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Prevalence of Bonding Failure Rate of Molar Tube: A retrospective Study

A Project Submitted to
The College of Dentistry, University of Baghdad,
Department of orthodontic in Partial Fulfillment for the
Bachelor of Dental Surgery

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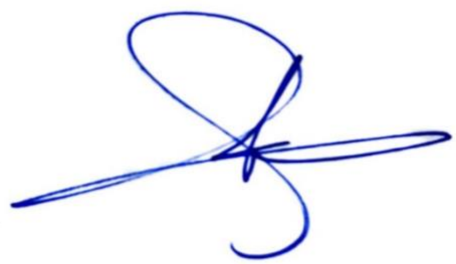
Certification of the Supervisor

I certify that this project entitled **" Prevalence of Bonding Failure Rate of Molar Tube, a retrospective study"** was prepared by the fifth-year student **Mina Tariq Fouad** under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.



Assist. Prof. Dr. Harraa Sabah Mohammed-Salih

24/04/2022

Dedication

I would like to dedicate this work to my beloved family, the reason of my success who stood by myside who taught me throughout 17 years, who believed on me, and who supported me with every step of my life, and to everyone who helped me to make this project.

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Introduction

The global prevalence of malocclusion is reported to be approximately 50-80% **(Singh *et al.*, 2016; Shen *et al.*, 2018)**. However, malocclusions themselves include a wide area of research. In general, malocclusions are classified into Cl I, II, and III. Among these, Cl I malocclusions are the most prevalent type in the world, and then Cl II and Cl III **(Nucera *et al.*, 2017).**

Not all malocclusions need orthodontic treatment, the need for orthodontic treatment is influenced by the malocclusion's severity, its effect on the stomatognathic system, and the request of the patient. Orthodontic therapy in treating malocclusion involves various forms of appliances. In contemporary orthodontic practice, pre-adjusted edge-wise systems are the most frequently used over the world **(Thickett *et al.*, 2007)**. The goals of orthodontic therapy are the perfection of oral and dental health state and, as a consequence, well facial aesthetic and appearance (obtain the maximum esthetical outcome), which are the reasons of increasing request of treatment by individuals **(Murakami *et al.*, 2016)**.

Orthodontic attachments are generally bonded to enamel using mechanical locking created by acid-etching the enamel surface of the teeth. Direct bonding places the attachments on the teeth individually at the chairside and indirect bonding places the attachments on study models in the laboratory and these are transferred to the teeth using a positioning tray. The advantage is greater accuracy of bracket positioning, however, the extra cost and time involved make this process less popular for routine orthodontics with labial appliances, although it is used when placing lingual fixed appliances **(Cobourne and DiBiase, 2016)**.

The steps involved in bonding are cleaning the tooth surface, to remove any pellicle using a slow hand piece and prophy brush or cup, acid-etching the enamel surface using 37% phosphoric acid for 20–30 seconds, washing and drying the tooth surface, placing unfilled primer on the etched area of the tooth, placing composite resin on the attachment base, positioning the bracket on the tooth crown, cleaning up excess composite from around the bracket base and curing the composite, either chemically or with a blue light source **(Cobourne and DiBiase, 2016)**.

Bonding is the early phase in the treatment of a patient by fixed orthodontic appliance. Placing of orthodontic appliance is probably the most significant mechanical process in the treatment of orthodontic patients. As the final phases are approached, appropriate placement of attachments can be produced in situation which start to occlude fairly acceptably with slight effort, while inappropriate bracket placement can be produced in condition which need several additional months of finishing and detailing **(Naqvi *et al.*, 2019)**.

