimethylbenzoyldiphenylphosphine oxide). A better photoinitiator that have a wide-range ability to absorb more into blue spectrum area was also developed; which is1-phenyl-1,2-propanedione, this kind of initiators belongs to Type 2 initiators. It is combined with Camphorquinone, resulting in enhanced resin polymerization, but it slows the speed of reaction, of course with less remaining yellow color (34). The latest initiator Ivocerin®, provides even wider spectrum of absorption. All the initiators have different absorbance range and the ability to receive-absorb light (Figure 6).

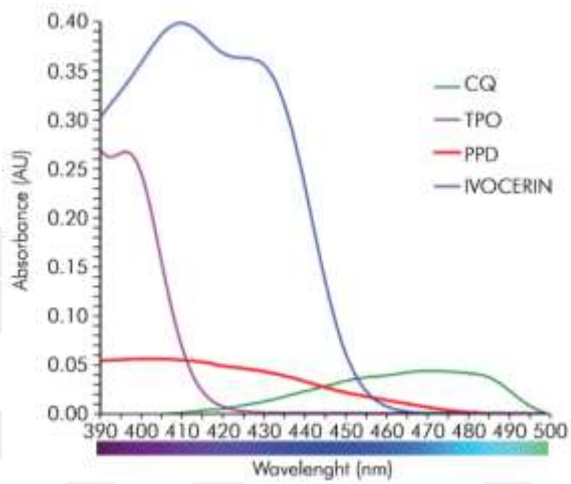


Figure 5: changes in spectral absorption types and absolute absorption values among the dental photoinitiators

1.1.3 Visible light curing lights

1.1.3.1 Quartz-tungsten-halogen lights (QTH)

First approach to use these lights in the dental field was with the first esthetic composite filling was put in a dental cavity in 1976 (35). The bulb is made up of tungsten filament, crystalline quartz filled with kind of halogen gas. This kind of apparatus requires a huge amount of filtration because of big amount of infrared band radiation because of heating of the tungsten. They come in two forms, either gun like hand-held which contains the bulb and a helping cooling fan to keep the temperature cool enough for the apparatus to function, and a user-desire timing selection which vary from 40 to 60 seconds.

Other more rapid curing lights were invented later (PACs) by increasing the light intensity. additionally, the enhanced output was only achievable in a small space in front of the tip of the apparatus which lead to less irradiance, because of the broadened beam divergence of the turbo tip (36). The last try to catch irradiance levels, BOOST mode was integrated into QTH models. This mode depends on increasing the voltage and using a turbo tip (37).

On the other hand, clinicians have big concerns about these devices especially about the scaling effects of rapid polymerization on causing big values of internal stress causing marginal gaps. Because of that, QTH devices became obtainable with "soft start" specification. The philosophy about it is to slow down the rate of polymerization and let the flow of in-polarized restoration that can relief internal stress.

1.1.3.2 Plasma-arc lights (PAC)

Basically, they are two tungsten rods, encased in a high-pressure envelope of xenon, a sapphire window to let radiation escape (Figure 7).

Figure 6: PAC light with heat sinking device

With PACs only small exposure duration of 3 seconds was needed. This was a big enhancement over the long durations QHTs needed. Intraoral tooth whitening became wide-spread by using PACs. As a result, companies started to produce less chromogenic photo initiators, composite colors that are convenient to bleached teeth were available in markets.

1.1.3.3 Argon-ion lasers

Their purpose was to enhance the vital tooth bleaching, and also used in the light curing procedures (37). It was found to be a big, heavy, expensive apparatus, but was still useable in dental office, despite the fact that it produces very short-wave lengths that CQ doesn’t need but still it contained the light band CQ needs to be cured. Unfortunately, there was no light supplied to polymerize TPO, a limited spectrum of PPD was excitable. Then, when other better photo initiators were used, interest in this this kind of apparatus decreased.

1.1.3.4 Light-emitting diodes

1.1.3.4.1 Background

LEDs using in dentistry was also borrowed from using them in other industries. They are not expensive; they can give high output blue LEDs. Blue LEDs was first producing in 90s, they use indium-gallium-nitride (InGaN) (38, 39). and then used in dental curing lights. The advantages of these devices are simply: They require low power, they do not use filament, optical filter and provided much greater efficiency of generating photons more than any other light source. They can get energized by battery power and the LED lamps last for thousand hours of function.

1.1.3.4.2 First generation

It was an experimental prototype to test the efficiency of these LEDs in dental curing (39). It was found that individual LED unit provides a very low output power, so they were arranged in groups (8 to 64) (40), after that, irradiance-increasing-turbo-tip was used to achieve competent light power to QTH for CQ-based composites. After on, and because close-arranged LEDs generated high amount of heat a convenient cooling method was needed to overcome heating. For example, pencil-shaped light cure devices used metal body to distribute heat all over the metal body. Unfortunately, battery technology was very limited at this time and depended on nickel cadmium (NiCAD) (37). The spectrum emitted by these devices was affective for CQ and PPD, but not for TPO.

1.1.4.3 Second generation

1-watt chips were available, consisting of four areas of lighting every area consists of four LED lamps (total of 16). Then, 5-watt devices were produced which made it possible for LEDs to make effective photocuring within short time comparing to QTH and PAC devices. Later on, 10- and 15-watt devices were available in markets (37,41). On the other hand, battery technology was obviously advanced and used nickel metal hydride (NiMH) in it and better ways to decrease heating was developed (37). But till now to TPO interaction was available.

1.1.4.4 Third generation

Just to be able to activate TPO curing the manufacturing companies tried to add violet and blue wavelengths. It was achieved by adding violet light source to the group or by replacing one of the blue lights with violet one. This significantly increased the spectral effect of LEDs and now TPO, PPD, and CQ are all excitable. These devices come in 2 designs gun design and pencil design and used optic fibers to transfer light or without the fiber by putting the emitting portions right on the tip of the device to obtain maximum transfer of light. Lithium batteries are being used in this kind of devices which allows extended clinical operation time.

1.2 Enamel structure and characteristics

The toughest tissue of our bodies is enamel because it is the most mineralized tissue of our bodies (Figure 8). It is thin and translucent calcified tissue. Enamel takes place all around the anatomic crown. The thickness and hardness of enamel differs from person to person and from tooth to another tooth as well as the color. It can be called a dead tissue because no vital supply of blood or nerve endings reach to it. It is made up of inorganic materials: calcium and phosphate ions (hydroxyapatite crystals) form 95 -98 % of its structure, other minerals form a small percentage of it such as magnesium, lead, strontium, and fluoride (42-44).

Beside inorganic materials 1 to 20 percent of enamel is built up from organic stuff, it was found that enamel contains specific proteins called enamelins which bind to hydroxyapatite crystals. 4% of enamel is made up of water.

These materials are not randomly set but the opposite is right, minerals, proteins and water are very arranged. Hydroxyapatite crystals are set in long thin units called (rods) (4-8 μm) diameter (42-44). Generally, these rods go in right angles from dento-enamel junction to tooth surface. Around each rod there is rod sheath made up of protein matrix. Interrod enamel is the area between rods.

There are very small empty spaces made up to open the way for fluids to go through enamel or happened because of demineralization of enamel. Demineralization occurs when pH of the mouth drops below 5.5 that is when crystals shrink and pores become bigger (44, 45).

Ameloblasts which are epithelial cells, are the cells that build up enamel. Before eruption these cells break down, because of that, enamel cannot repair itself. When the tooth erupts the enamel is still not mature and it takes the rest of minerals from saliva (44).

Genetic disorders such as amelogenesis imperfecta and some pathologic factors such as gastroesophageal reflux disease (GERD) weakens the structure of enamel leaving it breakable and weak against cariogenic factors (45-47).

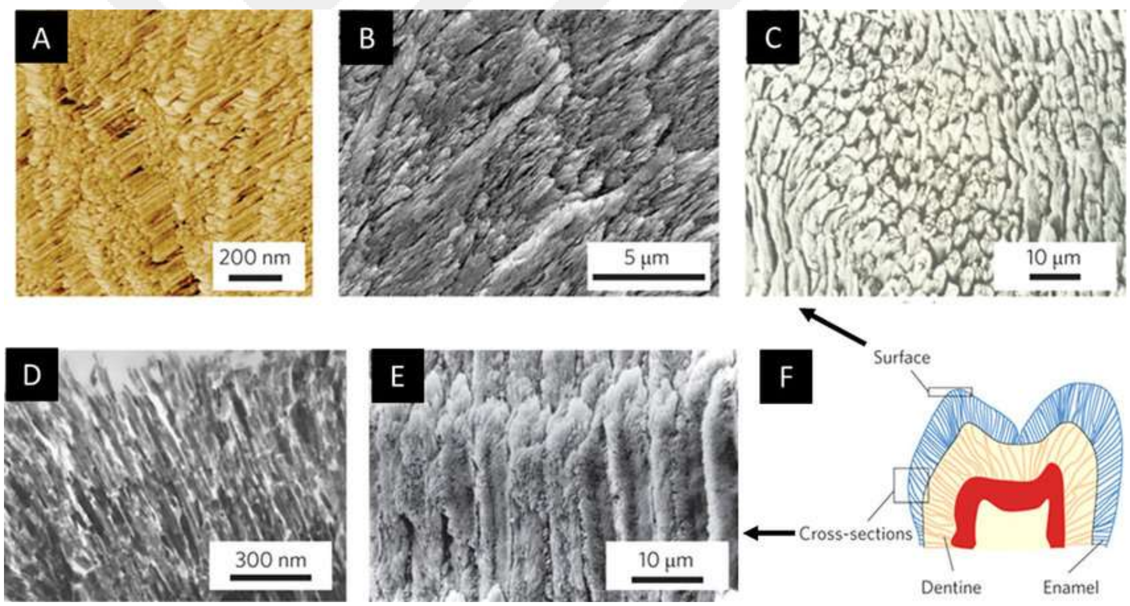


Figure 7: Human dental enamel structure (SEM)

1.3 Preparation of tooth surface for clinical procedures

1.3.1 Prophylaxis

Prophylaxis is a medical term which stands for professional dental surface cleaning. It is advised to do this procedure before applying any chemical etchant on tooth-surface in order to make it easy for the etching material to reach and interact with the surface. A brush or rubber bur is used for prophylaxis, the criteria here is to do it without harming enamel surface with the very least abrasion possible. 10 µm of enamel is lost after using abrasives and apply it by a low-speed brush bur.

