COMPARING BACTERIAL COLONIZATION OF LASER ETCHED AND ACID ETCHED ENAMEL IN BONDING ORTHODONTIC CERAMIC BRACKETS

by

Sibel Sofuoğlu

B.S. in Biomedical Engineering Yeditepe University, 2014

Submitted to the Institute of Biomedical Engineering
in partial fulfillment of the requirements
for the degree of
Master of Science
in
Biomedical Engineering

Boğaziçi University
2019

COMPARING BACTERIAL COLONIZATION OF LASER ETCHED AND ACID ETCHED ENAMEL IN BONDING ORTHODONTIC CERAMIC BRACKETS

APPROVED BY:

Prof. Dr. Murat Gülsoy ..... (Thesis Advisor)

Prof. Dr. Can Yücesoy .....

Assist. Prof. Dr. Hakan SOLMAZ .....

DATE OF APPROVAL:

ACKNOWLEDGMENTS

First of all, this is an honour for me to acknowledge the people who help on this thesis. I would like to express my appreciativeness to Prof. Dr. Murat Gülsoy for making this Master's Thesis available as my supervisor. It was a pleasure for me to work with him in this project. I couldn't complete this study without his invaluable comments, encouraging guidance every time and useful suggestions.

I owe my appreciate to members of my committee Prof. Dr. Murat Gülsoy, Prof. Dr. Can Yücesoy and Assist. Prof. Dr. Hakan Solmaz

I would also like to thank Ayse Sena Kabas Sarp for her amazing guidance and help on issues related to this thesis. I am thankfulness to her for sharing her experiences and for her support throughout my MSc study. Her experiences were very valuable for me. She was a helpful person every time when I don't know the subject.

I would also like to thank Mr. Enver Atalı for allowing us to use their laser system.

Finally , I would like to inscribe this thesis to my family. I would like to thank to my supportive mother Yasemin Sofuoğlu and my encouraging father Mustafa Sofuoğlu. Also I am so thankful to my closest friends Sıla Yıldız for supporting me with every issue about my thesis.

ACADEMIC ETHICS AND INTEGRITY STATEMENT

I, Sibel Sofuoğlu, hereby certify that I am aware of the Academic Ethics and Integrity Policy issued by the Council of Higher Education (YÖK) and I fully acknowledge all the consequences due to its violation by plagiarism or any other way.

Name :

Signature:

Date:

ABSTRACT

COMPARING BACTERIAL COLONIZATION OF LASER ETCHED AND ACID ETCHED ENAMEL IN BONDING ORTHODONTIC CERAMIC BRACKETS

The aim of this project comparing bacterial colonization of laser etched and acid etched enamel in bonding orthodontic ceramic brackets and also to develop a method which reduces the risk of enamel demineralization and tooth decay caused by acid etching. In this project, after cleaning bovine teeth, before the embedding gypsum block, 10*10 mm area was created a labial surface of teeth. Then, they were buried in gypsum block as the labial surface. They were put in the gypsum block as parallel as possible. Then, the first step is the bonding of ceramic brackets by using acid etching (for acid etching group phosphoric acid solution is used within the ratio of 37% to the bonding surfaces. Then laser etching method was applied. Universal testing machine was used to debond the brackets. The second step was inoculation of bacteria to measure colonization of bacteria on the teeth after laser etching and acid etching techniques. There were 4 different experimental groups: Acid etched group, Laser etched group, Non-etched group, and Gypsum group. Each group was composed of 12 samples. After the inoculation part, S. Mutants colonies were counted on a counting aid manually and the colony-forming units (CFUs) were examined. Results show that there was a significant difference between debonding forces (nonetched vs acid etched, laser etched) and there was a significant difference between CFU values of laser etched and acid etched groups. Mean value and average CFU values for laser etched groups were lower than acid etched groups.

Keywords: Acid Etching, Laser, Debonding, Ceramic Brackets, Bacteria

ÖZET

ORTODONTİK SERAMİN DİŞ TELLERİNİN ASİTLE VE LAZERLE PÜRÜZLENDİRME YÖNTEMİ KULLANILARAK MİNE YÜZEYİNE YAPIŞTIRILMASI VE BAKTERİ KÜMELENMESİNİN KARŞILAŞTIRILMASI

Bu projenin amacı, ortodontik seramik braketlerin yapıştırılmasında lazerle pürüzlendirilmiş ve asitle aşındırılmış emaye bakteriyel kolonizasyonunu karşılaştırmak ve ayrıca asitle aşınmadan kaynaklanan emaye demineralizasyon ve diş çürümesi riskini azaltan bir yöntem geliştirmektir. Seramik braket yapıştırılması, asitle aşındırma ve lazerle aşındırma gibi farklı yollarla yapıldı. Bu projede, sığır dişlerini temizledikten sonra, gömülü alçı bloğundan önce, dişlerin labiyal yüzeyinde 10 x 10 mm alan oluşturuldu. Daha sonra, mine yüzeyinin labiyal yüzeyi, bloğun yatay eksenine mümkün olduğu kadar paralel konumlandırıldı ve alçı bloğuna gömüldü. Alçı blokta sadece 10 * 10 mm alan belirmiştir. Daha sonra ilk adım, seramik aşındırıcıların asitle aşındırma yöntemi kullanıldı ve lazerle aşındırma tekniği uygulandı, daha sonra kopma kuvvetini ölçmek için universal test makinesiyle seramik braketler mine yüzeyinden çıkartıldı. İkinci adım, lazerle aşındırma ve asitle aşındırma tekniklerinden sonra bakterilerin dişlerdeki kolonizasyonunu ölçmek için bakteri aşılama olmuştur.Sonuçlar, kopma kuvvetleri arasında anlamlı bir fark vardır (işlem uygulanmayan ve asit, lazer grupları karşılaştırıldığında). Ayrıca, lazerle aşındırılmış ve asitle aşındırılmış grupların CFU değerleri arasında anlamlı bir fark olduğu göstermiştir. Ancak lazerle oyulmuş gruplar için ortalama değer ve ortalama CFU değerleri asitle aşındırılmış gruplardan daha düşüktü.

Anahtar Sözcükler: Asit ile aşındırma, Lazer, Seramik Braketlerin Çıkarılması, Bakteri

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

LASER	Light Amplification by the Stimulated Emission of Radiation
nm	nanometer
CW	Continuous Wave
°C	Celcius degree
FDA	United States Food and Drug Administration
CO_2	Carbon dioxide
Nd:YAG	Neodymium-doped Yttrium Aluminium Garnet
Cl	Chloride
F	Florine
K	Potasyum
Na	Sodium
$Ca_{10}(PO_4)_6(OH)_2$	Hydroxyapatite
^{1}m	micrometer
Bis-GMA	Bisphenol-a and methylmethacrylate
4-META MMA	4-methacryloxyethyl trimellitate anhydride
mm	millimeter
NIR	Near Infra-red
N	Newtonv
W	Watt
sec	second(s)
ARI	Adhesive Remnant Index
kPa	kilopascal
cm_2	centimetersquare
mm_2	millimetersquare
MPa	Megapascal
cm	centimeter
s	second(s)
kg	kilogram

J	Joules
SEM	Scanning Electron Microscope
A	Ampere
US	United States
ER,CR:YSGG	Erbium, chromium:yttrium-scandiumgallium-garnet
S.Mutants	Streptococcus mutants

1. INTRODUCTION

1.1 Motivation and Objectives

Dentistry is the one of the important part for human health. Every people want to see their teeth in a good appearance for good impression. To get a beautiful smile and regular teeth orthodontics is very important. One of the most common problems is tooth irregularity or improper sequence of the teeth. It can be fixed with brackets. In this treatment orthodontic wires and braces are using. They are providing come together teeth in a proper sequence. Ceramic brackets are the one of type brackets that are using in orthodontic treatments. When we compared with other type of brackets, patients are generally preferring ceramic brackets because of elasticity and their appearance. Ceramic brackets are also providing higher strength. After the treatment, they should be debond from enamel surface of the teeth [1]. There are many techniques to debond ceramic brackets. Bracket failures and the pain are one of important issues in conventional debonding technique [2]. Also conventional debonding method may damage the enamel surface and be time consuming. Poor esthetics is the important for damage on enamel surface [3, 4]. Therefore, application of the laser systems can be an alternative for debonding brackets.

Beginning of the 1960's the optic laser technology started to use with ruby laser. Lasers in dentistry has some advantages. For example; there is no need for suture using. Bleeding can be minimized and laser can provide clotting. Sometimes, anesthesia can be unnecessary. Bacterial infection chance is lower when we compared with conventional methods. Wounds can heal faster. Finally, laser is giving minimal damage to the surrounding tissue. Laser usage in dentistry were approved by the United States Food and Drug Administration (FDA) on 1980s and early 1990s. Dental lasers have been using in some areas like removing of soft dental tissues, cavity preparation, Root disinfection and cleaning in endodontics, tooth bleaching and debonding ceramic brackets etc.

In this study erbium, chromium: yttrium, scandium, gallium, garnet (Er,Cr:YSGG) laser is used. Eversole and Rizoiu researched an erbium, chromium, yttrium, scandium, gallium, garnet (Er,Cr:YSGG) laser system on 1995 by [5] the same laser is used for also hard tissue treatment , soft tissue treatment [6–8] this lasers appears exact difficult tissue cuts by ethicalness of laser vitality interaction with water at the tissue interface. The Er,Cr:YSGG laser produces small scale blasts amid tissue removal, coming about in plainly visible and tiny irregularities [9]. The Er,Cr: YSGG laser at first causes vaporization of water and other hydrated natural components of the tissue. However, this laser can cause undesirable result for example heat effect on tissues although there is a lots of advantages. There are lots of studies about thermal effects of laser on dental tissues. Zach and Cohen [10] while applying external heat on teeth of monkeys said that no histological changes were found with an intra pulpal temperature increase of 1.8 ±C. Also with an increase of nearly 5.5 ±C in pulpal temperature they mentioned that pulpal necrosis had occurred 15% of teeth. 5.5 ±C can be the limit for heat interactions.

1.2 Outline

Chapter 2, defines general information about dentistry, orthodontics and dentistry in lasers. Also, bonding and debonding bracket techniques are clarified in this chapter.

Chapter 3, explains detailed information about materials and method that used in this study. The experimental setup clariid in details.

Chapter 4 includes results and

Chapter 5 includes discussion of proposed study and

Chapter 6 conclusion and future works of the study are given.