The bonding of molars is becoming increasingly more agreeable and predominant, as bonding involves less chair-side time, the bonding tubes are friendly to gingiva, and the interdental zone is free of bands, which is more comfortable and pleasing for patients. At the same time, molar banding become less popular among orthodontist in recent year as it is associated with the pain which results from the separator as well as the impinging on of the interdental zone by the band material **(Kafle and Rajbhandari, 2012)**. Also, banding is related with the growth of dental decay and white-spot lesions **(Srivastava *et al.*, 2013; Munjal *et al.*, 2016).**

Unfortunately, bonded molar has many drawbacks. The most common is the bond failure such as inadequate drying of the dentition after etching and wetted with saliva **(Roelofs *et al.*, 2017)**. According to **Umeh *et al.* (2021)** bond failure is offered to either patient related factors include differences in enamel composition of the patient’s and/or masticatory forces, or bonding procedure related factors including trouble in preserving appropriate isolation of the area during bonding, insufficient adaptation of the attachment base (tube, bracket) to the tooth surface, improper etching and bonding procedure **(Sukhia *et al.*, 2011).** Therefore, this study aimed to identify the prevalence of bond failure rate of molar attachments (tubes) in relation to patient factors.

Aim of the Study

The aim of this retrospective study is to evaluate the rate of bond failure of molar tube in patients treated at postgraduate clinic of orthodontic department at the College of Dentistry/ University of Baghdad in the last of 5 years.

Primary Objectives:

- Evaluate the failure rate between gender.
- Evaluate the failure rate in relation to the age range.
- Evaluate the failure rate in relation to the arch (maxilla and mandible).
- Evaluate the failure rate in relation to the side (right and left).
- Evaluate the failure rate of molar tube between upper and lower molars (1^{st}, 2^{nd} molars).

Chapter One: Review of Literature

1.1. Fixed Orthodontic Appliance

Fixed, rather than removable, appliances create an improved the result of therapy **(O'Brien *et al.*, 1993; Richmond *et al.*, 1993)**, and are preferred by the greatest number of orthodontists. The prosperity of a fixed appliance relies moderately on the metal attachments (brackets and bands) being attached to the teeth so that they do not become de-bond throughout treatment **(Chestnutt *et al.*, 2006)**.

Brackets (metal squares) are typically bonded to teeth other than molars, where bands (metal rings that bonded around each tooth) are more frequently utilized for molars **(Stirrups, 1991)**. Orthodontic tubes (stainless steel tubes that permit wires to go through them), are usually welded to bands but they may also be bonded directly to molars. In the last instance, they may be made of either stainless steel or titanium; several manufacturers yield typical and smaller sizes molar tubes. The percentage of US orthodontists who regularly bond 1^{st} or 2^{nd} molars has nearly multiplied (twice) in the past 6 years; with exclusion of 2^{nd} upper molars, ≃50% of orthodontists are bonding, instead of banding, molars (≃49% upper 1^{st} molar; ≃41% upper 2^{nd} molar; ≃48% lower 1^{st} molar; ≃52% lower 2^{nd} molar) **(Keim *et al.*, 2008)**.

Different systems have developed of fixed orthodontic appliance. the standard edgewise appliance which originated from the work of Edward Angle, on which most fixed appliances are now based **(Angle, 1928)**. The standard edgewise appliance became the fixed appliance of choice up until the late 1970s, but it did suffer from several disadvantages. Light wire appliances, in an effort to overcome the high anchorage demand associated with the standard edgewise appliance, an Australian orthodontist, **P. Raymond Begg** developed a fixed appliance system where tooth movement was based around the concept of differential force **(Begg, 1956)**, so the

Begg technique was much lighter on anchorage and became very popular during the 1960s and 1970s. Later on, Tip-Edge appliance was developed by Peter Kesling in the late 1980s, (as shown in Figure 1.1). **(Kesling *et al.*, 1991)**.

After that, the pre-adjusted edgewise or 'straight-wire' appliance that **Andrews** described is the most popular fixed appliance system in use today. Unlike standard edgewise brackets, which are identical for each tooth and require bends within the archwire to generate individuality of tooth position, each tooth in the pre-adjusted edgewise system has a customized bracket. In this pre-adjusted system, the work is accurately positioning the teeth by the bracket prescription, significantly reducing the amount of wire bending required. A further advantage is that it also allows groups of teeth to be moved and spaces closed by sliding them in unison along a rigid archwire, because once tooth alignment has been achieved, the archwire sits passively in each bracket slot **(Cobourne and DiBiase, 2016)**.