1.3.2 Acid etch technique

Buonocore's study in 1955 made a study about acid etching that was used in industrial field to get more efficient resin coatings to metallic surfaces. He tried this method with dental acrylic filling in conservative-treatment cases. In 1974 and depending on investigation done by Silverstone and Retief acid solutions with concentration between 20 and 50 percent applied for one to two minutes were believed to make the best retention, and were ready for clinical use (48-49).

Phosphoric acid change enamel surface in two ways:

- Dissolving a thin layer of enamel
- Creating enamel porous by melting down the ends of enamel rods.

Buoncore (1955) assumed dental etching using 85% phosphoric acid for 30 seconds (55). In 1971 practically the enamel was etched by phosphoric acid 50% solution for 2 minutes application, the estimated amount of enamel loss was between 5 and 25 µm. Six years later, Fitzpatrick and Way found 9.9 µm enamel loss when used 30% concentration solution for 90 seconds (51).

In 1980, Pus and Way treated 50 premolars using 43% phosphoric acid gel and 50 premolars with 37% liquid etching acid, both of the groups in that study were treated for 90 seconds. The result showed average loss of enamel 7.5 and 6.5 µm respectively. In 1973, Wichwire and Rentz decided that premolars' enamel dissolve-rate increases with duration (52).

1.3.3 Concentration of etchant

In 1978, bond strength measured by researchers after using 2-60% phosphoric acid liquids. The best bond strength was done by 16% concentration of acid, the result of 2% and 40% was very similar. In 1986, there was no significant statistical difference in tensile bond strength after 60 seconds treatment by 2%, 5% and 35% acid (phosphoric acid) while the loss of enamel was much greater when 35% acid was used in comparison with 2% of the same acid.

The best method and uniform of etching pattern was introduced right after using phosphoric acid with 30 to 40% concentrations.

In 1974, Rock has reported better more than better bond strengths for human teeth treated with 30% phosphoric acid than with 50% of the same acid (53). Then, the concentration of 37% was and still the common product used in clinics because it offers very good bond strength which is similar to other higher concentrations but with less damage to enamel surface structure.

1.3.4 Duration of etching

In 1990s, etching time was reduced and bond strength was increased all when premolars were etched for 15 sec. and 60 sec. using phosphoric acid of 37% concentration. In 1985m Barkmeier et al. made their research with 15 sec. and 60 sec. etching time, while in 1980, Beech and Jalaly evaluated 5, 15, 60 and 120 second intervals (54, 55).

All of the previous researchers said that there was no decrease in bond strength when etching time was reduced. In 1999, Osorio et al. found that shear bond strength was to increase when enamel was etched for 60 seconds and not only the bond strength but also the residual adhesive material on the tooth surface was bigger (56).

15 seconds etching-time was preferred because it produced more than enough bond strength for orthodontic appliance bonding, and, by using this method researchers could obtain a clean surface after debonding brackets.

In 1996, shear bond strength after 15, 30 and 60 sec etching times, using 37% phosphoric acid as an etchant substance was examined. The debonding procedure was done 5 min., 15min., and 24 hours after bonding. 15 seconds etching / 5 minutes debonding time group showed a lower shear bong strength when compared with other groups. On the other hand, 60 seconds tooth-etching caused damage to tooth surface after being debonded.

In 1986, Carstensen made a clinical study about failure rate of mesh-based brackets bonded to 1134 anterior teeth, these teeth were watched for 30-35 seconds with 37% phosphoric acid-based etchant. In this study, only ten brackets were lost during the 16 months which was the study period. In another study, which compared between the effects of etching for 15-20 seconds and 30-55 seconds, it was found that 15 seconds etching was enough for bracket bonding on anterior teeth (57).

From this study also, 15 seconds etching time became recommended for bonding orthodontic appliances. Anyway, if the bracket is to be aligned within 5 minutes after bonding then 30 seconds etching period is recommended. Then, 60 seconds etching method was found severe and shouldn't be used at all.

1.3.5 Etch pattern

All the studies that are done about shear bond strength were done on extracted human premolars. But it was found that shear bond strength differs according to tooth structure and more specifically it is all about enamel structure, types of teeth and the dental arch in which the teeth are positioned in. exempli gratia, upper anterior teeth have more shear bond strength values than posterior teeth, the opposite was to be found in lower teeth.

Thus, different type of teeth means biological difference in etch pattern which affects SBS that can be obtained. In 1974, Marshall et al. put etched dental surfaces under SEM and made a study about them, they concluded a bigger degree of difference in etching pattern from tooth to tooth and even in different parts of the same tooth, using the same procedure for etching them. Some portions in enamel have thicker aprismatic layer that facilitates melting of the underlying enamel, this phenomenon was observed in premolars more than molar teeth. Depending on these findings researchers assumed that premolars need less etching time than molars (Add marshall's reference).

1.4 Adhesion and adhesives

1.4.1 Resin-based composites

It is made up of organic material and inorganic substance (filler). Monomer is used for Bowen's resin or bis-glycidyl methacrylate. The resin is objected to free radicals adding. This kind of resins is more stable in dimensions and has a lower thermal expansion and shrinkage rates than methyl1-methacrylate based composites. It is a viscous material thus should be mixed with lower viscosity dimethacrylate monomers in order to make it usable in clinical practice.

Resin-based adhesives are classified depending on filler's particle size:

- Macro-filled 10 -100 μm
- Mid-sized 1 – 10 μm
- Mini-filled 0.1 – 1 μm
- Micro-filler <0.1 μm

The RBCs that are being used in our clinics are filled with 0.1 to 1 micrometer diameter particles.

These products differ in setting type it is chemical cured or light cured or even occupies both the chemical and light curing

1.4.2 Glass ionomer cements

This kind of cements come in generations, the first generation of it is luting cements, and it is used in orthodontic practice. It is famous to be used to cement bands around teeth especially molars. The second generation of GICs are restorative materials and the third generation are lining materials.

Glass ionomer cements depend on mixing glass and aqueous polyacid all together to activate acid-based chemical reaction. This reaction releases hydrogen that in turn penetrate the Fluro-aluminosilicate glass and release calcium, strontium and aluminum. It is a long-term reaction; the final setting reaction can continue for weeks or may be for months. Compressive strength of this cement increases over one year while bond strength increases rapidly for a month after that the velocity of this reaction slows down.

GIC material is subjected to hygroscopic changes during setting. Adding a very small amount of water can cause dehydration and increase the excitability of the reaction, as well as damaging the cement surface. Wilson and McLean in 1988 concluded problems while testing bond strength values by mixing conventional glass ionomer cement and putting it in water for 24 hours, the ions' elution theoretically needed formation of cross linked polyacrylate chains (58).

GIC directly sticks to enamel surface. The mechanism of this action is based on the acid's ability to clean, roughen and penetrate the surface of a tooth that in turn decreases the surface energy and facilitates mechanical and chemical bonding.

In 50-75% of orthodontic patients, demineralization occurs on at least one buccal surface at when a bracket is debonded. Demineralization was specified as imperative clinical problem follows long periods of orthodontic treatment starts at the point when glass ionomer discharges its fluoride load, this affects demineralization rates and caries' progression. Antimicrobial effect of fluoride is affirmed.

1.4.3 Resin modified GICs

Glass ionomer cements were prepared to be mixed with water-solvent resin monomers and poly-acrylic corrosive. This product was called resin modifies glass ionomer cement (RMGICs), it is a material which is subject to polymerization and acid-base reaction, which offers ability for setting in darkness.

As same as any GIC product, acid-base response starts when powder and liquid are mixed. The reaction produces low pH mix (3.7) pH degree. Cross-interface is started by an oxidation reaction or by discharging free radicals. A hard blend frames inside which the corrosive base response proceeds. The advantage of RMGIC is that the polymerizing agent improves the setting all the more rapidly and diminishes the affectability of the materials to water. The concoction response proceeds after light reaction is done. RMGICs are also preferred because of its fast speed in the improvement of mechanical specifications. The hydrogel stage isn't generally seen with regular cement after light treatment on the grounds that the polymerization response in the monomer gives incredible quality to material. Monomer polymerization reaction gives big strength to the material.

1.4.4 Self etch primer

Self-etch primers do chemical effect by methacrylic acid that will bond to dental structures. In 1955 Buoncore assumed that glycerophosphoric acid-methacrylate containing resin is able to bond to acid etched dentine (50).