2. BACKGROUND

2.1 Dentistry

Dentistry could be a department of medication that comprises of the think about, conclusion, avoidance, and treatment of infections and disarranges of the oral depression. The verbal depression speaks to the primary portion of the stomach related tube. The verbal depression is anteriorly encompassed by lips, the cheeks along the side, the floor of the mouth inferiorly, the oropharynx posteriorly, and the sense of taste superiorly [4, 11]. The verbal depth is legitimately bounded by the alveolar curves, teeth and gums, and sense of taste and tongue. The verbal depth is oval molded and it comprises of two parcels, the vestibule and the verbal depth appropriate (lingual).The hard base of the depression is appeared by the maxillary and mandibular bones. (Figure 2.1)

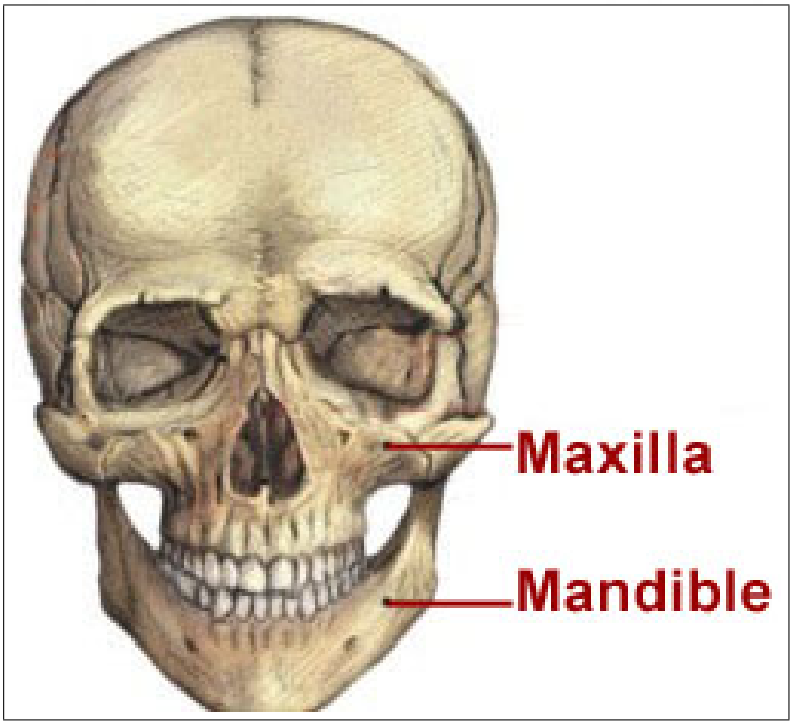

Figure 2.1 The Bony Base of the Cavity [11].

Verbal depth is the interior of the mouth, bounded by the sense of taste, teeth, and tongue. The maxilla is the top jaw is called and mandible is the lower jaw. The teeth of the upper curve are called maxillary teeth, since their roots are implanted inside the alveolar prepare of the maxilla. Those of the lower curve are called mandibular teeth since their roots are implanted inside the alveolar prepare of the mandible. Teeth have advanced distinctive capacities - incisors for gnawing, canines (eyetooth) for tearing, molars and premolars for chewing. The nonexistent plane which is acknowledged within the center isolating the dental archright from cleared out is called Middle sagittal plane. (Figure 2.2)

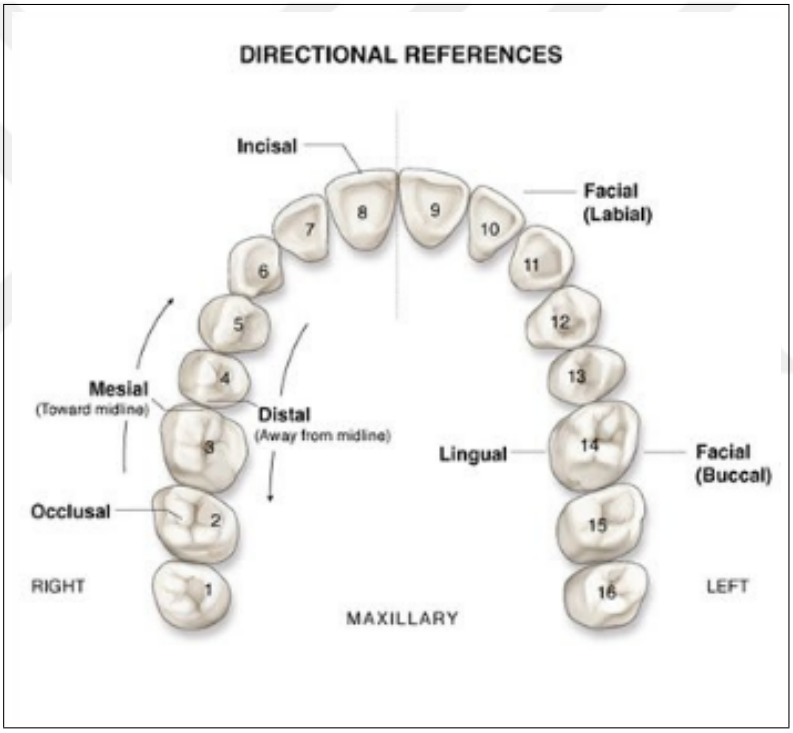

Figure 2.2 Midline, Mesial, Distal, Lingual, Labial, Facial, and Buccal terms are indicated [4].

A tooth is composing of four dental tissues: Finish, dentin, cementum, which is difficult (calcified) and mash, that's delicate (noncalcified). The obvious portion of the teeth names as the crown. It is made of finish. The finish is for the most part made of calcium phosphate, a rock-hard mineral. Finish the hardest and most highly mineralized substance within the human body. Dentin could be a calcified tissue and a layer basic the finish in the human body. It is the biggest portion of the tooth.

When compared to the finish, it has a milder structure in the tooth. It contains 70% hydroxyapatite (Ca10(PO4)6(OH)2), 20% natural matter and 10% water. Dentin is additionally more touchy to cold and hot. Natural and inorganic components appear distinctive sums in dentin when compared to the finish. Within the composition of finish, it stores 95% hydroxyapatite (Ca10(PO4)6(OH)2), 4% water and 1% natural matter. The chemical representation of hydroxyapatite is given by the chemical equation (Ca10(PO4)6(OH)2). Cementum is difficult connective tissue and hard fabric. It covers the tooth root and gives a connection to the periodontal tendon. The peridontal tendon is the tissue that bolsters hold the teeth solidly against the jaw. A root is secured by cementum and the portion of the tooth implanted within the alveolar prepare. The conclusion of the root tip is the summit and apical foramen is the opening at the root tip. Mash is milder compared to the other parts of the teeth. It is found the inward structure of teeth. Mash contains blood vessels and nerves. In expansion to that, it incorporates connective tissues. Connective tissues offer assistance compatibility between mash and dentin. When an individual encompasses a toothache, the mash is what harms. Tooth structure composition isn't homogenous (Figure 2.3).

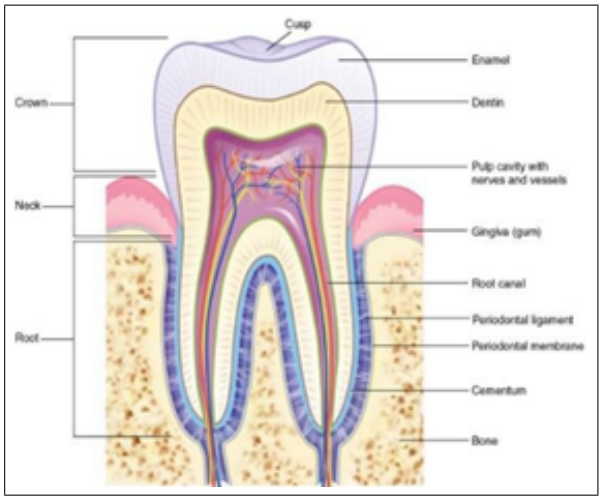

Figure 2.3 Basic Human Tooth Anatomy [12].

2.2 Orthodontics

Orthodontics itself could be a word that comes from Greek and it implies to rectify terrible chomp legitimately. In arrange to have an alluring grin and straight grouping of the teeth, orthodontic treatment is a compelling way. Orthodontic treatment can center on dental relocation as it were or can bargain with the control and facial development alteration. In today's orthodontics, dental relocation is illuminated by bracket treatment (Figure 2.4)

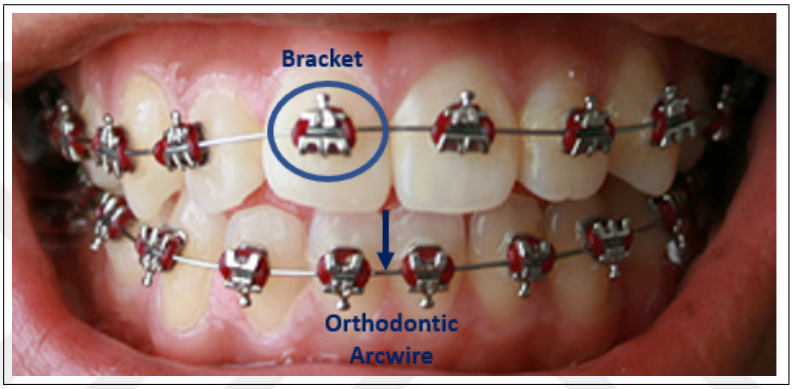

Figure 2.4 Bracket Treatment of Tooth Irregularity [12].

The extraordinary mechanical development happened within the final a long time has brought a number of benefits to orthodontics. Research-based discoveries have always driven to the improvement of unused materials and methods that are pointed at streamlining the clinical methods. There are a few diverse sorts of apparatuses utilized in orthodontics:

Dental braces are gadget utilized in orthodontics to adjust teeth and their position with respect to a person's chomp. They are regularly utilized to rectify malocclusions such as underbites, overbites, cross chomps and, open chomps, or warped teeth and different other jaws of teeth and jaws, whether restorative or basic. A bracket of orthodontic is frequently utilized in relationship with other ortho apparatuses to extend the sense of taste or jaws or something else shape the teeth and jaws. Teeth move through the utilize of constraint. Braces include numerous diverse parts that work together to rectify your teeth.

An orthodontic archwire, going over the teeth from bracket to bracket, may be a wire adjusting to the alveolar or dental curve that can be utilized as a source of constraint in rectifying abnormalities within the position of the teeth with dental braces. An archwire can moreover be utilized in order to preserve the dental position; in this case, it contains a maintenance reason. Orthodontic archwires can be created with distinctive combinations. These are most commonly stainless steel, nickel-titanium combination, and an amalgam composed essentially of titanium and molybdenum

Brackets are the other part of the teeth treatment and they are providing holding archwires.

2.3 Bonding Orthodontic Brackets

The method of holding orthodontic brackets on a finish has changed significantly within the last 30 years. Typically due to the presentation of materials and methods that permit effective joining of the orthodontic brackets straightforwardly to the finish. Process of joining orthodontic brackets on a finished surface is based on a grip between two different materials. Attachment can be defined as the debonding drive between filling material and tooth structure when they are come into insinuating contact. In an attempt to give holding or attachment, cement is utilized that's the fabric to which it is applied is called the adherend. The holding cement utilized to stick orthodontic bracket to finish has moved forward a massively long time. The execution of all dental materials, whether ceramic, polymeric or metallic is based on their structure [2]. Before the bonding process, orthodontists must be beyond any doubt that the enamel surface is clean conjointly dry, or else no joining will be performed. A dry and clean region is exceptionally vital since the materials utilized for holding require a clean enamel surface.This certifies that the bonding material has the most excellent conceivable chance of creating a total connecting to the finish. The nearness on the surface of anything might be considered as a contaminant itself is feebly reinforced to the strong and will avoid the aa adhesion of cement to substrate [12]. Grip may be isolated into two mechanisms: mechanical and chemical. Chemical attachment contains joining or holding