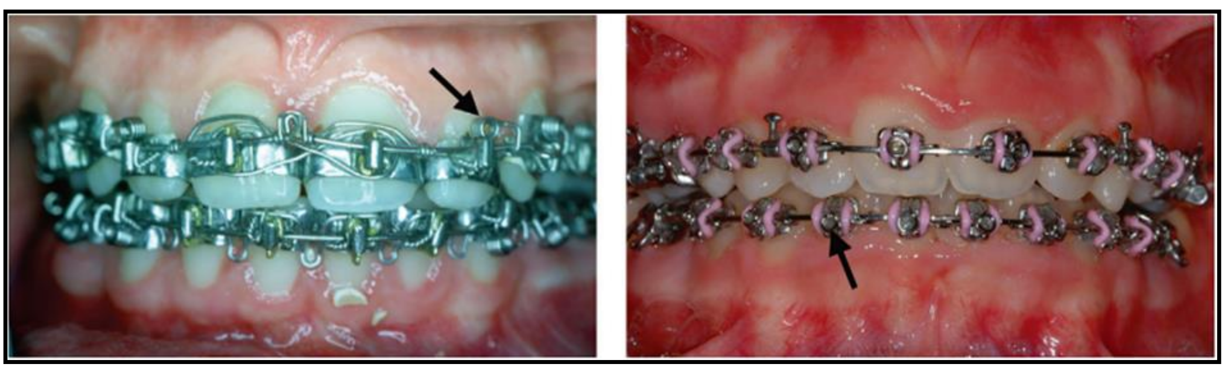

Fig.1.1: A fully banded Begg appliance (left) and bonded Tip-Edge appliance (right). [Modified from **(Cobourne and DiBiase, 2016)**].

1.2. Components of Fixed Orthodontic Appliance

The main components of modern fixed appliances are molar attachment (bands and tubes), brackets and arch wires, as shown in Figure 1.2.

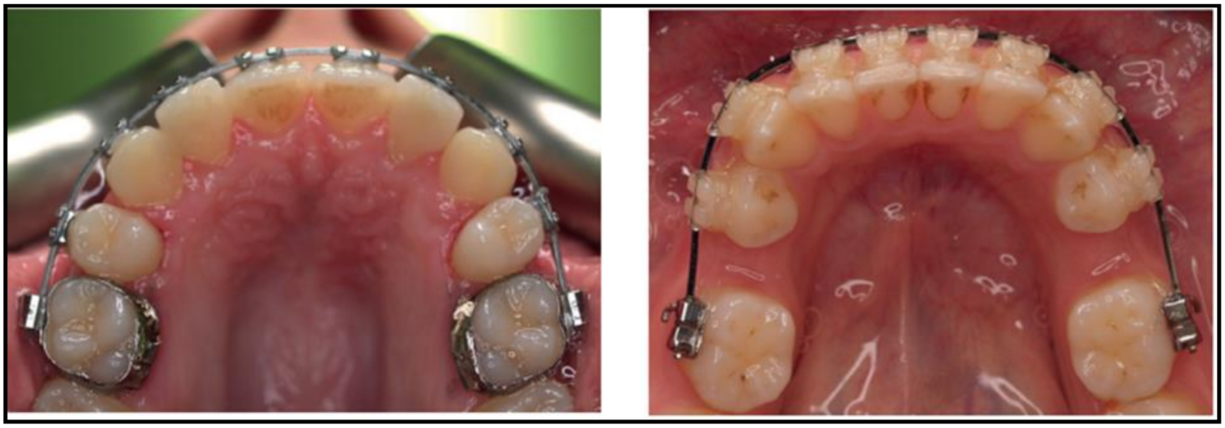

Fig. 1.2: Main components of fixed orthodontic appliance. [Modified from **(Cobourne and DiBiase, 2016)**].

1.2.1. Molar Attachments

Metal bands are cemented to molars which offer connection to other auxiliaries. Preformed steel bands came into prevalent use throughout the 1960s and are now presented in anatomically accurate forms for all the dentition. Afterward the introduction of acid etching of enamel by Buonocore in 1955, direct attachment of orthodontic brackets to incisors, canines, premolars and even molars is now carried out regularly as part of fixed appliance treatment **(Al Agili, 2015)**.