As an efficient substitute to phosphoric acid, polyacrylic acids are used as an approach to overcome the enamel demoralization problem caused by phosphoric acid. But unfortunately, obtained bond quality was bad.

In some new bonding techniques, the primer and conditioner were mixed in one container so bot enamel and dentin can be penetrated, never forget the cost effectiveness of this kind of products.

The active element of self-etch primer is methacrylate phosphoric acid. Phosphate group in phosphoric acid ester methacrylate breaks down calcium atoms and removes it from the hydroxyapatite prisms. Not only breaking down calcium, it combines to phosphate molecule and incorporate into tooth structure when polymerization comes to balance point.

Transbond Plus© 3M Unitek is an orthodontic bonding primer. 3M thought this one-phase etch and primer product can lessen the time needed for bonding fixed appliances. In 2001 White approximated this time-save internal that we are assumed to save while bonding to be 65 % (59). But this saved time is questionable, where pumicing and priming stages are erased and self-etch primers must interact with tooth surface for 3 to 20 seconds. Producers also guarantee that the item works adequately in a humid situation. In this way, the disengagement of the enamel surface to anticipate salivary contamination may not be unequivocal when utilizing SEP. self-etch primers is less sensitive system on the grounds that the material endures the moister contamination. Basically, lower shear bond strength quality in the test group that did not include air drying procedure after applying SEP than the other two test groups (included air drying stage). Using SEP depends on removing debris from enamel using pumice prophylaxis right before bonding. This step can be erased in traditional bonding.

If bond-failure with one-phase system is higher than or equal to conventional (two-stage technique) and if bonding time can be minimized, it is going to better to use a one-phase adhesive system in orthodontic daily treatment. In 2005

Manning *et al.* made a prospective clinical experiment to measure bond failure rates of brackets bonded with SEP-base product (Transbond Plus©) and a conventional acid-etch technique with control adhesive (Transbond XP©). No significant statistical difference was registered between clinical bond failure rates of the brackets bonded using SEP or a traditional acid-etch and resin technique respectively. In 6 months, the bond failure rate for both groups (1.8 %) was low compared with other published similar data (60).

SEP products are less consumed nowadays because significantly more residual adhesive was detected on tooth surfaces after using SEP. Also, bond strength was greater in two-step adhesive than the one-step self-etching primer system. However, both adhesives performed clinically well, and the difference in SBS may be clinically insignificant.

Hirani and Sherriff in (2006) tested SBS debond forces and failure areas of traditional brackets we bonded using SEP based product (Transbond Plus©) and traditional acid etching and conditioning and precoated brackets. Not a single difference was detected in shear bond strength between traditional brackets with SEP and APC. Most of the problems happened at the enamel-adhesive hybrid area (61).

1.5. Orthodontic bracket design

1.5.1. Metal brackets

First approach to make metal brackets was to mill cold stainless steel, it came with perforated-base design to allow adhesive material to flow in. there is no chemical connection, only mechanic interlocking takes place to hold still brackets (Figure 9).

Base design: plain surface with a line of perforations on the outer sides. The modern base design is a mesh-base design which is found to be better for bonding and cleanliness.

Figure 8: 3M Unitek Victory© series

1.5.2. Plastic brackets

First production was in 1970s they were fabricated out of acrylic and polycarbonate as an esthetic alternative to metal brackets. Later on, when they were used by practitioners a lot of problems emerged especially color change and bad smell. The biggest problem was the lack of strength and the permanent change in shape during time and with using metal ligature. Their slots are weak that they cannot express torque as wanted.

Some edits were offered to overcome these problems such as adding metal slots or even changing the whole composing materials (ceramics of fiber glass).

1.5.3. Ceramic brackets

Ceramic brackets are more esthetic than metal brackets. They are stronger than metal brackets as well as they are resistant to deformation and wear, with much better color stability than acrylic brackets. Ceramic brackets sit on the top of pyramid of aesthetic brackets.

They were made of aluminum oxide. The first brackets were each milled using diamond tools. The latest monocrystalline alumina (MCA) brackets are formed from extrusions of synthetic sapphire. Ceramic brackets cannot chemically bond with acrylic and diacrylate bonding adhesives because of their inert alumina composition. As a result, the first ceramic brackets used a silane coupling agent to act as a chemical intermediary between the ceramic bracket base and therefore the adhesive resins. This chemical retention led to very high bond strengths that caused the enamel / adhesive interface to be stressed while removed, leading to irreversible damage to the enamel.

In 1988, The American Association of Orthodontists ran a survey of members' experience with ceramic brackets which were chemically-bonded. The results have led the association to tell its members on potential health problems with ceramic arches and recommended practitioners to debate possible hazards with their patients as they consent them. The most important number of ceramic brackets depend upon mechanical retention only using standard adhesion and that they don't need specific bonding agent.

Birnie found it bad to use sliding mechanics with ceramic brackets, and suggested that if it's necessary it's better to bond metal brackets to premolars if this movement is required (62)

Ceramic brackets are very easy to interrupt while removed. They are tuff and may cause serious damage to the opposing enamel (Figure 10).

Figure 9: 3M Unitek Transcend© ceramic bracket

1.5.4. Metal-reinforced ceramic brackets

Made to enhance the frictional specifications of polycrystalline ceramic brackets, producers made reinforced metal slots to make it possible to obtain smooth slipping mechanics and more strength to ceramic (Clarity© brackets, 3M Unitek). 18 carat gold or other alloys are used to produce these slots (Figure 11).

Figure 10: 3M Unitek Clarity© series bracket

1.5.5. Bracket base morphology

Base design affects both percentages of bond failure and enamel surface damage while debonding. Mechanical interlock is guaranteed by undercuts on bracket internal surface. In metal brackets, manufacturers used to weld a mesh to the base. In clinical use, the mesh shall be thin thus easies to remove. When removing metal brackets this welded mesh can separate from the body of the bracket and stay glued to tooth surface.

Diameter of foil-mesh of brackets, thickness and width of wire mesh, number and size of pores affects shear bond strength. Penetration of the resin depends on filler molecules' size.

When testing the adhesive-base area under microscope air bubbles can be found, may be because of contraction or air retention during bracket bonding. Knox *et al.* (2000) researched the effect of shape of bracket base and bonding material on bond strength and found that adhesive had a big effect on bond strength and that special base formations improved adhesive penetration or enhanced penetration of a curing rays (63).

There are different conflicting reports on the thermocycling effect using different ceramic bracket kinds on shear bond strength. The shear bond strength of a couple of kinds of metallic brackets (one of them comes with one mesh shape and the other one comes with doubled mesh base design) was measured bonded deploying Transbond XT© adhesive. The shear bond forces of each groups of test shown impressive similarity and the when comparing Adhesive Remnant Index (ARI) it has been shown same types of failure patterns. These outcomes showed that the single and double mesh bracket bases have similar shear bond strength and percentages of failure.

Ceramic brackets are very good in aesthetics, but it was a big concern that they can seriously damage enamel surface when debonded with no statistical difference in bond strengths in metal and ceramic brackets.

The trend nowadays is to enhance the advantages and decrease or lessen the disadvantages so researchers and manufacturers are looking forward to make orthodontic brackets that can bond to the tooth tightly enough to hold on till the end of treatment without damaging the dental material.

1.5.6. Adhesive pre-coated brackets

Pre-coated brackets were made to equalize the quantity of composite on the base. Both metal and ceramic brackets with pre-coated base are available. The composite used in this kind is Transbond© XT (3M Unitek), edited to have more viscosity. It is also being used with Transbond© Plus Self-Etching Primer (TPSEP). Pre-coated brackets are designed to reduce chair time by permitting for more rapid and easy bonding steps.

This system has a lot of advantages compared with conventional systems:

- Better adhesive quality,
- Easier finishing after bonding,
- Less residual,
- Better infection-control,
- Better inventory control.

More controllable brackets and adhesive with the use of APC is counted responsible of enhancing shear bond strength and reducing clinical failure rates. Light-cured adhesives provide to orthodontists adequate time to place the bracket on the enamel surface accurately before setting up. It has some disadvantages such as, we know, it takes time to expose each bracket to light.

In 1975, Reynolds found that the clinically acceptable shear bond strength to be 6-8 MPa (64). Sfondrini *et al.* reported in 2002 bigger amount of bond strengths than that despite of the type of bracket or light used (60). Even light-curing for 2 seconds with the micro-xenon light could give clinically approvable bond strengths for both normal and precoated kinds of brackets. The incredibly lessen time of setting obtained by micro-xenon light gives a huge pro for the patient and the practitioner.

1.6. Bracket removal

1.6.1. SBS test

Shear bond strength test is designed to measure the adhesion potential force of dental adhesives Barkmeier and Cooley (1992). Vitro bond strength tests are beneficial for guessing the performance of adhesive systems.

A lot of publications on bond strength tests have been done, the outcomes of which were adapted by producers to support their products' stocks. However, it seems that a lot of those researches were done depending on different methods that made it hard to compare outcomes of different bonding procedures. Thus, it is better standardizing test procedures to measure bond strengths.

Hobson and McCabe (2002) researched the interaction between the characteristics of etching and enamel-resin bond strength. Twenty-eight participants had their dental buccal areas etched and then examined under SEM. Result was no distinguished statistical difference in both patterns in upper and lower jaw teeth. Anyway, the median showed variations between tooth kinds, the least bond strength was found on the upper first molar and the least on the lower first molar. Ideal etch method was not basic in order to obtain sufficient bond (65).