at the atomic or atomic level. Mechanical one is depended on maintenance by the entrance of one phase into the surface of the other. In numerous cases, it is additionally conceivable to watch both chemical and mechanical connecting together. The entrance of the holding fabric into microscopic or submicroscopic inconsistencies (i.e as pores and hole) within the surface of the substrate by acid-etching strategy may be watched in the mechanical grip. Bonding with composites has been done by carving the tooth surface with phosphoric corrosive [13]. Acid carving guideline is to basically clear infinitesimal sums of finish clearing out pores and cleft. Characteristically, the carving is accomplished utilizing phosphoric corrosive (34-37%). Capillary infiltration into surface inconsistencies motivates joining of tars to etched enamel. These projections of polymer into the finish have been named as gum labels. A later illustration of mechanical debonding is that of gum remedial materials. The corrosive produces minute pores and other abnormalities within the surface of finish into which the tar subsequently own when it is put into the planning. The most prominent issues related to bonding to finish surfaces are the in satisfactory expulsion of carving flotsam and jetsam and contamination by water or spit [14]. Concurring to their chemical highlights, dental adhesive materials that are utilized for orthodontic bracket grip may be recognized into two types.They are both polymers additionally categorized as acrylic or diacrylate resins. The acrylic tars are subordinates of ethylene and contain a vinyl bunch in their structural formula [15]. Chemical title of acrylic gum is "polymethylmethacrylate". It is transparent and transmits light within the ultraviolet extend to a wavelength of 250 nm [14]. Depolymerization happens between 125 °C and 200 °C. Roughly at 450 C, nearly 90% of the polymer depolymerizes to create the monomer [5]. Most diacrylate resins are based on the acrylic adjusted epoxy gum. One of the first methacrylates used in dentistry was Bis-GMA. Bis-GMA tar is portrayed as the response item of bisphenol. It is utilized as a bond embed fabric and as the resin component of dental sealants. There's a critical distinction between sort gum and second type resin [7]. A few ponder are worn out arrange to compare the debonding cement. For example, in 1995 Mimura et al. [7] examined the comparison of two holding materials for laser debonding. The chosen holding specialist in this consider were 4-META MMA (4-methacryloxyethyl trimellitate anhydride) gum and Bis-GMA cement gum. In this consider, it is watched that debonding drive for MMA gum was sufficiently at the lowest power of vitality

than required for Bis-GMA tar bunches. On the finished surface in MMA tar gather, more cement remained compared to Bis-GMA tests. As a conclusion, they concluded that debonding MMA gum with a laser is more secure than debonding Bis-GMA tar with a laser. Moreover, in Rueggeberg and Lockwood's ponder was on ten commercial brands of orthodontic materials speaking to three modes of delivery systems: Two glue, no blend, and control fluid sorts [16]. Stainless steel orthodontics brackets were fortified on bovine teeth. Amid warm application to the brackets, each temperature at debonding was spared. They concluded that the next temperature was observed for two-paste frameworks compared the no blend frameworks. In orthodontic treatment, orthodontic brackets are using to fix irregularities. They are exceptionally little and also used to join a curved wire.It has two wings, a base and channel (most slender portion) for locating an archwire (Figure 2.5). Orthodontic brackets are isolated into three types: ceramic based brackets, plastic based brackets and metal-based brackets (Figure 2.6). Of these, most orthodontists favor utilizing metal brackets for scheduled medicines.

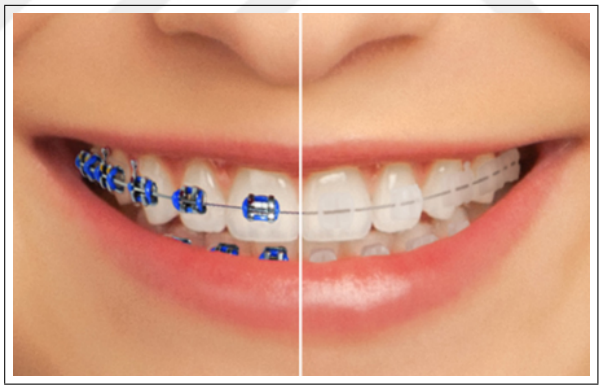

Figure 2.5 Appearance of Metal and Ceramic Brackets [14].

Metal brackets were presented within the early 1970s. A number of a long time afterward plastic brackets were utilized since of their stylish appearance compared to the metal counterparts. In the mid-1980s, ceramic brackets were presented into orthodontics. Ceramic brackets are more best sense of the predominant esthetics when compared to the metal brackets. During the orthodontic treatments, metallic brackets have a lengthy story. Initially, metallic brackets had been produced from an assortment of stainless steel combos the place the base and wings have been manufactured by using

molding and various components were participated by means of fastening. Titanium and amalgams, mixing of cobalt chromium and gold alloys production was increased to make brackets after innovations such as metal infusion molding and laser welding [17]. After these consequences, it is concluded that orthodontic brackets have some conflicting properties. The opinion which is contacting with orthodontic wire should be produced with flexibility from production in terms of view. Because it is decreasing the undesired outcomes, for example, plastic deformation. In a different hand, the main element of the braces in relation with teeth finish should be in a position of enough changes to motivate removing from the finish area after the conclusion [18].

Figure 2.6 Bracket Surface [15].

Metal infusion molding (MIM) was produced in the 1980's [18] and it was approved by the producers of dentistry machines [19]. In that technique powders of metal are blended with characteristic covers, making a pure mix; this blend is at that point implanted to the molding device that gives the infused parts with the extreme craved shape. In any case, the shape is nearly 20% bigger than regular to retrieval for ensuing shrinkage amid the ending organize. The combination of liquid or warm is dismissed a ratio of 90% which is another step debonding. Getting very high cost at MIM treatment for orthodontic brackets due to materials perspective. For daily brackets production, two combinations of stainless steel are using. Other cobalt chromium and iron-chromium have more been used.

For the aesthetic treatment, plastic brackets have produced [20, 21] A later

consider has detailed that plastic brackets displayed satisfactory clinical and tasteful outlook over the time period examined. The primary era of plastic brackets had issues with torque capacity and over the top creep deformation when subjected to torsional loads created by archwires actuated to the tooth [22]. Amalgamations have moreover been utilized to get rid of the esthetically unwanted decolorization. Hardness and the wear resistance still are the major problem for plastic brackets. And also, it has an undesired color result when they are used in the long term which is proved by the clinically. It is thinking that taking advantage of plastic brackets without a metal space embed is unseemly to convey the wanted amount of torque within the clinical usage.

Numerous orthodontic supplies are shaped from metals, which ordinarily has predominant mechanical specialties compared with other materials; be that as it may, ıs has tasteful problems with metal orthodontic materials. Plastic and ceramic brackets are started to use in orthodontic treatments because of their usage. Taking after the presentation of brackets of polycrystalline alumina within the late 1980s, both brackets are commercially accessible. In spite of the fact that ceramic brackets display amazing esthetics, with a blur white appearance, These problems emerge from the delicate character [23, 24] and tall hardness of the ceramics. In ceramic brackets treatments, some dentists are thinking that they have some advantages in terms of the mechanical view. It has insignificant water absorbable and showing better mechanic specialties and biocompatibility during the treatment when we compared with plastic brackets. The braces of single-crystal alumina which is showing more true conjunction with high quality than the polycrystalline alumina brackets high see break durability.

In today's orthodontics, all right now accessible ceramic brackets basically incorporate aluminum oxide. The manufacturing process of ceramic brackets may be a vital angle and plays an imperative part in the clinical execution. The generation prepare of the single precious stone braces is a lot complicated compared to the generation of braces of polycrystalline ceramic. In the manufacturing prepare of polycrystalline ceramic brackets, it is started with blending the particles with a folio. It is moderately cheap and because of this property, it is an exceptionally prevalent fabricating strat-

egy. Tragically, this prepare causes basic defects at the boundaries and the joining of following sums of impurities. These flaws and debasements may serve as foci for the propagation of splits beneath connected stack or stretch. So, all in all, bracket fracture can be watched. In any case, polycrystalline brackets are more promptly available at present. Braces of monocrystalline ceramic are made from aluminum oxide. The optical clarity is the foremost clear difference between polycrystalline and monocrystalline ceramic brackets. Single-crystal ceramic brackets are more transparent. Luckily, both of them set against recoloring and discoloration [25]. Ceramic brackets are famous for their hardness and their resistance to debasement at tall temperature and to chemical corruption. Physical properties of ceramic brackets that are significant to the orthodontics contain ductile quality, hardness and break durability or brittleness. Tensile strength is another significant property of ceramic brackets. In monocrystalline alumina, the ductile quality is much higher than in polycrystalline alumina, that's in turn significantly more than stainless steel. This property is dependent on the condition of the ceramic bracket's surface. In other word metal brackets misshapes [26] in orthodontics, ceramic brackets have exceedingly localized, directional nuclear bonds. During ceramic bracket debonding, finish fracture is a relationship to the tall bonding quality of braces of ceramic and related with sudden impact stacking. There are two significant issues that are stemmed from the combination of exceptionally difficult and fragile properties and tall bond quality. One of them is bracket disappointment amid debonding and the moment one is finished disappointment which may occur during work but generally amid debonding. Ceramic brackets are radiolucent and if they are breathed in, they would not be obvious on the radiograph. Ceramic brackets are esthetic, solid, and safe to chemical corruption. In any case, the nuclear structure that clarifies these focal points moreover accounts for the foremost self-evident blame of ceramics, namely their brittleness and moo break durability. Due to their benefits, ceramic brackets to appear a few critical disadvantages.

There are lots of considers that have been assessed the bond quality of braces of ceramic with unlike conservation components and resulted that mechanically held ceramic braces have sufficient bond quality and appears to lead less finish break of disappointment during debonding when compared to the chemically held varieties [27,

28]. By the selection of cement fabric, different sorts of finish conditioning and different lengths in etching handle, bond quality can be modified. Omana et al. appeared that cruel shear bond quality of the braces of polycrystalline ceramic is significantly more noteworthy than that gotten when braces of stainless steel are utilized. When compared to stainless steel brackets, the frictional properties of braces of polycrystalline ceramic are most noticeably awful [29, 30]. The moo break durability (the capacity of a fabric to resist break) of ceramic brackets causes to the next rate of bracket breakages or disappointment than with stainless steel brackets. Tie wings of the brackets can effortlessly be broken of a break since of the tall torsional debonding strengths in ceramic brackets.

In our study, the brackets that are used have a base sort that supplies mechanical maintenance, as well as a chemical coating, was used on base to improve the bond quality. Holding the handle of orthodontic brackets has been utilized as a clinical strategy since 1970. Within the holding process, enamel surface changing or change that's made by corrosive carving may be a pivotal strategy. This procedure was created by Buonocore in 1955. The steps that must be taken after by clinicians are given underneath:

1. Cleaning,
2. Etching,
3. Sealing,
4. Bonding.

During specimen preparation, before bonding soft tissue debris and coronal pulps must be removed. The holding surfaces of finish must be cleaned with a non-fluoridated pumice glue to expel plaque and the natural pellicle that normally covers the teeth surface. At that point, the teeth are conditioned with a 37% phosphoric corrosive for 15 to 30 s, taken after by exhaustive washing and drying. After that handle,

by utilizing orthodontic composite adhesive fabric orthodontic brackets are reinforced by one administrator on the labial surfaces of incisors. After all carved finish surfaces are coated, bracket situation should be begun promptly (Figure 2.7) [16]. Abundance cement must be expelled before storing the arranged example in unadulterated water at 37°C for 48 hours in arrange to minimize the probability of bracket break.

Figure 2.7 Bracket Bonding [16].

2.4 Debonding Orthodontic Brackets

Ceramic brackets need to be debonded after treatment from the enamel surface. Removing the adhesive resin from the enamel without possible minimum damage is the debonding orthodontic brackets. If debonding can be made with the wrong technique, it causes the damaging to the enamel [29].

There are several methods for debonding orthodontic brackets:

1. Conventional method: Debonding with pliers
2. Debonding with the electrothermal unit,

3. Debonding with the ultrasonic unit,

4. Debonding with debonding agents,

5. Debonding with Lasers.

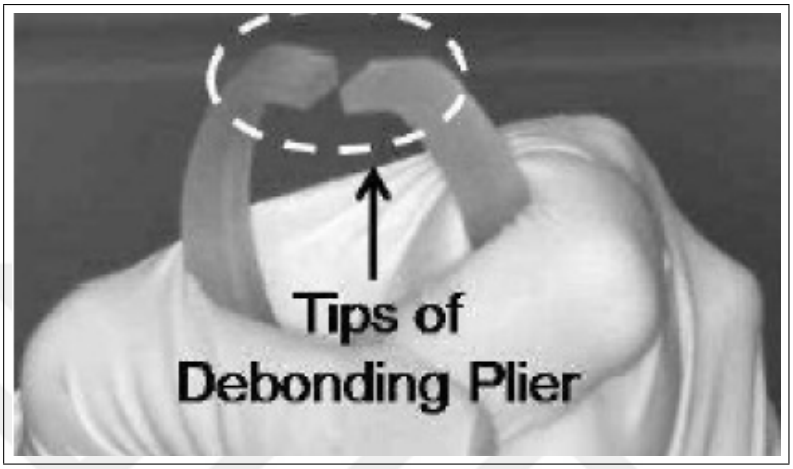

Figure 2.8 Tips of Debonding Pliers [13].