1.2.1.1. Molar Bands

These are rings surrounding the tooth, frequently and mostly the molars, to which buccal, and as required, lingual, attachments are fused or welded **(Mitchell, 2013)**. Despite the common use of bonded brackets and molar tubes, conventional stainless-steel bands have a site in clinical orthodontics, mostly for 2nd bicuspid, 1st and 2nd molar teeth. Bonded tubes on molar teeth have a failure rate, 33.7% in comparison with conventional bands, 18.8% **(Banks and Macfarlane, 2007)**. While several orthodontists presently bond all teeth involving 2nd molars, in several cases the reliability of well-banded molars provides the clinician with a comfort region knowing that all molar attachments are good protected during orthodontic treatment **(Mizrahi, 2015)**.

To create space for the placement of bands, the contact points need to be opened by placing separators between the teeth for a few days. There are four probable adverse effects may caused by orthodontic band (rise in the gingivitis related to orthodontic bands). First, orthodontic bands mechanically irritate gingival tissues. Second, chemical irritation may happen owing to the cement utilized to retain the band which is nearby the gingival tissues. Third, a larger hazard of diet impaction and hence posterior gingival and periodontal irritation may happen. Lastly, patients may have a propensity to clean their frontal teeth more successfully than their posterior teeth (**Atack *et al.*, 1996)**.

1.2.1.2. Molar Tubes

Tubes, which are frequently attached to the molars in the dental arch, might be rounded or four-sided in section, to take either round or rectangular section arch-wire. Bigger tubes are utilized to take extra-oral arches **(Foster, 1990)**. The buccal tube is a metal tube secure to the facial (buccal) surface of an orthodontic molar band or straight to the surface of the tooth which permits the arch wire to go through while applying either a torqueing force or permitting the wire to slide as tooth movement happens **(Jones Jr *et al.*, 2002)**. According to **Bennett and McLaughlin (2014)**, there are four rudimentary categories of buccal tubes obtainable:

- Mandrel formed: the tube is pressed and machine-folded to the wanted size.
- Drilled formed: the tube is machine-formed and drilled to the size.
- Metal Injection Mold formed: the tube with its slot shaped by milling machine, which consider as a precise manufacturing procedure.
- The CNC machine - utilizing computer numerical control machining.

1.2.2. Brackets

Orthodontic brackets bond to the tooth crown and mediate forces applied by the archwire and auxiliaries to the tooth. Brackets are either routinely cast or injection-molded from stainless steel, although to reduce the chance of allergic reaction, nickel- free brackets made from titanium or cobalt chromium are now available. Also, brackets are either buccally or lingually attached to tooth surfaces as shown in Figure 1.3, **(Cobourne and DiBiase, 2016)**.

Fig. 1.3: Brackets type, buccally attached (left) or lingually attached (right). [Modified from **(Cobourne and DiBiase, 2016)**].

1.2.3. Archwires

The original archwires used in orthodontics were made of gold, but metallurgical advances have meant that a wide range of metal alloys are now available. These different alloys all offer a variety of physical properties. The ideal properties required of an orthodontic archwire will depend upon the stage of treatment and the type of tooth movements being carried out; no archwire material will offer all of these together **(Kapila and Sachdeva, 1989)**. For this reason, a number of different archwires are required during a course of orthodontic treatment and these will vary in both the type of metal used and the dimensions. The metal alloys currently used for the fabrication of orthodontic archwires include stain less steel, nickel titanium, cobalt chromium and beta titanium are available with different cross section and dimensions **(Cobourne and DiBiase, 2016)**.

1.3. Bonded *versus* Banded Molar Attachments

Molar banding is a well-established process in orthodontics as it produces good retention and resistance to orthodontic forces **(Oeiras *et al.*, 2016)**, but many drawbacks are listed including patient hygiene may be compromised, permitting for plaque growth and accumulation and for the development of periodontal complications, which are more dangerous in adult patients **(Boyd and Baumrind, 1992)**, aching experience both before and during the process **(Erverdi *et al.*, 1999)** and an extra appointment is required for previous separation of the adjacent dentition and fitting of the molar band **(Oeiras *et al.*, 2016)**.