When SBS with SEP were compared with traditional bonding products in lab researches, brackets attached by SEP had a lower mean of shear bond strength opposite to traditional products. Anyway, after putting those brackets under physical stress, both showed same mean value of holding times.

1.6.2. Unit of measurement of shear bond strength

The standardized unit of measurement that can describe bond strength is questionable. Units such as Pascal, Mega Pascal, and Newton per millimeter squared or Mega Newton per meter squared have been used. Only when we have a controlled place, we can deploy force as a guide for bond strength values, at all circumstances it is hard to precisely measure it. When bracket base's dimensions are mentioned, it is good to use Newton or Mega Pascal in recording bond strength.

1.6.3. Method and direction of debonding

Most of Fox and McCabe (1994) research documents, used Instron just like the machine used in this study. Sum of other kinds of machines were used in the rest of their documents, such as machines prepared with opening pliers and other kinds also. 44 out of 66 papers tested units in shear mode, while 16 papers tested tensile strength and 6 tested the combination of directions.

Other researches which deployed Instron machine for testing specimens shows variant changes in the direction and method of debond. There is a problem about the precise relationship between tested brackets and its linking method to the testing machine. A big number of researchers have used a wire loop to pair brackets with machine.

The majority of research into SBS with the same testing device has applied one-side force to tested brackets. The results don't reflect clinical bracket removing. Removing rackets with pliers in the clinic means to-side force application at the adhesive-base level which is effective way to remove ceramic brackets and using them in in vitro stems can give real outcomes for clinical conditions.

1.7 Transbond™ XT

A study done to evaluate shear bond strength of couple of self-etch and bond products and compare them to Transbond™ XT said that "Using the two self-etching adhesives (Prompt L-Pop™ and Scotchbond™) for orthodontic appliances does not affect either \the SBS or ARI scores compared with the commonly used total-etch system Transbond™ XT". Additionally, Scotchbond™ Universal can bond efficiently all kinds of tissues and materials from enamel to metal, porcelain and composite without any other primers. Then, it is going to be good to make orthodontic bonding easy.

1.8 Woodpecker iLED 1sec.

1.8.1 Features:

- The ability to set 2 mm. thickness in one sec.
- Twin Mode- P1 (High intensity mode); P2 (Normal intensity).
- Maximum Intensity 2300 - 2500 Mw/cm^2.
- Intensity meter offered for free in the package.
- Disposable sleeves.
- Strong tip which is able to rotate in every direction.
- Its light intensity is stable so you don't have to worry about battery drainage effect on light efficiency.
- Can stand by to 60 days.

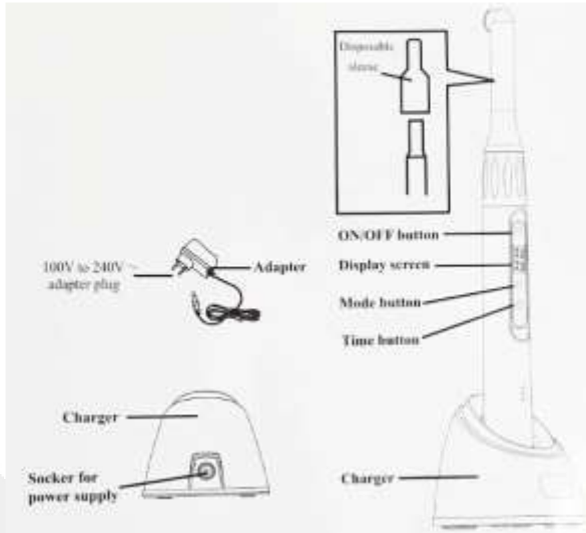


Figure 11: Woodpecker iLED apparatus

1.8.2 Technical specifications

- Dimensions: 25 mmx25mmx240mm.

- Net weight: 278g.

- Power source: rechargeable lithium battery ICR 18490 with 3.7V voltage and 1400mAh capacity; the battery has protection against high voltage.

- Adapter with power input: 100V to 240V, 50Hz/60Hz.

1.9 Woodpecker LM-1 digital intensity meter

This kind of appliances are being used to estimate the efficiency of light curing systems. They have a built-in radiation meter used to measure the wavelengths produced by LED appliance that we have used in our study (Figure 13).

Figure 12: Woodpecker LM-1 intensity meter

2. Materials and Methods

Laboratory workshop examination divided into two groups both tested for shear bond strength. The two groups consisted of human extracted teeth prepared previously by bonding one bracket for each tooth. Two different light curing methods were used, one of them is the conventional 20 seconds LED light cure and the other is the new 1 second LED light cure (both sides of a bracket for both groups). Shear bond strength was tested using Instron universal examination mechanism.

2.1 Tooth specifications

A total of forty intact human premolar teeth (maxillary and mandibular) extracted for orthodontic reasons (crowding, etc.) were cleaned and separated into two groups; each group contained 20 premolar teeth. These teeth were healthy but extracted for orthodontic reasons, which is why they were easy to acquire. They were collected from clinics of Istanbul Yeni Yuzyil University, School of Dentistry and from other private clinics.

Those teeth were preserved in distilled water containing thymol which inhibits growth of microbes, and they were set in dark place at 37°C. (Fox et al, 1994).

All teeth were tested under surgical emission to insure their reliability for the test.

<u>Exclusion criteria:</u>

- Teeth with caries.
- Teeth with restorations.
- Teeth with cracks or with defects in enamel.
- Improper conserving and storing of the extracted teeth.

- Teeth with enamel hypoplasia.

<u>Inclusion criteria</u>

- Intact teeth.
- Non-restored teeth.
- Healthy enamel.
- Well stored teeth.

2.2 Sample preparation

Each sample was put vertically from apex till cemento-enamel junction in self-curing orthodontic acrylic within special box (cubic containers). The teeth were allocated in a way so the labial surface of crowns was obviously above acrylic surface. Samples were then stored again in distilled water at room temperature to prevent dehydration (Figure 14).

Figure 13: Tooth embedded in acrylic cube

2.3 Enamel surface preparation and bracketing

First of all, buccal surfaces were cleansed and polished using fluoride-free pumice utilizing rubber-cub bur on micromotor hand piece for 10 seconds for each sample (Figure 15).

Figure 14 : Sample's enamel buccal surface polishing

Then, every sample was rinsed with air/water pump (spray) for 15 seconds and dried with oil-free compressed air for 10 seconds (Figure 16).

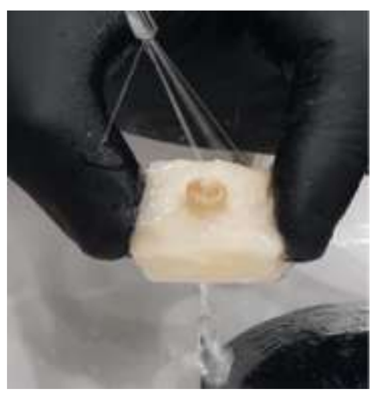


Figure 15: Tooth being rinsed

The samples were then etched by phosphoric acid gel 37% concentration for 40 seconds and then the teeth was rinsed and dried just like the previous step (Figure 17).

Figure 16: Etching and rinsing the samples

Later on, samples were separated into 2 groups, each group contained 20 teeth (Figure 18).

Figure 17: Group arrangement

2.4 Power analysis

In this research, power analysis was an important part of course to determine the accurate number of needed samples. The acceptable sample size was found equal to 17 for each group. This analysis was performed with G* power 3.1 program and sample spectrum analysis performed by taking 0.8 power value in two groups (alpha error probability = 0.05). According to this calculation we decided our groups to be 20 sample for each group.

2.5 Bracket selection

2.5.1 Bracket type used in this study

In our study metal brackets were used for all of the specimens.

Upper first premolar brackets were used in our research as they are convenient for our specimens (extracted upper first premolars teeth).

FAIRFIELD Stratus product was selected because more and more practitioners are using it for its good outcomes for convenient price. Stratus brackets come with 0.018 mil slots and MBT Rx (Figure 19).

Figure 18: Fairfield Stratus metal bracket set

2.5.2 Group A – phosphoric acid etch, primer, metallic bracket, traditional light cure 20 second

This group contained 20 elements as was mentioned before, each element (tooth) was etched with phosphoric acid 37%, rinsed with water flow for 10 seconds, a layer of 3M Transbond bonding agent was applied by its special brush and cured for twenty seconds. 3M Transbond XT adhesive material was applied to whole brackets then the brackets were placed on the center of the long axis of each crown and light cured for 20 seconds with the tip touching bracket surface perpendicular to bracket’s long axis. (Figure 20).

Figure 19: Bracket placing and light curing of each group in different time

Figure 20: Used materials

2.5.3 Group B – Phosphoric acid, primer, metal brackets, WOODPECKER iLed light cure 1 second

This group also contained 20 teeth, etched with phosphoric acid 37%, rinsed for ten seconds, a layer of 3M Transbond applied and cured by Woodpecker iLED light cure apparatus, 3M Transbond XT adhesive applied to the brackets and then placed properly on the center of the long axis of each crown and light cured for one second with the tip touching bracket's surface.