Figure 2.9 Conventional Debonding Method [13].

Debonding techniques have advantages and disadvantages (Figure 2.10). All these techniques have their own advantages and limitations. The use of lasers in debonding is a new and established method.

Debonding technique	Advantages	Disadvantages
Debonding lift-off pliers	Quick and simple, Standard orthodontic instrument.	Increased debonding force, Risk of enamel damage, Risk of bracket fracture and aspiration of fragments.
Hows or Weingart pliers and ligature cutters	Quick and simple, Standard orthodontic instrument.	Risk of bracket fracture, Risk of aspiration of brackets or bracket fragments, Risk of enamel damage.
Special debonding pliers	Quick and simple, More consistent debonding, Reduced risk, compared to conventional ones.	Additional expense of separate instruments, Brackets and enamel damage still possible.
Electrothermal Debonding	Reduced debonding force, Reduced risk of enamel damage, Reduced incidence bracket fracture, Reduced patient discomfort.	Risk of pulpal damage, Risk of soft tissue burns, Expense of unit, Increased clinical time, Bracket failure may not occur at first attempt.
Ultrasonic	Reduced debond force, Decreased chance of enamel damage, Reduced incidence bracket fracture, Removal of residual resin with same instrument.	Time consuming, Excessive wear of ultrasonic tips, Water spray coolant required to minimise the detrimental heating effect on the pulp.
Debonding agents	Reduced debonding force, Promote failure at the adhesive/enamel interface, Reduced enamel damage.	Questionable effect on the bond strength of the adhesive resins, Increased clinical time, Additional expense of agent.
Laser	Reduced debonding force, Reduced risk of enamel damage, Reduced incidence bracket fracture, Potentially less traumatic and painful.	Potential pulpal damage due to heat production, Expensive units, Laser hazards.

Figure 2.10 Advantages and Disadvantages of Debonding Techniques [29].

A study for comparing debonding forces belongs to Thomas and Prassana [30] who studied the effects of debonding metal and ceramic brackets on enamel by conventional methods. Four groups of brackets were used in this study. Metal brackets were used in the first group and the other three groups were different types of ceramic brackets. Enamel damage was seen significantly more in the groups with ceramic brackets than debonding metal brackets. Also, they mentioned that ceramic brackets using mechanical retention appear to cause enamel damage less often those using chemical retention. In the ultrasonic debonding method, erosion for adhesive layer on the

enamel surface and bracket base, special tips are used at the bracket-adhesive interface. The resulting force magnitudes required with the ultrasonic way are importantly lower than if we compare with the conventional method. But, this method has some disadvantage. Between 30 seconds to 60 seconds to the removal of brackets are taking when compared to others. Others are taking 1 second to 5 seconds In electrothermal debonding, instruments are rechargeable. To debond bracket from the enamel surface, the instrument that is using in this method transfer the heat through the bracket. Required debonding force, risk of the enamel damage, pulpal damage, soft tissue burns, and patient discomfort reduce when compared to other types of methods. On the other hand, water spray coolant needed to minimize the detrimental heating effect on pulp is one of the disadvantages of this technique [31]. Totally, laser debonding is one of the trends for orthodontics.

2.5 Lasers in Dentistry

The laser is an acronym for "Light Amplification by the Stimulated Emission of Radiation." A laser creates and amplifies a narrow, intense beam of coherent light. With the invention of the ruby laser in the early 1960's the optic laser technology started . Starting from the late 1960s, lasers were introduced to many medical areas. First studies were published in ophthalmology and dentistry. Laser systems can be classified due to their wavelength, active material used, power or mode of operation (Table 2.1). Wavelength is one of the most important laser parameters that determine how deep laser light penetrates into the tissue.

Table 2.1
Classification of Laser Parameters [5].

Parameter	Wavelength	Active Material Used	Power	Mode of Operation
Classification	UV Visible IR	Gas Solid Liquid Electronic	Low Power High Power	Continous Wave Pulse Mode

When the matter is exposed to light basically four phenomena occur:

1. Reflection,
2. Refraction,
3. Absorption,
4. Scattering.

It is the same as when medical lasers interact with tissue.

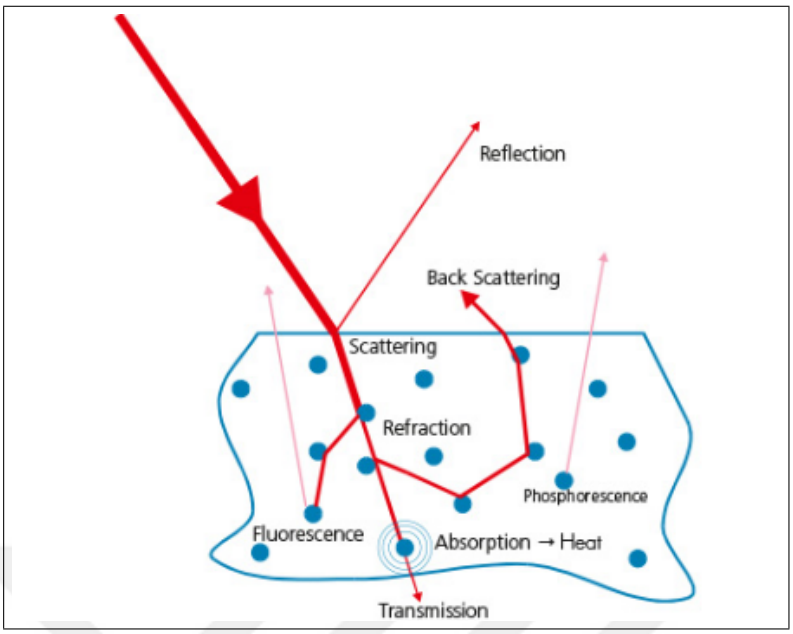

Figure 2.11 The mechanism of light explosion [5].

If the coming light is reverberated from or transmitted through tissue, there will be no heat effect. However, if the light is absorbed by thetissue, it will be converted into heat. Proteins can be defined as water molecules. We can call them as an absorbing agent. The absorption coefficient is the term for describing the power of absorption. The important thing is that nearly 75% of tissue content is water. In the ultraviolet, the absorption of light by water is inversely proportional to the wavelength. Because of the protein, DNA or other molecules shows high absorption at the shorter wavelengths. In the infrared region, the absorption increases with longer wavelengths. In the red to near-infrared (NIR), absorption of light by water molecules reaches its minimal value. It can be called as a diagnostic and therapeutic window.

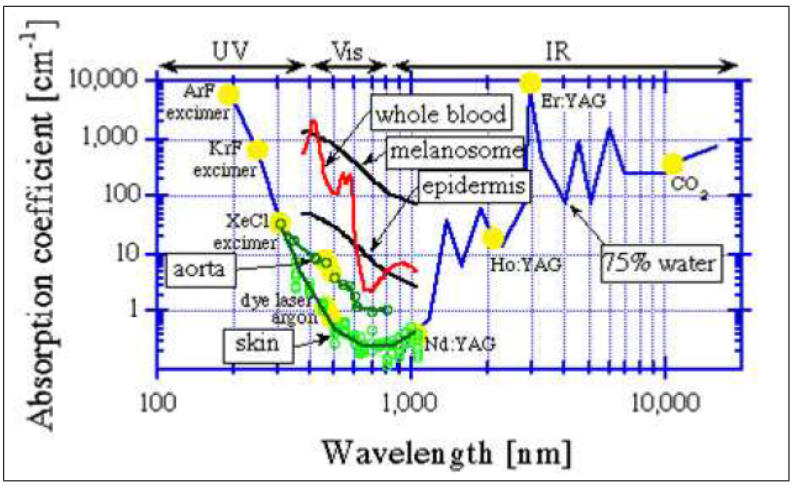

Figure 2.12 The absorption spectra of biological tissues [5].

Lasers in dentistry have some advantages. For example; there is no need for suture using. Bleeding can be minimized and laser can provide clotting. Sometimes, anesthesia can be unnecessary. Bacteria infection chance is lower when we compared with conventional methods. Wounds can heal faster. Finally, the laser is giving minimal damage to the surrounding tissue.

The optical properties of the components and the concentration of the materials are important to define optical properties. The composition of tooth structure is not homogeneous. The amounts of both organic and inorganic components in dentin diverge from the amounts of these components present in enamel. Therefore their absorption coefficient is different.

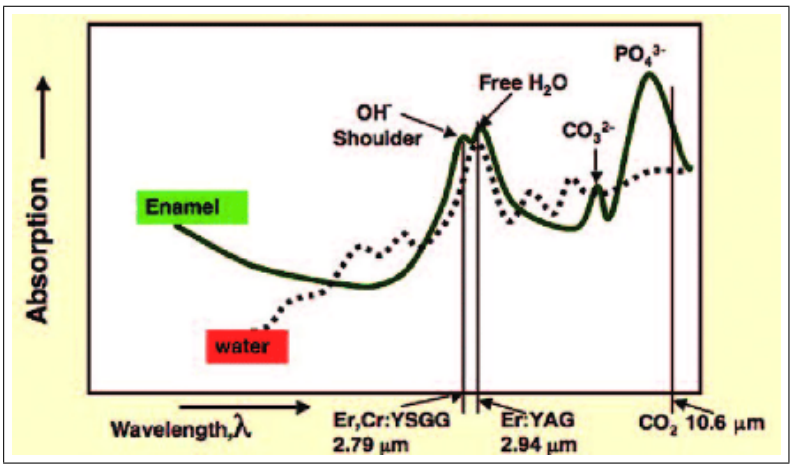

Figure 2.13 The absorption of enamel and water [5].

Lasers were presented to the orthodontic treatments at the 1980s and 1990s. It was approved by the United States Food and Drug Administration (FDA). Dental lasers have been using in some areas like removing of soft dental tissues, cavity preparation, Root disinfection and cleaning in endodontics, tooth bleaching and debonding ceramic brackets, etc. In this study erbium, chromium: yttrium, scandium, gallium, garnet (Er, Cr: YSGG) laser is used. Erbium, chromium, yttrium, scandium, gallium, garnet (Er, Cr: YSGG) laser system was developed in 1995 by Eversole and Rizoiu [5]. The same laser is used for also hard tissue treatment, soft tissue treatments [6–8]. However, besides lots of advantages, heat effect during the laser procedures on dental tissues can provide unwanted consequences. There are lots of studies about the thermal effects of laser on dental tissues. Zach and Cohen [10] study said that the intrapulpal temperature increase of 1.8 °C. Also with an increase of nearly 5.5 °C in pulpal temperature, they mentioned that pulpal necrosis had occurred 15% of teeth. 5.5 °C can be the limit for heat interactions.

2.6 Lasers in Bonding Ceramic Brackets

In later a long time, there has been developing utilizing lasers for treating therapeutic and dental issues. In this manner, distinctive laser frameworks delivered for distinctive needs. Laser irradiation provides heat changes in the surface area. Depending on the laser wavelength and power. The etching is the procedure of vaporization and micro explosions. Photon is the main criteria for the energy level. It has no pain, pulse or heat effect. The surface is also acid resistant which is using laser etching. Calcium to phosphorus ratio is depending on the laser radiation and it reduces the carbonate-to-phosphate ratio. It is also more consistent and low acid composite. Therefore it is decreasing the caries attacks [32, 33] and the studies are showing that cancreate remineralization micro spaces [34, 35]. Therefore, laser-induced caries resistance can be of great significance in dentistry [36–38].