Orthodontists have usually used to band molar teeth throughout fixed appliance treatment. In the early years of direct bonding, bonded molar attachments were found to have an increased failure rate (up to 30%) in comparison with bonding other teeth **(Banks and Macfarlane, 2007)**. More newly, there has been rise in the admiration of molar bonding, which is more suitable for both patient and clinician. The necessity for separators and, therefore, anti-biotic prophylaxis in patients at danger from bacteremia is decreased (separator placement, which go before band position, has been stated to induce transient bacteremia and poses a danger to patients at risk of infective endocarditis (**Umeh *et al.*, 2016)**. In addition, oral hygiene is simplified as bonded attachments attract a lesser amount of plaque **(Banks and Macfarlane, 2007)**.

Bonding of attachments to molars has become progressively common in recent years due to the utilities that bonded molar tubes offer in comparison with bands, which include bigger time efficiency with no need for separation, minimize of band spaces that may present after treatment, minimized contamination risks, more quickly placement, greater patient comfort, a more esthetic appearance, reduced risk of decalcification that may accompany moveable (loos) bands, and easier finding of decay subsequent to greater visibility of the enamel **(Talpur *et al.*, 2012)**.

In spite of the advantages in terms of comfort, slight periodontal damage and shorter chair period, direct bonding of molars is not yet commonly accepted amongst orthodontists. Fail of tubes bonded to molars is significantly more than molars bands **(Millett *et al.*, 2017)**. However, the vast majority of patients involved of kids and teenagers. This aspect is of paramount importance since patient age has an important effect on the failure of orthodontic appliances **(Millett *et al.*, 1999)**.

The failure rate of bonded molar tubes was meaningfully higher than (practically twice) that seen for bands and the survival time of the bonded tubes was nearly half that of the bands **(Banks and Macfarlane, 2007)**. The bonding of attachments to molar teeth throughout fixed orthodontic therapy has nearly doubled, this has been attributed to better understanding of the bonding procedure, enhancements in bond systems and better design of molar buccal tubes **(Keim *et al.*, 2008)**.

1.4. Bond Failure Rate of Molar Attachment

The accidental detachment of a bracket or tube throughout orthodontic therapy will be named ‘‘bond failure.’’ In bond failures, the time of the therapy enlarged and affect the prices of orthodontic treatment **(Millett *et al.*, 2011)**. A glued attachment must resist forces produced during orthodontic treatment and those conducted to the teeth during chewing and occlusion. Failure to withstand these forces can be result in bond failure **(Abu-Alhaija *et al.*, 2017)**.

Next to preparation of the tooth surface, contamination of the tooth surface with saliva fluid should be averted by utilizing of cotton rolls, dry angles, suction, and cheek retraction are used to avert contamination with saliva at the time of bonding process **(Umeh *et al.*, 2021)**. The bond strength of tube has been enhanced by utilize of a 15-30-second etch time (37% phosphoric acid have demonstrated acceptable bond strength for orthodontic attachments) **(Umeh *et al.*, 2016)**, since molar buccal enamel microstructure has less prisms present **(Mattick and Hobson, 2000)**. Testing *in vitro* has revealed a difference in bond strengths for different tooth kinds, and unpredictably, lower molars showed the maximum value **(Hobson *et al.*, 2001)**. Composite type testing *in vitro* studies revealed its superiority to glass ionomer cement (GIC) in attachment retention**, (Millett and McCabe, 1996)**, while light and chemical-cured composite kinds yield similar failure rates **(Sunna and Rock, 1998)**.

Band cementation using GIC has formed clinical failure rates from 0.6 to 20% in diverse studies, **(Stirrups, 1991)** while different types (resin-modified, light-activated and conventional) of GIC make equally well **(Fricker, 1997)**. Micro-etching of the fitting surface of bands has been shown to decrease their failure rate significantly, **(Hodges *et al.*, 2001)** while sandblasting molar tubes had slight effect on their bond strengths **(Johnston and McSherry, 1999)**.