Table 1: Test groups

Group	Number of samples	Etchant	Bonding agent	Adhesive material	Bracket type	Light Cure
A	20	Phosphoric acid (37%)	Transbond ™ XT Primer	Transbond ™ XT Adhesive	Metal bracket	Traditional iLed light cure 20 second
B	20	Phosphoric acid (37%)	Transbond ™ XT Primer	Transbond ™ XT Adhesive	Metal bracket	Woodpecker iLed light cure 1 second

Table 2: Apparatus properties

Wavelength range	Period of exposure	Intensity
420 - 480 nm	20	950mW/cm²
420 - 480 nm	1	2300 mW/cm²

2.6 Bond strength testing

Before starting the test, authorization marked by the analyst, the administrator and the chief of the lab. SBS test of this research was done in hard tissue laboratory in Bezmialem Vakif University. SBS was tested using Instron Universal Testing Machine, (The Shimadzu Autograph AGS-X series model 3655, Japan) with a limit of 5000 newton. It gives the predominant performance and viable testing answers for a wide array of uses. Offering abnormal state control and intuitive operation, the AGS-X series sets another standard for strength evaluations while giving the most extreme in security consideration in advanced, stylish design.

Each inserted example was amassed in a modified jig in the lower crosshead of the Instron Universal testing machine (Figure 22). The jig had a square gap in every brass mold has been matched the space. A brass mold will be balanced, empowering shear effort to aim to the best direction into an axis of the bracket body. Examples has been putting intentionally into aimed the connected force occluso-gingival also analogy into a labial tooth surface.

The blade was parallelly oriented to the bracket base and an occluso-gingival force was connected at a crosshead speed of 1mm/min. This separation has been locked into every example; the expansion in gap to a tooth will rise these bond strength (Katona, 1997) (66). When it is been examination procedures, an Instron was 2 kW load cell also cross-head speed of 1.0mm/min (Sunna and Rock, 1999) (67).

The Instron machine connected with electronica reader that records the estimation of greatest load connected at failure in Kg and Newton and this information were in this way changed over to mega Pascal (MPa) as a ratio of Newton to the surface area of the bracket utilizing the following equation:

MPa= (Load (mass) (kg))/ (Bracket base area) X gravitational acceleration constant (9.81):

1 Kg = 9.81 N

1 MPa = N/mm

That bracket base size in every bracket type dictated by using that average sum for that widths and lengths of ten brackets systematic utilizing digital calipers. The connected force makes tensile stress that will, in general, peel the bracket far from the tooth surface, in view of that the term 'shear–peel' is more accurate to use at an article so it can accept that reality than 'shear–bond' (Katona, 1997) (66).

The vivo, differed effort is applied on the brackets and stress dispersions produced inside the adhesive is compound (mix from tensile, compressive force system also tensile). Therefore, an Instron machine was bound so it will make a shear-peel force which copies a clinical circumstance albeit not under any condition honestly show that (Tavas & Watts, 1979).

Figure 21: Instron Universal Testing Machine

2.7 Method error calculation

20 % of samples were randomly selected and reexamined with an interval of one week. The standard error of method, as calculated using Dahlberg's formula (1940) was below the level of statistical significance, $p>0.05$.

2.8 Statistical analysis

Statistical calculations were performed with SPSS (Statistical Package for the Social Sciences, 2008) statistical software program for windows. Independent t-test was used to assess for a statistically significant difference in mean values between test groups for SBS. Equal variance t-test was performed during the evaluation qualitative data. Statistical significance level was established at $p<0.05$.

3. Results

The shear bond strength of the Woodpecker iLED (1 second) light cure is more in value than the traditional (20-second) light cure.

Group A contains 20 specimens cured with traditional LED device for 20 seconds. Results of Group A are showed in Table 3.

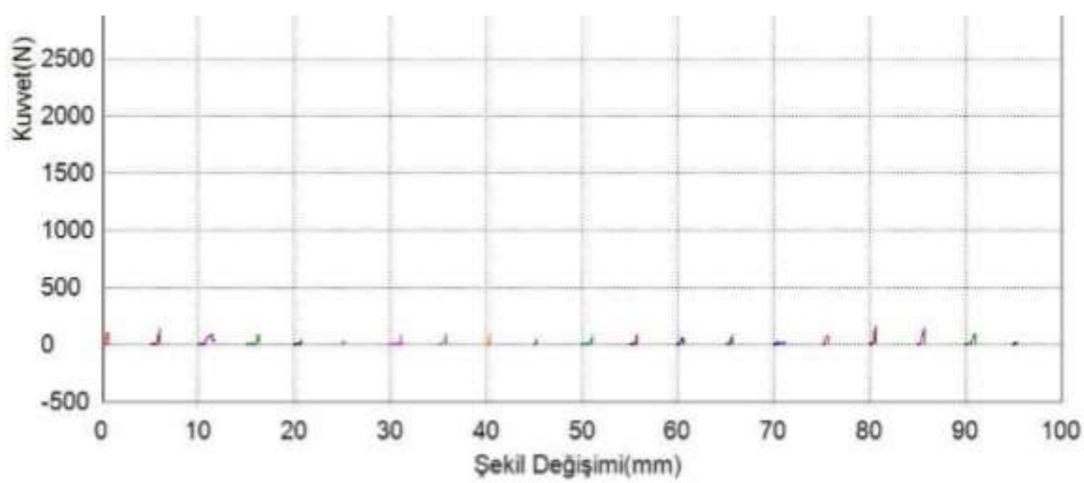
Table 3: Group A results

Name	Max-force	Max-stress
Parameters	Entire area calculation	Entire area calculation
Unit	N	Mpa
G1 – 1	100.4820	8.37353
G1 – 2	133.8960	11.1580
G1 – 3	80.5820	6.71433
G1 – 4	83.9440	6.99533
G1 – 5	38.6691	3.22243
G1 – 6	28.3082	2.35902
G1 – 7	76.0110	6.33425
G1 – 8	91.3986	7.661655
G1 – 9	92.9499	7.74582
G1 – 10	40.6098	3.38415
G1 – 11	83.0301	6.91917
G1 – 12	86.3822	7.19852
G1 – 13	60.2786	5.02322
G1 – 14	77.4678	6.45565
G1 – 15	27.3395	2.27829

G1 – 16	71.6551	5.97126
G1 – 17	156.3250	13.0271
G1 – 18	138.4940	11.5412
G1 – 19	93.7303	7.181086
G1 – 20	14.3123	1.19269
Mean	78.7928	6.56607
Stardent deviation	37.413	3.11776
Maximum	156.325	13.0271
Minimum	14.3123	1.19269
Mid range	81.8011	6.81675

The results above were arranged in chart table form in Figure 23. This chart expresses the force each bracket could handle before breaking in group A.

Figure 23: Chart table showing the result of group A



Group B contains 20 specimens cured with Woodpecker iLED 1 second device for one second curing time. Results of Group B are showed in Table 4.

Table 4: Group B results

Name	**Max-force**	**Max-stress**
Parameters	Entire area calculation	Entire area calculation
Unit	N	Mpa
G2 – 1	225.093	18.7577
G2 – 2	193.466	16.1222
G2 – 3	196.621	16.3851
G2 – 4	236.276	19.6897
G2 – 5	159.988	13.3324
G2 – 6	106.154	8.76281
G2 – 7	95.1998	7.93331
G2 – 8	76.3687	6.36405
G2 – 9	235.562	19.6302
G2 – 10	172.101	14.3418
G2 – 11	127.538	10.6282
G2 – 12	188.042	15.6702
G2 – 13	105.681	8.80679
G2 – 14	56.3391	4.69493
G2 – 15	170.834	14.2362
G2 – 16	82.1106	6.84255
G2 – 17	185.261	15.4384
G2 – 18	205.028	17.0857
G2 – 19	118.046	9.83715

G2 – 20	110.008	9.16733
Mean	152.236	12.6863
Stardent deviation	56.2014	4.68346
Maximum	236.276	19.6897
Minimum	56.3391	4.69493
Mid range	165.411	13.7843

The results above were arranged in chart table form in Figure 24. This chart expresses the force each bracket could handle before breaking in group B.

Figure 24: Chart table showing the results of group B.

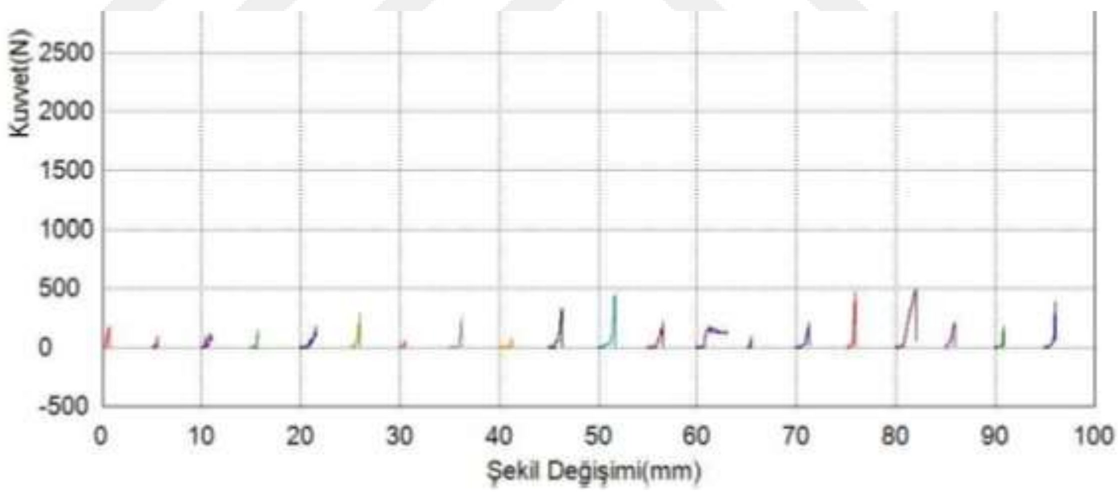
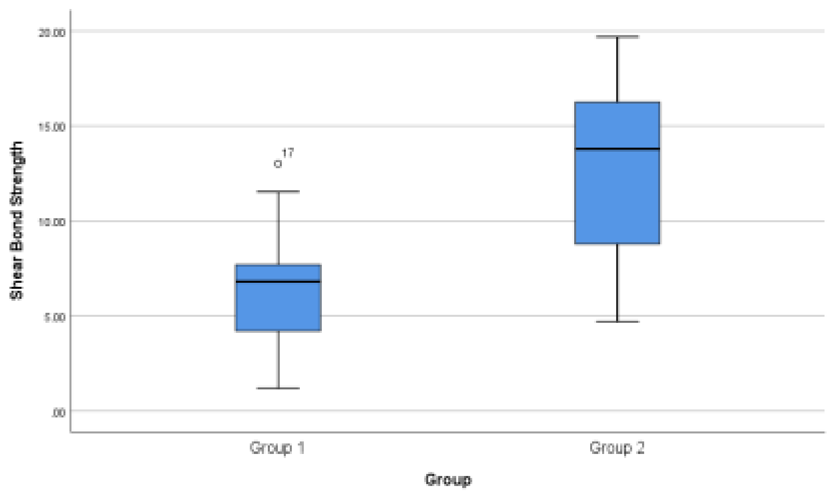