In Usumez study, Er; Cr: YSGG laser efficiency is tested versus acid etching technique. 3 groups were composed. One of them is acid etching, other were laser

etching. But, the laser outputs were different (1W and 2W). Brackets were bonded with these techniques and they were debonded with the universal testing machine. 7.11 ± 4.56 megapascals (MPa) are the consequences of 2W applied which was not significantly from the acid-etched technique. 5.64 ± 3.19 MPa is the consequences of laser applied techniques, it was importantly different from acid etching technique. When the surface was investigated, laser applied surfaces showed minor irregularities. In spite of the fact that laser gadgets are successfully utilized in a few other zones of dentistry, finish conditioning with an Er, Cr: YSGG laser cannot be considered a fruitful elective to the ordinary strategies of expanding bond qualities to finish.

In another study of Arturo Martínez-Insua, the tensile strength of bracket bonding were compared with using acid etching laser etching techniques. Er: YAG laser was applied. It is effective for removing dental tissues. Acid-etching technique was applied (37% phosphoric acid, 15s for enamel, 5s for dentin). Er: YAG laser was used for laser etching. Tensile bond strength for acid-etched enamel which is 14.05 ± 5.03 MPa was showing important results than for laser-etched enamel and showing importantly results for acid-etched dentin 4.70 ± 2.50 MPa than laser-etched dentin 2.48 ± 1.94 MPa. In conclusion, Adhesion to dental difficult tissues after Er: YAG laser carving is the second rate to that gotten after routine corrosive carving. Finish and teeth area arranged by Er: YAG laser carving appears broad subsurface [39, 40].

In another study of Aslihan Usumez, the tensile strength of bracket bonding were compared with using acid etching laser etching techniques. The laser was Er, Cr: YSGG. 4 groups were composed.

1. laser exposed from an Er, Cr: YSGG laser unit;
2. 37% phosphoric acid;
3. 10% maleic acid.

Ten samples have no surface treatment and served as the control group. No,

statistically significant differences were found between the bond strengths of veneers attached to teeth area etched with Er, Cr: YSGG laser 12.1 ± 4.4 MPa, 37% phosphoric acid, and 10% maleic acid.The control group showed the minimum bond strength compared in all groups [36, 41]. Smaller scale pliable bond qualities of porcelain cover lacquers fortified to tooth surfaces that were laser-etched appeared comes about comparative to orthophosphoric corrosive or maleic corrosive carved tooth surfaces [42].

In another study of Torun Ozer, shear bond strength was compared, and also the surface characteristics, and the adhesive remnant index scores were compared using, Er, Cr: YSGG laser etching, and phosphoric acid etching and a self-etching primer. 4 groups were composed. The groups; laser power was 0.75 W with 15s with Er, Cr: YSGG laser, the laser power was 1.5 W with 15s with Er, Cr: YSGG laser, 37% phosphoric acid and finally self primer. Applied 0.75 W laser showed the minimal shear bond strength when we compared other groups. Between the 1.5 W and acid etching, self primer etching group, there was no significant difference. Adhesive remnant scores showed a significant difference in all groups. When we excluded 0.75 W, there was no significant difference. 1.5 W was showing more efficient when we compared with 0.75 W.

In another study of Emine Goncu Basaran; different laser was used with Er, Cr: YSGG. 2W,1.75W, 1.5W, 1W,0.75W,0.5 W or with 38% phosphoric acid were applied. The acid-etched group showed the top mean of shear bond strength. Laser irradiation at 2W, 1.75W, 1.5 W was the same as that produced by acid etching. There is no significant enamel surface etching was obtained by 0.5 W or 0.75 W laser irradiation. In sum, laser etching techniques are showing importantly result when we compared with acid etching.

3. MATERIALS AND METHOD

3.1 MATERIALS

3.1.1 Teeth

Fresh bovine teeth were used because they can found easily and shows similar characteristics to when we compared to fellow teeth. They also do not cause contamination to the handlers and they are risk-free of infectious disease transmission.

Figure 3.1 Sample of Teeth.

3.1.2 Laser

In this experiment Er, Cr: YSGG laser was chosen. It is used for bonding ceramic brackets on enamel. The laser power was 1W along 7s. The distance between the laser and the samples was 0.5-0.7 cm. This laser is obtained from Unimed Medical and Analytical Instruments Industry and Trade Ltd. Co. Sti.

3.1.3 Orthodontic Ceramic Brackets

Polycrystalline ceramic brackets for maxillary lateral incisors were bonded to the etched bovine incisors. Polycrystalline brackets were used in this study because they are the most preferred brackets type because of esthetical reasons.

Figure 3.2 Ceramic Brackets.

3.1.4 Acid Etchant

For the acid-etching technique, 37% phosphoric acid solution (3M ESPE Scotch bond) was applied to teeth surface with an applicator.

3.1.5 Adhesive Material

In this study, as a bonding agent chemically curing Bis-GMA resin set was used to bond brackets to the surface etched by acid or laser.

Figure 3.3 Acid Etching Materials.

3.1.6 Debonding Test Machine

A universal testing machine was chosen to measure the shear bond strength. To debond the brackets from teeth, the gypsum blocks were placed in this testing frame.

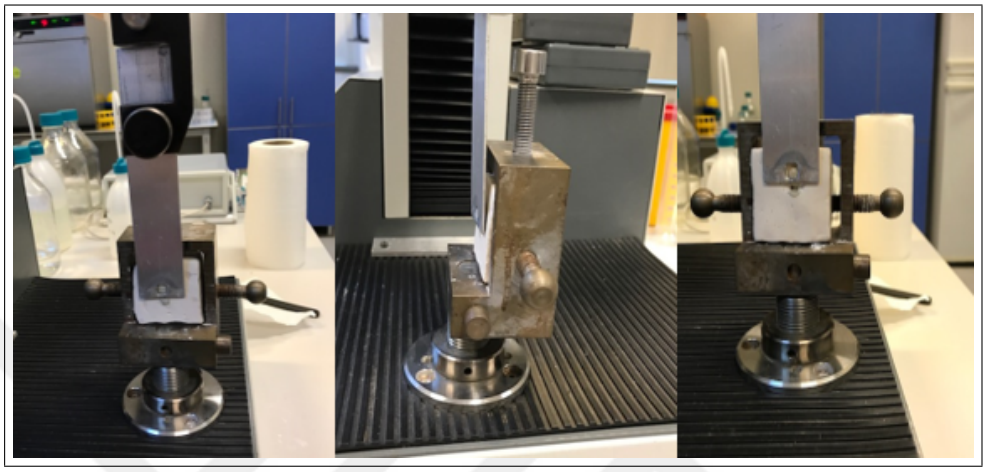

Figure 3.4 Universal Testing Machine.

3.1.7 Streptococcus Mutants

In this experiment, S.Mutans was used to measure colonization of bacteria on enamel. Streptococcus mutans could be a facultatively anaerobic, gram-positive coccus (circular bacterium) commonly found within the human verbal depth and could be a critical supporter to tooth rot.

3.2 METHODS

3.2.1 Sample Preparation

Fresh bovine teeth were used because they can be found easily and shows similar characteristics to fellow teeth. They also do not cause contamination to the handlers and they are risk-free of infectious disease transmission. After removing out, the tooth was rinsed and removed from calculus, soft tissue debris and blood and then washed.

The surface was polished. Water was used for storing at room temperature until bonding. After cleaning bovine teeth, before the embedding gypsum block, 10*10 mm area was created the labial surface of teeth. Then, they were put in gypsum block to the labial surface of the enamel. It was positioned as parallel as possible to the horizontal axis of the block. Only 10*10 mm area will appear on the gypsum block.

Figure 3.5 Embedded Bovine Teeth.

Polycrystalline ceramic brackets were used to bond teeth. Because of their availability and providing higher strength. They are giving less harmful to enamel when we compare stainless steel brackets.

We have three groups for bonding ceramic brackets in our experiment. These are;

1. Acid etched group
2. Laser etched group
3. Nonetched group
4. Only gypsum block (control group)

Each group composed of 12 samples. Before the bonding surfaces of all specimens cleaned and polished with a paste, rinsed with water and dried to remove plaque and the organic items.

3.2.2 Acid Etching

For the acid-etching technique, 37% phosphoric acid solution was applied to teeth surface with an applicator.

Figure 3.6 Phosphoric acid etchant.

In this study, as a bonding agent chemically curing Bis-GMA resin set was applied to attach brackets to the area etched by acid or laser. Acid-etching technique was used to prepare the control group. 37% phosphoric acid solution was applied to the area, which is 10x10 mm2 area, of 12 teeth with, for 30 s, rinsed with water, and dried.

Figure 3.7 Adhesive, sealant and their applicators.

3.2.3 Laser Etching

The Er, Cr: YSGG laser was used for bonding ceramic brackets. Laser energy diverges with a fiberoptic framework. The energy densities, laser parameters, applied durations, fiber tip distance will be determined during the experiments.

3.2.4 Bonding Ceramic Brackets

The surface which is etched by acid or laser and bracket base was covered with a low amount of bonding sealant. The adhesive was put to the bracket surface. Excessive sealant and adhesive were removed to put the bonding surface of every teeth same surface. Removing excess adhesive is important to prevent periodontal damage and possibility of decalcification. All bonded samples were washed with distilled water inside and stored in an incubator at 37°C for 48 hours in to keep moist and to complete composite polymerization of the resin.

3.2.5 Debonding Ceramic Brackets

A universal test device was to be used to calculate the shear bond strength and detachment time of each specimen. To start debonding, the teeth with gypsum block were put in the testing frame. To control the machine, read, collect and, record data, a computer was using.

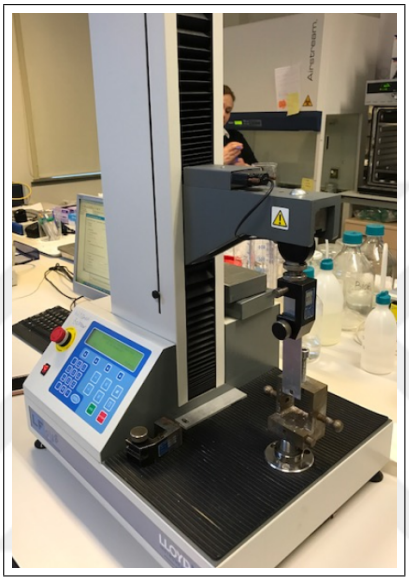

Figure 3.8 Universal Testing Machine.

The etched teeth specimens were be placed in a testing frame before debonding procedure. The tensile load was used to the specimens and the point where the bracket detachment from the tooth will be recorded in Newton. The results acquired from the tensile strength of the acid groups, the laser group, and the nonetched groups were compared.

3.2.6 Inoculation of Bacteria

Brain heart infusion (BHI) is one of the nutrient-rich growth mediums for growing microorganisms, which is suitable for S. Mutants. BHI Broth (Brain Heart Infusion Broth, Acumedia, USA) was prepared with distilled water according to its preparation manual. Then 120 ml BHI solution was put in each Erlenmeyer flasks. Then, teeth

samples were added. They were sterilized in an autoclave for 15 minutes at 121 °C. Those Erlenmeyer flasks were incubated at 37 °C in a CO2 incubator for 24 hours to check contamination. After incubation, 2 ml of S. Mutants was inoculated into the 120 ml sterilized broth, and then it was placed into the CO2 incubator at 37 C with a shaker for a homogenous inoculation. BHI broth was changed with two days period. After 10 days, samples were washed with sterilized distilled water. Then, they were put in a sterile BHI solution for 3 days. After 3 days, contamination was checked.