Many factors which may affect molar attachment failure rates are:

- Patient-related factors including: age **(Millett *et al.*, 1999)**, gender, the tooth kind, the position of the arch and occlusal stress **(Umeh *et al.*, 2021)**
- Treatment-related factors (**Millett and Gordon, 1992)**.
- Diverse operators **(Millett and Gordon, 1992; Millett *et al.*, 1999)**.

The younger patients (children) show a much higher bond buccal tube failure than adult patients **(Aikins and Ututu, 2017)**. This may be credited to a reduced level of motivation and adherence to dietary and oral hygiene advices (instruction) and self-motivation in young patient while experiencing orthodontic treatment when compared to old patient **(Therneau *et al.*, 2003; Sukhia *et al.*, 2011)**. The age maturity may be similarly contributory to the progressive decline in the buccal tube loss as treatment advanced. This may affect the preference of the utilize of bands in the younger orthodontic population (children) but may not be required for adult patients who may have current periodontal disease which may be deteriorated by band placement **(Umeh *et al.*, 2021)**.

There is found that there was a little higher male incidence of bond failure **(Aikins and Ututu, 2017; Roelofs *et al.*, 2017)**.

In our environment, our food includes mostly solid, hard and coarse diets; thus, dietary changes that exclude of the treatment. Adherence to this dietary counsel over a lengthy period might be difficult and may be related to the moderately high bonding failure. Lesser bond failure in the upper arch compared to the lower arch amongst patients experiencing orthodontic treatment **(Moninuola *et al.*, 2010; Aikins and Ututu, 2017)**.

The report on the bond failure pattern on the side of the jaw is equivocal **(Moninuola *et al.*, 2010; Aikins and Ututu, 2017).** In some studies, have been stated that the right side of the jaw showed an increase in bond failure in comparison to the left side. Masticatory behaviors of the patient may be associated to bond failure **(Umeh *et al.*, 2021)**. The side of the jaw that the patient utilizes more can influence the side where bond failure happens. Masticatory preference has been found with possible origins in the main hemisphere of the brain **(Khamnei *et al.*, 2019)**. So, right-sided people (more common) are more possible to masticate on the right side of the jaw, with subsequent higher bond failure **(Umeh *et al.*, 2021)**.

A glued molar tube should be able to withstand tensile, shear, torque and peel functional stresses if it is to persist bonded to the tooth surface **(Millett *et al.*, 1999)**. The adhesive should be sturdy sufficiently to preserve the molar tube bonded to the tooth for a long-time during treatment, but not so sturdy that the tooth surface is injured (damage) when the tube is detached. It should also perfectly be easy to use clinically, defensive against dental caries (decay) and sensible cost **(Millett *et al.*, 2017)**. The use of resins for attachment of tubes to molars is more challenging than attachment of brackets to anterior teeth. There is a poorer quality of etch pattern and it is difficult to preserve complete moisture isolation **(Mattick and Hobson, 2000)**. With the number of adhesives existing, it is essential to know which group bonds tubes most reliably to molar teeth as well as decreasing or preventing dental caries throughout the treatment time **(Millett *et al.*, 2017)**. In addition, larger chewing forces, at the posterior rather than at the anterior of the mouth, may induce higher molar bonding failure rates mainly of lower molar tubes **(Pandis *et al.*, 2005, 2006).**

Chapter Two: Materials and Methods

2.1. Sample

In this study, orthodontic case sheets of 407 cases were selected from the archive for the last 5 years (from 2017 till 2022) of the Orthodontic Department undergoing orthodontic treatment by post-graduate students in the hospital of College of Dentistry, University of Baghdad.

2.2. Selection Criteria and Sample Size

Based on the inclusion and exclusion criteria, only 367 cases were treated with fixed orthodontic appliance by using 0.22” slot bracket and have bonded molar tubes on at least 1st molar in both upper and lower arches and have complete details of the treatment were included and further analyzed for study purposes.

Case sheets with insufficient details, sectional and retreatment cases, patients treated with removable and myofunctional appliances and patients with craniofacial anomalies were excluded from the study.