Table 5: Tests of Normality

Tests of Normality			
Group	Shapiro-Wilk		
	Statistic	df	Sig.
Group 1	0.950	20	0.360
Group 2	0.942	20	0.258

Table 6: Comparison of SBS between two groups (MPa)

Group	N.	mean	Standard Deviation	Minimum	Maximum	95.0% CL for Mean	
						Lower	Upper
Group 1	20	6.56	3.11	1.19	13.03	5.08	7.99
Group 2	20	12.69	4.68	4.69	19.69	10.49	14.88



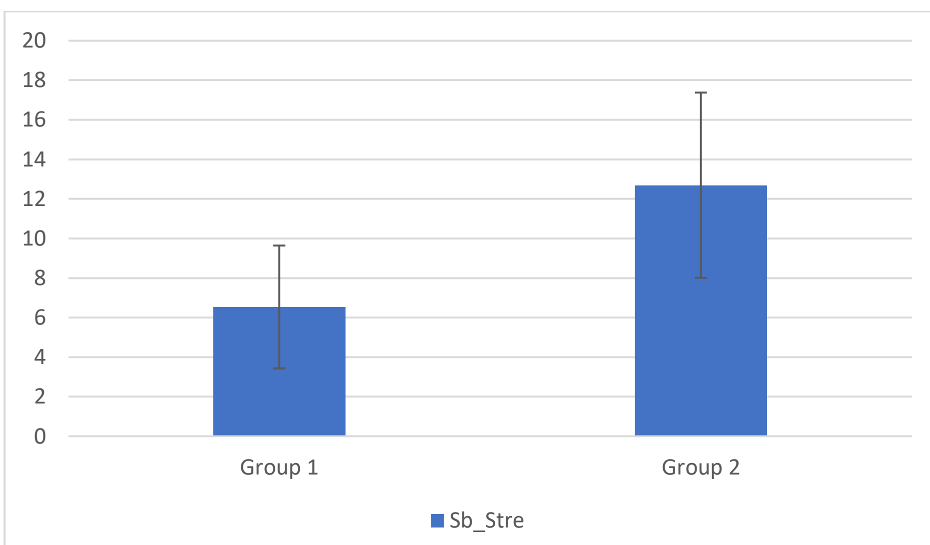


Figure 22: Bar-chart of shear bond strength in MPa between two study groups

Table 7: Mean difference of shear bond strength in MPa between two study groups

	t	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
Shear Bond Strength	-4.892	0.000	-6.15	-8.69	-3.60

Data are mean ± standard deviation, unless otherwise stated. An independent-samples t-test was run to determine if there was a difference in shear bond strength between the two groups. One outlier was detected that was more than 1.5 box-lengths from the edge of the box in a boxplot. Inspection of its value did not reveal it to be extreme and it was kept in the analysis. Shear bond strength scores for each group were normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$). The shear bond strength was greater in Group 2 (12.69 ± 4.68) Mpa than Group 1 (6.56 ± 3.11) Mpa, with statistically significant difference of -6.15 Mpa (95% CI, -8.69 to -3.60), $t = -4.892$, $p<.0005$.

4. Discussion

Recently, with the wide spread of light activated dental materials, light curing's efficiency became very important for success of the practice of any dentist or orthodontist. Successful fixing of orthodontic attachments is not a subject of discussion because these attachments are being used to move teeth in all directions of three dimensions, which requires the ability to handle all forces of movement and mastication during the whole treatment period.

Many techniques were developed in bonding and adhesion materials in order to enhance the productivity of bonding procedures and ensure the required stability (Flurry et al, 2013; Price et al, 2010). A lot of studies were made in the field of easing bracket bonding procedures such as reducing chair time and maintain enough bonding strength in the time (68).

Polymerization is the chemical reaction in which low-molecular weighted monomers are remodelled into higher molecular weight chains of polymers. Polymerization is an infinite continuous reaction, it never ends.

In dentistry almost the whole chain of resin based restorative materials uses the same basic monomer family and polymerization mechanism: methacrylate and vinyl, free radical addition polymerization (26).

LED systems and light curing units (LCU) are widely used in orthodontic practice. The light used in these techniques have the specifications that allow them to emit a blue wave light which in turn activates the curing mechanisms (Mills and Jandt 1999; Uhl et al 2004). A second generation with higher power of LED and LCU was also developed. These second generations were supposed to be more effective than the previous generation especially in terms of time required for the curing to be done (Rueggeberg, 2011). Rueggeberg and Mills et al. also came with report that third generation of LED LCU can provide enough irradiancies with appropriate wavelengths which can polymerize any kind of resin based restorative materials and also it shortens curing time so much (37, 38, 69).

On the other hand, fixing firm brackets on the surface of teeth was a real great development in orthodontics because it allowed wide spectrum of movements. Buonocore (1955) found that bond strength increased after etching the enamel surface. Bonded brackets are found to be way better than the old fashion bands because they are easier to attach and remove, they don't require tooth separation, more aesthetic and hygienic and cause less irritating to the gingiva. Besides, the problem of high-frequency bond failure during treatment navigated manufacturers to focus on improving bonding systems and curing techniques. Thus, light curing systems were developed to improve the bonding (50).

Light cure systems were developed in the 1970s by Leonard et al (2004) and believed to become a very essential part of modern dental practice. They are multipurpose apparatuses that are used mainly to cure resin based composite restorative materials, resin modified glass cement, as well as to bond orthodontics brackets to the teeth (Leonard et al, 2004; Alshali et al, 2013). Light activated systems are likely to be used in dental clinics because the allow long working time controlled by the practitioner which allows precise positioning of brackets (70, 71).

The big advancing in the field of light curing started with the invention of light emitting diodes (LEDs) (Rueggeberg 2005). According to Uhl et al 2004 the modern light curing devices are dense, have unlimited lift, work at reduced voltage and they do not need filter to limit the wavelength range. The first generation of LEDs was limited due to its low power density 150mW/cm^2 and it was worse than conventional quarts tungsten halogen (QTH) lights. The second generation was better that it gives higher power output (Uhl et al 2004). The third generation of LED has even lower density chips, which emits light wavelengths in the violet colour area of the electromagnetic spectrum (400 nm)

(Price et al, 2005). In general, the LED lights is classified as broad banded (72-74).

Bondable brackets were in use in orthodontics since 1960s and used by acid etching technique (Buonocore 1955; Newman 1964). During that period, only chemical activated materials were available in markets. The production of light activated bonding systems improved working time and made it sufficient to properly locate the bracket and remove the excess. It also allowed new binding methods by using different composites and light curing devices (Stansbury, 2000) (75).

The use of LED systems in orthodontics was first suggested by Mills (1995). It was thought that LEDs can increase the efficiency of photo-activation, decrease polymerization time, reduce chair time and provides more comfort to patients (Mills, 1995; Price et al, 2003; Layman and Koyama, 2004). Moreover, LEDs are small, they have reduced noise and heat with longer life source and lower power (Dunn and Taloumis, 2002) (76).

In this study, we collected 40 intact human premolars that were extracted for orthodontic reasons. The samples were preserved in distilled water for a limited period before we finish collecting and start the examination. Later on, every tooth was imbedded into an acrylic cubic base to simulate periodontal support. Metal brackets (Fairfield Stratus) MBT Rx with 0.018 mil slot for each bracket; were put just like every single premolar bracket to one specimen, on its proper location on the buccal surface. Then, after separating teeth into 2 groups of 20s, one group was cured by conventional LED apparatus for 20 seconds each and the other group was cured by Woodpecker iLED apparatus for 1 second each. With the tip direct touching brackets surface, our specimens then were sent to the lab to be tested by the Instron machine to obtain measurements of SBS.

Research steps were as follows, forty intact human upper first premolars extracted for orthodontic reasons (crowding, etc.) were cleaned and separated into two groups, each group contained 20 premolar teeth. These teeth were healthy but extracted for orthodontic reasons that is why they were easy to acquire. They were collected from clinics of İstanbul Yeni Yuzyil University, School of Dentistry and from other private clinics.