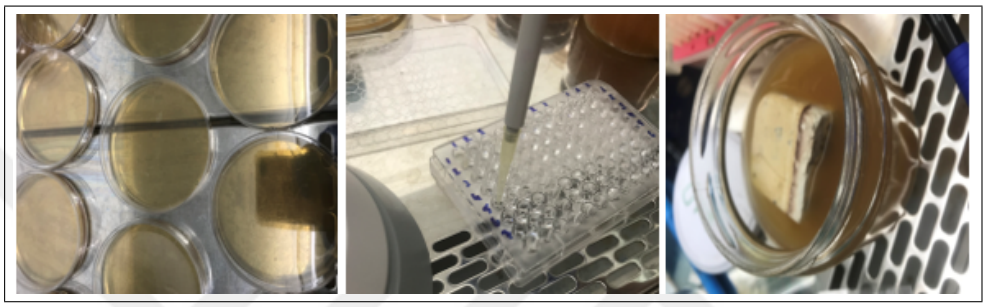

Figure 3.9 Agar Plates, 96 well Plate, Gypsum Block in Bacteria.

3.2.7 Treatment

Before treatment, the BHI Agar solution was prepared with distilled water according to its preparation manual. The agar is liquid at high temperatures, and get solid with the decreasing temperature. Each of sterile 10 cm disposable Petri dishes, plates, were filled with 20 l of sterilized agar and stayed in biosafety cabin for a night in order to get cool and to check contamination risk

3.2.8 Planting and Counting

All bacterial experiments take place in biosafety cabin and 96-wells plates were used as dilution plates in this part of the study. Each well, which was used in the experiments, was filled with a sterilized 180 µl of PBS before the operation. Then, 20 ml from the Erlenmeyer flasks were taken by a pipette and added into each well in the first line of an experimental study on the plate. Each sample was triplicated.

Each well was diluted 6 times which means three plates were obtained from one well; 18 plates from one teeth; 90 plates from a group. In the next stage, 20 ml liquid from each dilution-well was taken by a pipette and added on to the plate on rounding stand for inoculation.

Calculate the number of bacteria (CFU) per milliliter or gram of sample by dividing the number of colonies by the dilution factor. The number of colonies per ml reported should reflect the precision of the method and should not include more than two significant figures.

The CFU/ml can be calculated using the formula:

cfu/ml = (no. of colonies x dilution factor) / volume of culture plate

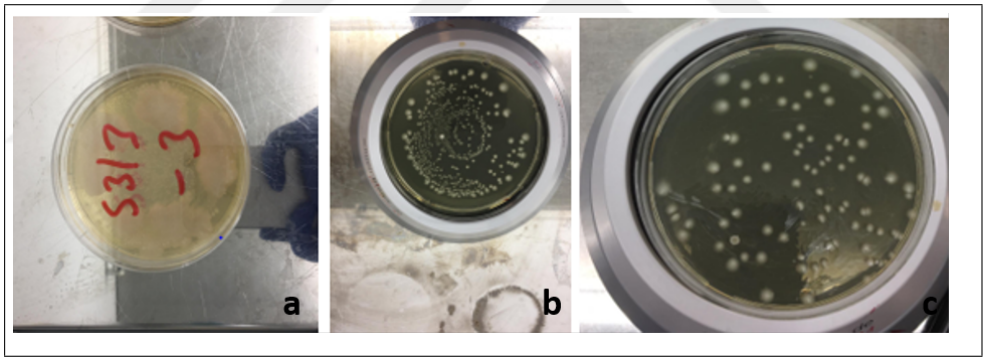

Figure 3.10 Counting Bacteria a) Inoculation of Bacteria after Acid Etching diluted by 10^{-3} b) Inoculation of Bacteria after Acid Etching diluted by 10^{-4} c) Inoculation of Bacteria after Acid Etching diluted by 10^{-6}.

After a 3-day-incubation period, the developing S.Mutants colonies foci was counted on a counting aid manually and the colony-forming units (CFUs) were examined.

4. RESULTS

4.1 Debonding Forces

The 2-way analysis of ANOVA test was applied to compare tensile bond strength. Below tables; mean, standard deviation, standard error, Maximum load, and Minimum load can be seen.

Table 4.1
Descripive Statistics for the non-etched group, acid group, and laser group

Group	n	Mean	SD	SE	Max. (Mpa)	Min. (Mpa)
1 (Non-Etched)	12	2.9425	1.33168	0.38442	4.75	0.34
2 (Acid Etched)	12	24.604	15.9878	4.61528	60.11	5.27
3 (Laser)	12	15.148	13.0526	3.76798	39.75	0.54

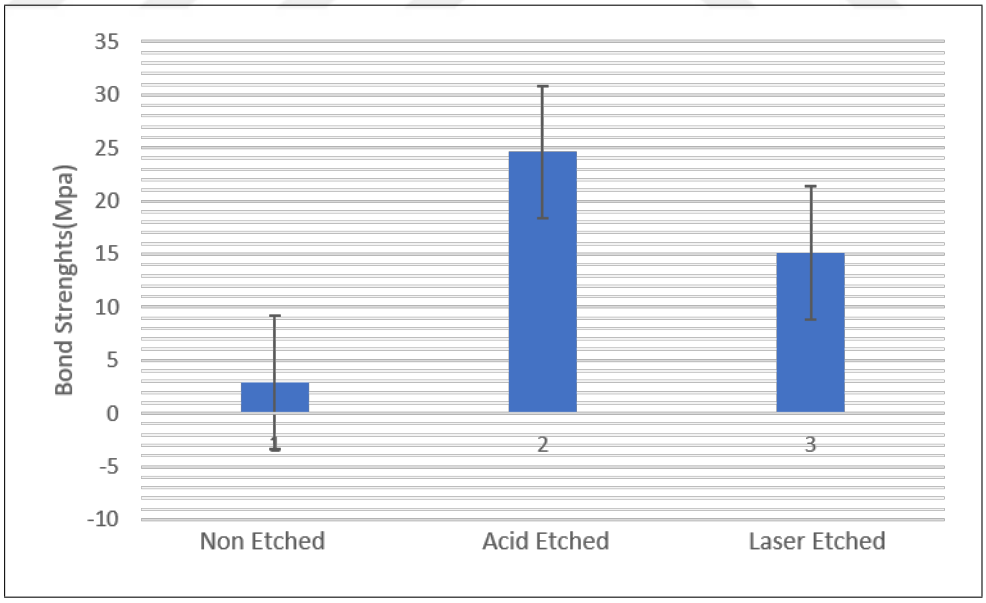

Figure 4.1 Means and Standard Deviation of Bond Strengths.

There was no critically contrast between corrosive gather and laser gather. Measurably noteworthy contrasts were found between the laser carved and the control bunch ($p<0.05$). The cruel bond quality of laser bunch was higher than the corrosive

bunch and control gather. The control bunch illustrated the least bond quality values in all test bunches.

4.2 Breaking Time

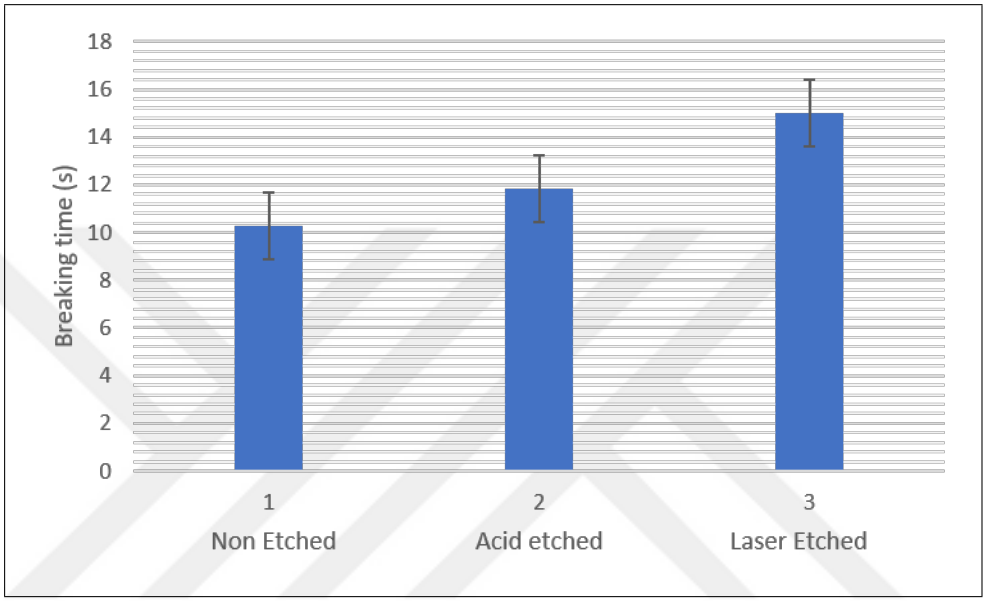

Figure 4.2 Breaking time of different techniques (according to means and the Standard Deviation).

4.3 Inoculation of Bacteria

In this study to calculate bacteria colonization 4 groups were used.

These are;

1. Acid Etched Group
2. Laser Etched Group
3. Negative Control Group (gypsum blocks)
4. Positive Control Group (nonetched group)

The inoculation techniques were the same for all experimental groups. CFU values were calculated for each group. You can see the results at below table.

Table 4.2
The CFU values and percentages of reduction in Bacteria for Selected Experimental Groups.

Groups	**CFU Values**	**The Percentage of Reduction in Bacteria Compared with Negative Control Group**
Negative Control Group	1.22 X 10^{-5}	
Non Etched	6.68 X 10^{-6}	45.3%
Acid Etched	8.54 X 10^{-6}	30%
Laser Etched	5.63 X 10^{-6}	53.8

The samples in the Negative Control Group (NCG) were not treated with any method during the experiment. All treated groups were compared to the CFU value of NGC. Shapiro-Wilk normality test showed non-parametric tests could be applied for this comparison.

Significance in the difference between CFU values of non-treated and all treated groups was examined with Kruskal-Wallis Statistical test. According to this test result, there is no meaning significance between the groups. Then each treatment was compared to NCG Group with Mann-U-Whitney comparison test. The CFU value of NGC was significantly much more than all treated groups ($p<0.05$)

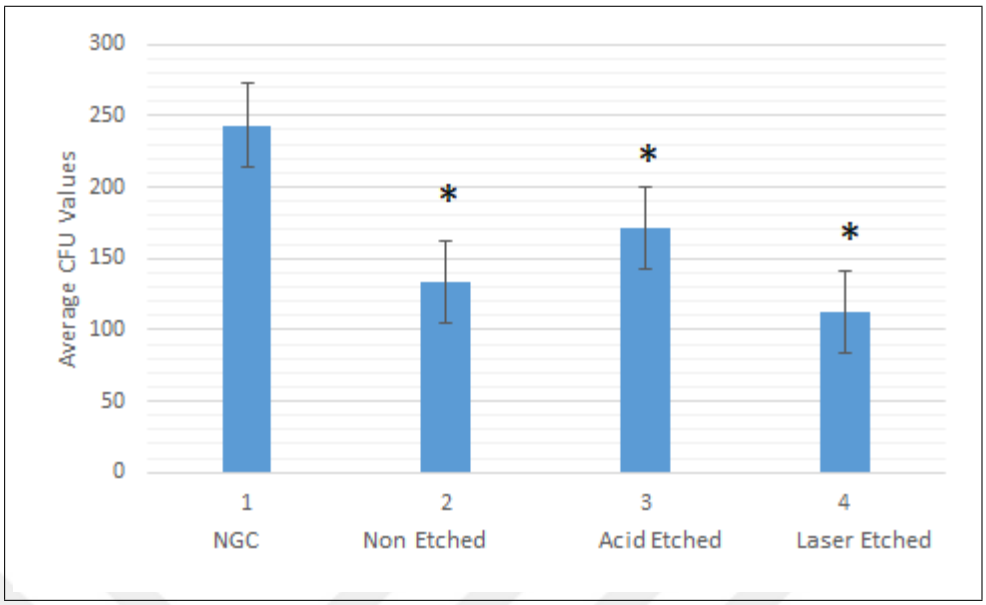

Figure 4.3 CFU of S. Mutants of non-treated and all treated groups were examined with Kruskal Wallis Statistical test and Mann-U-Whitney comparison test. The CFU value of NGC was significantly much more than all treatment groups ($p<0.05$). Significant differences were signed with asterisks (*).

According to the test result, the CFU value of NGC is much more than other groups. The difference between the other group is different.

According to t-test results, notching between acid etching groups shows a significant difference. Also, nonetching and laser group do not show significantly difference. Acid etching and laser etching groups show significantly difference.

4.4 Surface Assessment

SEM images were taken after debonding ceramic brackets.

Enamel etching with phosphoric acid creates an etch pattern characterized by surface irregularities and demineralization areas. Because of these demineralization areas, enamel becomes more susceptible to caries attack, especially under orthodontic attachments.

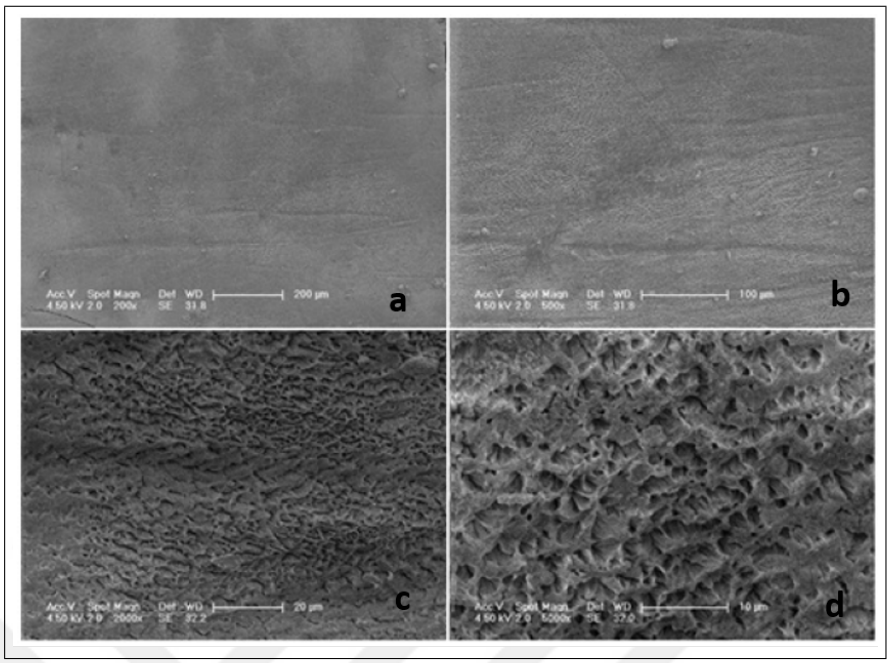

Figure 4.4 Conventional Acid Etching Method a) 200x Magnification b) 500x Magnification c) 2000x Magnification d) 5000x Magnification [43].

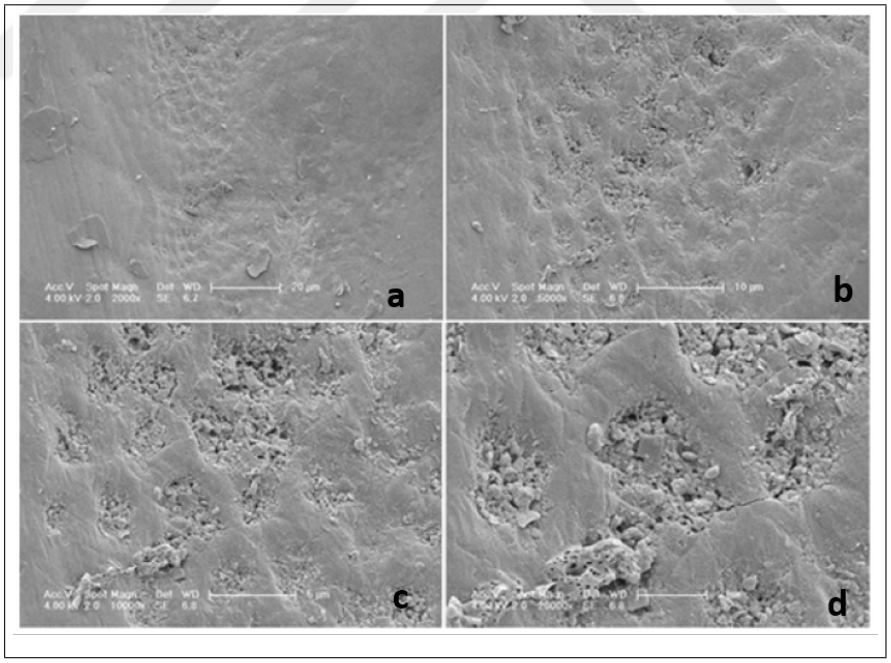

Figure 4.5 Laser Etching Method a) 2000x Magnification b) 5000x Magnification c) 10000x Magnification d) 20000x Magnification [43].

Laser etched surface produces less porous. Therefore, it is reducing the chance of carries attack.

5. DISCUSSION

Because of the availability, bovine mandibular incisors teeth were chosen in this experiment. Their physical specialties are almost the same as human teeth. In this study, the main areas that want to work firstly comparing debonding force of ceramic brackets which is applied different techniques and comparing bacterial colonization on enamel which is applied different techniques. In later a long time, there has been developing utilizing lasers for treating restorative and dental issues. Subsequently, diverse laser frameworks created for distinctive needs. Lasers in dentistry have some advantages. For example; there is no need for suture using. Bleeding can be minimized and laser can provide clotting. Sometimes, anesthesia can be unnecessary. Bacteria infection chance is lower when we compared with conventional methods. Wounds can heal faster. Finally, the laser is giving minimal harm to the area which is applied.

Laser irradiation resulted in heat changes in the surface area. It is up to wavelength and power, it causes surface roughening and inconsistency comparable to that of corrosive carving to a profundity of 10 to 20 µm. For the primary part of the test; the primary commercially accessible lasers. But the issue was, it can't be used for the hard tissues. But, Erbium doped:yttrium-aluminum-garnet laser(Er, Cr: YSGG) are using not only soft tissues but also hard tissues treatment without ant thermal side effect. Laser etching is getting an alternative way to acid etching. Er, CR: YSGG does not contain any heat or vibration and also it is not providing any pain. Also, the usage of this laser is very easy in the laboratory. In this study, Er, Cr: YSGG laser is used. Er, Cr: YSGG laser framework was found in 1995 by Eversole and Rizoiu [5]. The same laser is used for also soft and hard tissue treatment [7, 8, 16].

Laser irradiation is also acid resistant for the surface which is applied. It is providing stability and fewer acid compounds. Therefore, it is decreasing the probability of caries attack. Enamel etching is also causing irregularities and demineralization on the surface area. Since of these demineralization zones, finish gets to be more vulner-

able to caries assault, particularly beneath orthodontic connections. In this manner, laser carving of finish can be another advantage to phosphoric-acid carving.

The comes about gotten bolster the investigate speculation of an anticipated comparative cement drive after laser treatment. In Usumez study, Er; Cr: YSGG laser efficiency is tested versus acid etching technique. When the surface was investigated, laser applied surfaces showed minor irregularities. In spite of the fact that laser gadgets are viably utilized in a few other regions of dentistry, finish conditioning with an Er, Cr: YSGG laser cannot be considered a fruitful elective to the routine strategies of expanding bond qualities to finish.

In this study, debonding forces which is applied on the enamel surface to debond ceramic brackets were measure. It is concluding that there is a significantly difference between not only the non etched and acid etched group but also nonetched and laser group. There is no significantly difference between acid etched and laser group.

The second view of this study to compare the breaking time of the ceramic brackets. According to the data, there is no significantly difference between the groups. They are showing almost the same time to debond. It is showing that applying whether acid etching or laser etching techniques, the debonding time is almost the same.

The negligible mediation dentistry may be a winning concept in agent dentistry which addresses that the sum of finish and dentin ought to be maximally preserved through the sterilization of cariogenic microbes, and the incitement of remineralization. Clinically, the bulk of carious injury was as a rule evacuated by hand disobedient or rotational burs, in any case, the amount of leftover carious dentin to be evacuated, shows extraordinary contrasts among professionals. A common judgment of leftover carious dentin is based on the color by visual assessment and the hardness recognized by a sharp excavator. Be that as it may, this demonstrative model is or maybe subjective and cannot be connected to each dental specialist. Caries-disclosing colors were suggested as an objective strategy to segregate the sound dentin from contaminated dentin, but the comes about were not continuously dependable. In expansion, either

the hand disobedient or rotational burs can not ensure intensive a cleaning of the tainted dentin and remaining microbes.

Laser irradiation is also providing an antibacterial effect on the enamel surface. Heat is an effective stress factor so increasing temperature composes non-lethal damage on a cell wall. However, stress with a repetition of laser treatment converts this damage into a lethal irreversible change on the membrane. This mechanism was studied for several times, which is known as "knock effect". According to wavelength which is applied, the tissue is showing different characteristics in terms of the absorption. Water is showing highly absorption Er: YAG and Er, Cr: YSGG lasers.

According to SEM results, the surface produced by laser irradiation is also acid resistant. Laser irradiation of the enamel modifies the calcium-phosphate ratio and leads to the formation of more stable and less acid soluble compounds, thus reducing the susceptibility to caries attack. Enamel etching with phosphoric acid creates an etch pattern characterized by surface irregularities and demineralization areas. Because of these demineralization areas, enamel becomes more susceptible to caries attack, especially under orthodontic attachments. Therefore, laser etching of enamel might have another advantage to phosphoric-acid etching.

Caries assaults are among the foremost common maladies within the world and are caused by a blend of microorganisms and nourishment flotsam and jetsam. Particular sorts of acid-producing microbes, particularly Streptococcus mutants, colonize the dental surface and cause harm to the difficult tooth structure.

S. mutants give its title to a bunch of seven related with species collectively alluded. Mouth, pharynx, and intestine is the main area for attacks. Caries assaults are sourcing by many variables, such. as adherence to finish surfaces, generation of acidic metabolites. Mutans streptococci are composing corrosive environment which is lead to expanding the chance of caries assault. Ordinarily, the appearance of S. mutants within the tooth cavities is taken after by caries after 6-24 months. Streptococcus mutants were selected in this study because they were the predominant bacteria in

carious lesions and were broadly used to evaluate the bactericidal effect of restorative materials.

To calculate the killing power of laser on S.mutants, after the etching processes, the inoculation period is started. For the inoculation, it took nearly 20 days. The samples are put 2µl of S.mutants with the Brain Heart Infusion Samples. This liquid was changed each every 2 days. Then, all samples were washed with the sterilized distilled water. The reason for washing to avoid the bacteria on the surface which is not attached to the enamel surface. After washing the samples, all samples were put in sterilized BHI solution for 3 days. After 3 days, samples were taken to calculate the number of bacteria. Agar plates were used to calculate it. The samples were diluted 10-6 times. Then, CFU values were calculated.