Each sample was put vertically from apex till cemento-enamel junction in self-curing orthodontic acrylic within special box (cubic containers). The teeth were allocated in a way so the labial surface of crowns was obviously above acrylic surface. Samples were then stored again in distilled water at room temperature to prevent dehydration.

First of all, buccal surfaces were cleansed and polished using fluoride-free pumice utilizing rubber-cub bur on micromotor hand piece for 10 seconds for each sample.

Then, every sample was rinsed with air/water pump (spray) for 15 seconds and dried with oil-free compressed air for 10 seconds. The samples were then etched by phosphoric acid gel 37% concentration for 40 seconds and then the teeth was rinsed and dried just like the previous step. Later on, samples were separated into 2 groups, each group contained 20 teeth.

In this research, power analysis was an important part of course to determine the accurate number of needed samples. The acceptable sample size was found equal to 17 for each group. This analysis was performed with G* power 3.1 program and sample spectrum analysis performed by taking 0.8 power value in two groups (alpha error probability = 0.05). We decided our groups to be 20 sample for each.

In our study metal brackets were used for all of the specimens. FAIRFIELD Stratus product was selected because more and more practitioners are using it for its good outcomes for convenient price. Stratus brackets come with 0.018

mil slots and MBT Rx. Only upper first premolar brackets were deployed for this research.

First group contained 20 elements as was mentioned before, each element (tooth) was etched with phosphoric acid 37%, rinsed with water flow for 10 seconds, a layer of 3M Transbond bonding agent was applied by its special brush and cured for twenty seconds. 3M Transbond XT adhesive material was applied to whole brackets then the brackets were placed on the center of the long axis of each crown and light cured for 20 seconds with the tip touching brackets' surface.

Second group also contained 20 teeth, etched with phosphoric acid 37%, rinsed for ten seconds, a layer of 3M Transbond applied and cured by Woodpecker iLED light cure apparatus, 3M Transbond XT adhesive applied to the brackets and then placed properly on the center of the long axis of each crown and light cured for one second also with the tip touching brackets' surface.

Each inserted example was amassed in a modified jig in the lower crosshead of the Instron Universal testing machine. The jig had a square gap in every brass mold has been matched the space. A brass mold will be balanced, empowering shear effort to aim to the best direction into an axis of the bracket body. Examples has been putting intentionally into aimed the connected force occluso-gingival also analogy into a labial tooth surface.

The blade was parallelly oriented to the bracket base and an occluso-gingival force was connected at a crosshead speed of 1mm/min. This separation has been locked into every example; the expansion in gap to a tooth will rise these bond strength (Katona, 1997) (66). When it is been examination procedures, an Instron was 2 kW load cell also cross-head speed of 1.0mm/min (Sunna and Rock, 1999) (67).

The Instron machine connected with electronica reader that records the estimation of greatest load connected at failure in Kg and Newton and this information were in this way changed over to mega Pascal (MPa) as a ratio of Newton to the surface area of the bracket utilizing the following equation:

MPa= (Load (mass) (kg))/ (Bracket base area) X gravitational acceleration constant (9.81):

1 Kg = 9.81 N

1 MPa = N/mm

That bracket base size in every bracket type dictated by using that average sum for that widths and lengths of ten brackets systematic utilizing digital calipers. The connected force makes tensile stress that will, in general, peel the bracket far from the tooth surface, in view of that the term 'shear–peel' is more accurate to use at an article so it can accept that reality than 'shear–bond' (Katona, 1997) (66).

The vivo, differed effort is applied on the brackets and stress dispersions produced inside the adhesive is compound (mix from tensile, compressive force system also tensile). Therefore, an Instron machine was bound so it will make a shear-peel force which copies a clinical circumstance albeit not under any condition honestly show that (Tavas & Watts, 1979).

20 % of samples were randomly selected and reexamined with an interval of one week. The standard error of method, as calculated using Dahlberg's formula (1940) was below the level of statistical significance, $p > 0.05$.

Statistical calculations were performed with SPSS (statistical package for the social sciences, 2008) statistical software program for windows. Independent t-test was used to assess for a statistically significant difference in mean values between test groups for SBS. Equal variance t-test was performed during the evaluation qualitative data. Statistical significance level was established at $p<0.05$.

Genetic disorders such as amelogenesis imperfecta and some pathologic factors such as gastroesophageal reflux disease (GERD) weakens the structure of enamel leaving it breakable and weak against cariogenic factors (45-47).

Buonocore's study in 1955 made a study about acid etching that was used in industrial field to get more efficient resin coatings to metallic surfaces. He tried this method with dental acrylic filling in conservative-treatment cases. In 1974 and depending on investigation done by Silverstone and Retief acid solutions with concentration between 20 and 50 percent applied for one to two minutes were believed to make the best retention, and were ready for clinical use (48, 49).

In 1980, Pus and Way treated 50 premolars using 43% phosphoric acid gel and 50 premolars with 37% liquid etching acid, both of the groups in that study were treated for 90 seconds. The result showed average loss of enamel 7.5 and 6.5 µm respectively. In 1973, Wichwire and Rentz decided that premolars' enamel dissolve-rate increases with duration (52).

In 1986, Carstensen made a clinical study about failure rate of mesh-based brackets bonded to 1134 anterior teeth and these teeth were etched for 30-35 seconds with 37% phosphoric acid-based etchant. In this study, only ten brackets were lost during the 16 months which was the study period. In another study, which compared between the effects of etching for 15-20 seconds and 30-55 seconds, it was found that 15 seconds etching was enough for bracket bonding on anterior teeth (57).

Different type of teeth means biological difference in etch pattern which affects SBS that can be obtained. In 1974, Marshall et al. studied etched dental surfaces under SEM and they concluded a bigger degree of difference in etching pattern from tooth to tooth and even in different parts of the same tooth, using the same procedure of etching. Some portions in enamel have thicker aprismatic layer that facilitates melting of the underlying enamel, this phenomenon was observed in premolars more than molar teeth. Depending on these findings researchers assumed that premolars need less etching time than molars.

Hirani and Sherriff (2006) tested SBS debond forces and failure areas of traditional brackets bonded by using SEP based product (Transbond Plus©) and traditional acid etching and conditioning with precoated brackets. Not a single difference was detected in shear bond strength between traditional brackets with SEP and APC. Most of the problems happened at the enamel-adhesive hybrid area (61).

Bracket base design affects both percentages of bond failure and enamel surface damage while debonding. Mechanical interlock is guaranteed by undercuts on bracket internal surface. In metal brackets, manufacturers used to weld a mesh to the base. In clinical use, the mesh shall be thin thus easies to remove. When removing the metal brackets, this welded mesh can separate from the body of the bracket and stay glued to tooth surface.

The trend nowadays is to enhance the advantages and decrease or lessen the disadvantages so researchers and manufacturers are looking forward to make orthodontic brackets that can bond to the tooth tightly enough to hold on till the end of treatment without damaging the dental material.

In 1975, Reynolds found that the clinically acceptable shear bond strength to be 6-8 MPa (64). Sfondrini *et al.* reported in 2002 bigger amount of bond strengths than that despite of the type of bracket or light used (60). Even light-curing for 2 seconds with the micro-xenon light could give clinically approvable bond strengths for both normal and precoated kinds of brackets. The incredibly lessen time of setting obtained by micro-xenon light gives a huge pro for the patient and the practitioner. From our study we can approve with the main idea of beneficial of reducing curing time.

A lot of publications on bond strength tests have been done, the outcomes of which were adapted by producers to support their products' stocks. However, it seems that a lot of those researches were done depending on different methods made it hard to compare outcomes of different bonding procedures. Thus, it is better standardizing test procedures to measure bond strengths.

Hobson and McCabe (2002) researched the interaction between the characteristics of etching and enamel-resin bond strength. Twenty-eight participants had their dental buccal areas etched and then examined under SEM. Result was no distinguished statistical difference in both patterns in upper and lower jaw teeth. Anyway, the median showed variations between tooth kinds, the least bond strength was found on the upper first molar and the least on the lower first molar. Ideal etch method was not basic in order to obtain sufficient bond (65).

When SBS with SEP were compared with traditional bonding products, brackets attached by SEP had a lower mean of shear bond strength opposite to traditional products. Moreover, after putting those brackets under physical stress, both showed same mean value of holding times.

The majority of research into SBS with the same testing device has applied one-side force to tested brackets. The results don't reflect clinical bracket removing. Removing rackets with pliers in the clinic means to-side force application at the adhesive-base level which is effective way to remove ceramic brackets and using them in in vitro stems can give real outcomes for clinical conditions.

During function, orthodontic brackets are subjected to either shear, tensile or torsion forces, or even a combination of these factors. The brackets in vivo are also will be under the effect of heat change in the mouth, therefore in our study all teeth bonded with brackets were thermocycled for 5000 cycles between 5 C^o

and 50 C^{o} with a dwell time of 30 sec, which simulated 6 months of intraoral environment.

Axial loading that was performed in the present study may represent occlusal forces with the point of application at the same distance from the bracket resin interface in all cases, helping to make the method of testing more reproducible. Katone et al. (1997), reported that increase in distance from cross head of the Instron universal testing machine to occlusal tie wing of bracket would increase the bond strength.