According to the results, laser irradiation is showing significant results on the enamel surface in terms of a number of bacteria. The amount of bacteria is decreased above the 50% percentage. And, also comparing acid etching and laser etching results, again laser etching is showing significantly difference.

The laser type that we tried in our study may be an alternative to reduce the number of bacteria for removing ceramic brackets. Clinical considers are vital to affirm the comes about and to explore the laser wavelengths beneath in vivo conditions.

6. CONCLUSION AND FUTURE WORKS

In this experiment composing were 2 steps. The first one is comparing the tensile strength of different methods. Although laser etching and acid etching method worth significant results when we compare the conventional method, acid etching, and laser etching methods do not show any significant result. At the second part of the experiment, the number of bacteria was calculated on enamel. In conclusion, the CFU value of negative control group was much higher than nonetching, acid etching, and laser etching groups. Laser etching is also showing significance between nonetching group. However, acid etching and laser etching group do not show significance.

In A. Moritz study [44], cleaning, disinfection, and preparation of the root canal are indispensable requirements for successful endodontic treatment. In result, using laser beam to reduce the number of bacteria on teeth can be an alternative way. Because, this study was realized as an in vivo study. This study is showing that, when the laser is applied on the teeth, the number of bacteria was decreased the amount of more than 50% of the cases. Therefore, applying laser on enamel to reduce number of bacteria can be an encouraging method for applications on clinics.

In conclusion, laser etching of the enamel with Er, Cr: YSGG laser can be an alternative way to reduce the number of bacteria. However, further investigations are needed to find the best parameters necessary to improve the efficiency of the etching procedures and inoculation procedures. In addition, studies are showing that, in vivo experiments can be done by using these methods.

REFERENCES

1. Jena, A. K., R. Duggal, and A. Mehrotra, "Physical properties and clinical characteristics of ceramic brackets: a comprehensive review," *Trends Biomater Artif Organs*, Vol. 20, no. 2, pp. 101–15, 2007.

2. Bishara, S. E., and T. S. Trulove, "Comparisons of different debonding techniques for ceramic brackets: An in vitro study: Part ii. findings and clinical implications," *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol. 98, no. 3, pp. 263–273, 1990.

3. Azzeh, E., and P. J. Feldon, "Laser debonding of ceramic brackets: a comprehensive review," *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol. 123, no. 1, pp. 79–83, 2003.

4. O'Rahilly, R., and F. Müller, *Basic human anatomy: a regional study of human structure*, WB Saunders Company, 1983.

5. Graber, T. M., *Orthodontics: current principles and techniques*, Elsevier Mosby, 4 ed., 2003.

6. Rueggeberg, F. A., and P. Lockwood, "Thermal debracketing of orthodontic resins," *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol. 98, no. 1, pp. 56–65, 1990.

7. Mimura, H., T. Deguchi, A. Obata, T. Yamagishi, and M. Ito, "Comparison of different bonding materials for laser debonding," *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol. 108, no. 3, pp. 267–273, 1995.

8. Von Fraunhofer, J., and D. Allen, "Thermal effects associated with the nd/yag dental laser," *The Angle Orthodontist*, Vol. 63, no. 4, pp. 299–304, 1993.

9. Swartz, M., *et al.*, "A technical bulletin on the issue of bonding and debonding ceramic brackets," *Ormco Technical Bulletin*, pp. 1–15, 1988.

10. Zach, L., and G. Cohen, "Pulp response to externally applied heat," *Oral Surgery, Oral Medicine, Oral Pathology*, Vol. 19, no. 4, pp. 515–530, 1965.

11. Christopoulos, A., M. Nguyen-Tan, P. Felix, J.-C. Tabet, B. Fortin, D. Solières, D. Charpentier, and L. Guertin, "Neck dissection following concurrent chemoradiation for advanced head and neck carcinoma: Pathologic finding and complications.," *Journal of Otolaryngology–Head & Neck Surgery*, Vol. 37, no. 4, 2008.

12. Van Noort, R., and M. Barbour, *Introduction to Dental Materials-E-Book*, Elsevier Mosby, 2002.

13. Trostle, S. S., and M. D. Market, "Fracture biology, biomechanics, and internal fixation," *Veterinary Clinics of North America: Food Animal Practice*, Vol. 12, no. 1, pp. 19–46, 1996.

14. Anusavice, K. J., C. Shen, and H. Rawls, "Phillips' science of dental materials. st. louis," *Missouri Saunders*, p. 40, 2003.

15. Bishara, S. E., M. E. Olsen, L. VonWald, and J. R. Jakobsen, "Comparison of the debonding characteristics of two innovative ceramic bracket designs," *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol. 116, no. 1, pp. 86–92, 1999.

16. Rueggeberg, F. A., and P. Lockwood, "Thermal debracketing of orthodontic resins," *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol. 98, no. 1, pp. 56–65, 1990.

17. Anusavice, K. J., C. Shen, and H. Rawls, "Phillips' science of dental materials. st. louis," *Missouri Saunders*, p. 383, 2003.

18. Anusavice, K. J., C. Shen, and H. Rawls, "Phillips' science of dental materials. st. louis," *Missouri Saunders*, p. 35, 2003.

19. Kusy, R. P., and J. Q. Whitley, "Friction between different wire-bracketconfigurations and materials," in *Seminars in Orthodontics*, Vol. 3, pp. 166–177, Elsevier, 1997.

20. Larmour, C., J. McCabe, and P. Gordon, "Notching of orthodontic bonding resin to facilitate ceramic bracket debond–an ex vivo investigation," *British Journal of Orthodontics*, Vol. 25, no. 4, pp. 289–291, 1998.

21. Abdul-Kader, H., and S. Ibrahim, "Heat generated during laser enamel etching and laser debonding of ceramic brackets: a concomitant dental pulp histopathological changes," *Al-Azhar J Dent Scien*, Vol. 2, pp. 91–97, 1999.

22. Ahrari, F., F. Heravi, R. Fekrazad, F. Farzanegan, and S. Nakhaei, "Does ultra-pulse co 2 laser reduce the risk of enamel damage during debonding of ceramic brackets?," *Lasers in Medical Science*, Vol. 27, no. 3, pp. 567–574, 2012.

23. Dostálová, T., H. Jelínková, D. Houšová, J. Šulc, M. Němeć, J. Dušková, M. Miyagi, and M. Krátky, "Endodontic treatment with application of er:yag laser waveguide radiation disinfection," *Journal of Clinical Laser Medicine and Surgery*, Vol. 20, no. 3, pp. 135–139, 2002.

24. Jelinkova, H., T. Dostalova, J. Duskova, M. Miyagi, S. Shoji, J. Sulc, and M. Nemec, "Er:YAG and alexandrite laser radiation propagation in the root canal and its effect on bacteria," in *Lasers in Dentistry V* (Featherstone, J. D., P. Rechmann, and D. Fried, eds.), Vol. 3593 of , pp. 15–21, May 1999.

25. Swartz, M. L., "Ceramic brackets," Vol. 22, pp. 82–90, 1988.

26. Vukovich, M. E., D. P. Wood, and T. D. Daley, "Heat generated by grinding during removal of ceramic brackets," *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol. 99, no. 6, pp. 505–512, 1991.

27. Douglass, J., "Enamel wear caused by ceramic brackets," *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol. 95, no. 2, pp. 96–98, 1989.

28. Bishara, S. E., D. E. Fehr, and J. R. Jakobsen, "A comparative study of the debonding strengths of different ceramic brackets, enamel conditioners, and adhesives," *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol. 104, no. 2, pp. 170–179, 1993.

29. Redd, T., and P. Shivapuja, "Debonding ceramic brackets: effects on enamel.," *Journal of Clinical Orthodontics: JCO*, Vol. 25, no. 8, p. 475, 1991.

30. Storm, E., "Debonding ceramic brackets.," *Journal of Clinical Orthodontics: JCO*, Vol. 24, no. 2, pp. 91–94, 1990.

31. Keith, O., R. P. Kusy, and J. Q. Whitley, "Zirconia brackets: an evaluation of morphology and coefficients of friction," *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol. 106, no. 6, pp. 605–614, 1994.

32. Pope, M., "Dental laser. do they make cents," *Dental Economics*, Vol. 89, pp. 360–363, 1999.

33. Von Fraunhofer, J., D. Allen, and G. Orbell, "Laser etching of enamel for direct bonding," *The Angle Orthodontist*, Vol. 63, no. 1, pp. 73–76, 1993.

34. Oho, T., and T. Morioka, "A possible mechanism of acquired acid resistance of human dental enamel by laser irradiation," *Caries research*, Vol. 24, no. 2, pp. 86–92, 1990.

35. Morioka, T., K. Suzuki, and S. Tagomori, "Effect of beam absorptive mediators on acid resistance of surface enamel by nd-yag laser irradiation," *Journal of Dental Health*, Vol. 34, no. 1, pp. 40–44, 1984.

36. Visuri, S., J. Gilbert, D. Wright, H. Wigdor, and J. Walsh Jr, "Shear strength of composite bonded to er: Yag laser-prepared dentin," *Journal of Dental Research*, Vol. 75, no. 1, pp. 599–605, 1996.

37. Fowler, B., and S. Kuroda, "Changes in heated and in laser-irradiated human tooth enamel and their probable effects on solubility," *Calcified Tissue International*, Vol. 38, no. 4, pp. 197–208, 1986.

38. Keller, U., and R. Hibst, "Ultrastructural changes of enamel and dentin following er: Yag laser radiation on teeth," in *Laser Surgery: Advanced Characterization, Therapeutics, and Systems II*, Vol. 1200, pp. 408–415, International Society for Optics and Photonics, 1990.

39. Keller, U., and R. Hibst, "Effects of er: Yag laser on enamel bonding of composite materials," in *Lasers in Orthopedic, Dental, and Veterinary Medicine II*, Vol. 1880, pp. 163–168, International Society for Optics and Photonics, 1993.

40. Niemz, M., L. Eisenmann, and T. Pioch, "A comparison of 3 laser systems for dental enamel ablation," *Schweizer Monatsschrift fur Zahnmedizin= Revue Mensuelle Suisse D'odonto-Stomatologie= Rivista Mensile Svizzera di Odontologia e Stomatologia*, Vol. 103, no. 10, pp. 1252–1256, 1993.

41. Martínez-Insua, A., L. da Silva Dominguez, F. G. Rivera, and U. A. Santana-Penín, "Differences in bonding to acid-etched or er: Yag-laser–treated enamel and dentin surfaces," *The Journal of Prosthetic Dentistry*, Vol. 84, no. 3, pp. 280–288, 2000.

42. Hibst, R., and U. Keller, "Experimental studies of the application of the er: Yag laser on dental hard substances: I. measurement of the ablation rate," *Lasers in Surgery and Medicine*, Vol. 9, no. 4, pp. 338–344, 1989.

43. Şen, A., "Laser etching of enamel for bonding orthodontic bracket," Master's thesis, Bogazici University, Istanbul, Turkey, 2012.

44. Moritz, A., N. Gutknecht, U. Schoop, K. Goharkhay, O. Doertbudak, and W. Sperr, "Irradiation of infected root canals with a diode laser in vivo: results of microbiological examinations," *Lasers in Surgery and Medicine: The Official Journal of the American Society for Laser Medicine and Surgery*, Vol. 21, no. 3, pp. 221–226, 1997.

45. Dostálová, T., H. Jelínková, J. Šulc, P. Koranda, M. Nemec, J. Racek, and M. Miyagi, "Laser radiation bracket debonding," in *Lasers in Dentistry XIV*, Vol. 6843, p. 684304, International Society for Optics and Photonics, 2008.