The goal of this study was to compare the difference of shear bond strength using the new one-second LED curing system and conventional LED curing system. The mean SBS was 6.54 and 12.69 for group A and B respectively. These means are considered within the acceptable range. According to Bishara and Feh (1997), it is advisable to avoid tensile bond strength more than 13 MPa but around this range is acceptable. Reynolds (1975), suggested that a minimum bond strength of 5.9 to 8 MPa is adequate for most clinical orthodontic needs (77).

In our study, the average value of bond strength was 6.56 MPa for group A and 12.69 MPa for group B, which is adequate in both groups for good bond strength. On the other hand, if the force is higher than 25 to 30 MPa the bond may fracture and if the force is less than 13 MPa enamel fracture might occur if the force is applied on the curved area. It is argued that bond strength between 8 and 9 MPa are sufficient to withstand normal orthodontic forces. High bond strength might not be the most desirable characteristic since the brackets should eventually be removed and clinical problems with enamel damage may happen during debonding, if bond strengths are excessive (Swanson et al, 2004) (78).

Osama Murad (2019), made a similar study but used Blueray 3 LED curing device and concluded that SBS measurement were bigger for the new device with no significant statistical difference. Those results are similar to our results but we have had statistically differences to the side of iLED 1 second (85).

Mustafa M. Al-Khatieeb et al (2017) made a similar thesis about effect of reducing curing time on the shear bond strength of metal orthodontic brackets and found that the shear bond strengths of both groups of LED unit (iLED 3 seconds and 1 second respectively) were higher than halogen one, with a statistically high significant difference, and that both of the LED unit's groups showed clinically acceptable shear bond strength in comparison to halogen, so the time of bonding reduced without jeopardizing the shear bond strength or enamel damage after debonding (84). Those results totally support our results we gained during this research.

Back in the 1980s, my first unit had a power density of about 150 mW/cm^2. Since then, resin composites are more sensitive to light energy, and the light activation units themselves have become far more powerful. Clinically, 40 seconds does seem lengthy for activating a 2-mm layer, and expediency became a popular notion. Expediency was the driving force behind the appearance of plasma arc lights, which were typically of high-power densities (> 2,000 mW/cm^2). The promise of “3-second cures” were dangled before dental audiences, but there was a downside resin composite material shrink when they polymerize. This shrinkage exerts a force on the bonded surfaces and the force is multiplied as the number of bonded walls increases. The polymerization stress exerted is also highly dependent on the rate of polymerization, which is actually more important than the volumetric shrinkage. The faster a resin polymerizes, the greater the stress that is exerted on the bonded interfaces. This can lead to cracking of the enamel, i.e., white lines. Such cracking can lead to staining and permeation of oral fluids into the interface. Absolutely all of the literature on this topic agrees that rapid polymerization generates greater magnitudes of stress than does a slower rate of polymerization.

Guram and Shaik (79) compared the shear bond strength of orthodontic brackets bonded to teeth with conventional halogen LCU and LED LCU. They found that the shear of the bracket bonded by the LED LCU containing a single LED was comparable to the shear bond strength of brackets bonded with halogen LCUs (8.30 ±1.51 and 8.89 ± 2.46, respectively).

On the other hand, other researchers also compared the depth of cure and hardness of composite cured with halogen LCU are LED LCUs and found that the performance of LED LCU was lower or equivalent to that of halogen LCUs.

In this study and according to the results we have in our hands, shear bond strength was greater in group B than in group A, and there is statically significant difference between the groups ($p < .0005$). However, in general the LED and LCU shear bond strength are comparable (79).

Fleming et al (2013), conducted a systematic review, which aimed to assess the risks of attachment failure, and bonding time in orthodontic patients in whom brackets were cured with halogen lights, LEDs, or plasma arc systems (80). Their study concluded that there was no evidence to suggest any significant differences in the risks of bond failure with conventional halogen, plasma arc, or LED curing light systems. They also found no significant differences in bond failure between the three curing light systems (Plasma arc, LEDs and halogen). Thus, overall there was no difference between the groups in terms of shear bond. Moreover, Ravadgar et al (81). Compared the shear bond strengths of the stainless-steel metallic brackets bonded by three bonding systems and found no significant difference in the shear bond strength of the groups.

The shade and opacity of the composite are also important considerations (82). Darker and more opaque shades typically require longer curing times for a given thickness of composite. Recommended curing thicknesses are typically 2 mm, and it is reasonable to extend curing times by 50% for very dark shades, or reduce thickness by about 50%. Retinal burning and advancement of macular degeneration are potential risks when using light-curing units. Therefore, it is very important for clinicians to use protective reddish-orange eyewear or shields that act as “blue blockers” to help prevent potential problems (83). Today, LED activation units are commonplace and they are capable of producing anywhere from 700 mW/cm^2 to 3,200 mW/cm^2, yet they too must be operated judiciously. Despite the availability of smaller, higher energy activation units, the principles do not change. When it comes to resin composite polymerization, slower is better for teeth. This author is currently employing a modified “pulse activation” protocol in which the resins are exposed for a brief period of time, later followed by a longer period of exposure. This allows polymerization stress to be lessened, and in turn is less likely to result in damaged margins.

5. Conclusion

The current study compared the shear bond strength of orthodontic brackets bonded with new one second LED-curing system and conventional LED light curing system Within the limitations of this study and based on the recorded data and the statistical analysis the following conclusions may be drawn.

1. The shear bond strength of the new one second LED-curing system and conventional LED light curing system are considered acceptable.
2. There is statistically significant difference in the shear bond strength, shear bond strength for 1.sec iLED is bigger.
3. Rapid LED curing light devices generate big amount of heat, tooth capability of this heat should be observed well in future studies.

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7. Appendix

7.1 Lab Approval

Evrak Tarih ve Sayısı: 19/06/2019-4657

T.C.
BEZMİALEM VAKIF ÜNİVERSİTESİ
Diş Hekimliği Fakültesi Dekanlığı

Sayı : 38723131-200-
Konu : Araştırma İzni

Sayın Ahmad ELALEM
Yeni Yüzyıl Üniversitesi Sağlık Bilimleri Enstitüsü Doktora Öğrencisi

İlgi : 02/05/2019 tarihli ve bila sayılı Dilekçeniz.

İlgi tarihli dilekçeniz ile talep etmiş olduğunuz, Üniversitemiz Araştırma laboratuvarını **"Comparison of Shear Bond Strength of Orthodontic Metal Brackets Bonded With One Second LED Curing System and Conventional LED Light Curing System "** başlıklı tez çalışmanız için kullanmanız uygun görülmüştür.
Bilgilerinizi rica ederim.

e-imzalıdır
Prof.Dr. Alper ALKAN
Dekan

Evrakı Doğrulamak İçin : https://ebys.bezmialem.edu.tr/enVision/Dogrula/SN3ZJYA

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Bilgi için: Hatice ÖZTÜRK
Unvanı: Memur

Bu belge 5070 sayılı Elektronik İmza Kanununun 5. Maddesi gereğince güvenli elektronik imza ile imzalanmıştır.

7.2 Acceptance of Supervisor

16.12.2019

İLGİLİ MAKAMA

T.C. Yeni Yüzyıl Üniversitesi Diş Hekimliği Fakültesi Ortodonti Anabilim Dalı yüksek lisans programı öğrencilerimizden Ahmad Fidi Hussein ELALEM'in Comparison of shear bond strength of orthodontic metal brackets bonded with one second LED curing system and conventional LED light curing system" konulu projesini tanımlayıcı nitelikte bir araştırma yapılması planlanmaktadır. Araştırmanın yapılabilmesi için öğrencimiz, fakültemize ait hastanenin ortodonti kliniğinde tedavi edilen hastalara ait model ve kayıtlar üzerinde çalışma yapmak istemektedir.

Adı geçen öğrencinin bu çalışmayı yapmasında bir sakınca olmadığnı bildirir, gereğinin yapılmasını saygılarımla arz ederim .

Prof. Dr. M. Haluk İşeri

Ortodonti Anabilim Dalı Başkanı

7.3 Ethic Approval

T.C.
İstanbul
YENİ YÜZYIL
ÜNİVERSİTESİ

FEN,SOSYAL VE GİRİŞİMSEL OLMAYAN SAĞLIK BİLİMLERİ ARAŞTIRMALARI ETİK KURULU

11.02.2020

Sayı : 2020/02
İlgi : Etik Kurul Onayı,

Sayın
Ahmad ELALEM

İstanbul Yeni Yüzyıl Üniversitesi Etik Kurulunun 10.02.2020 tarih ve 2020/ 02 sayılı toplantı sonucunda '' Comparison of shear bond strength of orthodontic metal brackets bonded with one second LED curing system and conventional LED light curing system'' başlıklı çalışmanız Fen, Sosyal ve Girişimsel Olmayan Sağlık Bilimleri Araştırmaları Etik Kurul Kurulumuzca oy birliği ile **UYGUN** bulunmuştur.

Araştırmanız süresince çalışmanızda özellikle konu başlığı, gereç ve yöntemler konusu ile ilgili olarak değişiklikler söz konusu olursa tekrar değerlendirilmesi gereklidir.

Not: İşbu belge İstanbul Yeni Yüzyıl Üniversitesi Fen, Sosyal ve Girişimsel Olmayan Sağlık Bilimleri Araştırmaları Etik Kurul Yönergesi temelinde kaleme alınmıştır.

İş bu belge kurum onayı dahilinde geçerlidir.

Prof.Dr.Cuma BAYAT

İstanbul Yeni Yüzyıl Üniversitesi
Fen,Sosyal ve Girişimsel Olmayan
Sağlık Bilimleri Araştırmaları
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