2.3. Data Collection and Arrangement

Data were collected in an Excel spreadsheet. The collected data include patients age at time of commencement of the treatment, gender, date of commencement of the orthodontic treatment and date of finished treatment. Information on the failure of buccal tubes bonded on either the upper and lower arch, right and/or left side. This retrospective study also obtained information about the type of malocclusion in the patients undergoing orthodontic treatment to evaluate their relation on the failure rate of molar tube on the 1st and 2nd molar, as well as the time (during treatment) the bond failure occurred.

2.4. Statistical Analysis

Descriptive statistics were applied to determine the prevalence of bond failure, using excel program to determine bond failure rate among genders and type of malocclusion.

Chapter Three: Results

A total of 367 patients comprising of 236 females (64.3%) and 131 males (35.6%) had bonded tubes on molars. Nearly, 52% of the study sample had age range 12-17years while ≃23% were 18-20years and quarter of the sample were aged above 20years. Half of the sample exhibited Cl I malocclusion, followed by Cl II, 33.5% and the least were with Cl III malocclusion, as shown in Table 3.1.

Table 3.1: Sociodemographic variables of the study population.

Variables	Frequency (n=367, 100%), n (%)
Genders	
Females	236 (64.3%)
Males	131 (35.6%)
Ages range (years)	
12-17y	190 (51.8%)
18-20y	84 (22.9%)
>20	93 (25.3%)
Type of malocclusion	
Cl I	194 (52.9%)
Cl II	123 (33.5%)
Cl III	50 (13.6%)

In general, only 6.5% of total sample experienced bond failure (24 cases), 24 case out of 367 comprising of 11 females and 13 males. Table 3.2, showed that out of 131 male, buccal tube failure rate occurred in 13 (9.9%~10% failure rate) of them, whereas in females, out of 236, buccal tube failure occurred in 11 (4.6% failure rate) of them in relation to total number of cases that was collected.

Table 3.2: Percentage of buccal tube bond failure with gender of the patients.

Gender	Bond failure (n=24), n (%)	Non-bond failure (n=343), n (%)	Total (n=367), n (%)
Male	13 (10%)	118 (90%)	131 (35.7%)
Female	11 (4.7%)	225 (95.3%)	236 (64.3%)

An estimated of the bond failure between gender showed increased percentage of the male patients in comparison with the females. Regarding to de-bonded cases that were detected (24 cases), female comprising 46% bond failure rate, whereas male exhibited 54% bond failure rate, as shown in Figure 3.1.

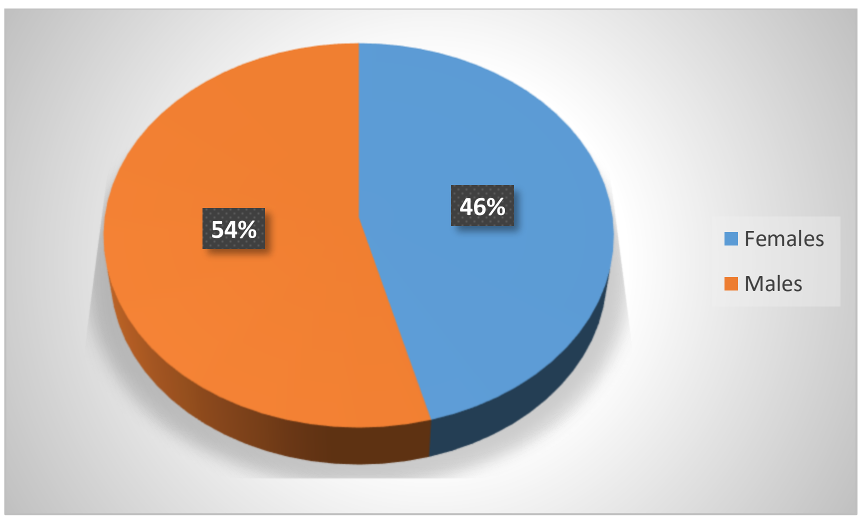

Fig 3.1: Percentage of bond failure rate in relation to gender differences.

Within 24 cases of molar tube failure, the relationship between age and bond failure rate showed a greater increase in the failure rate in the younger age group (12-17years) in comparison with adult patients, as shown in Figure 3.2.

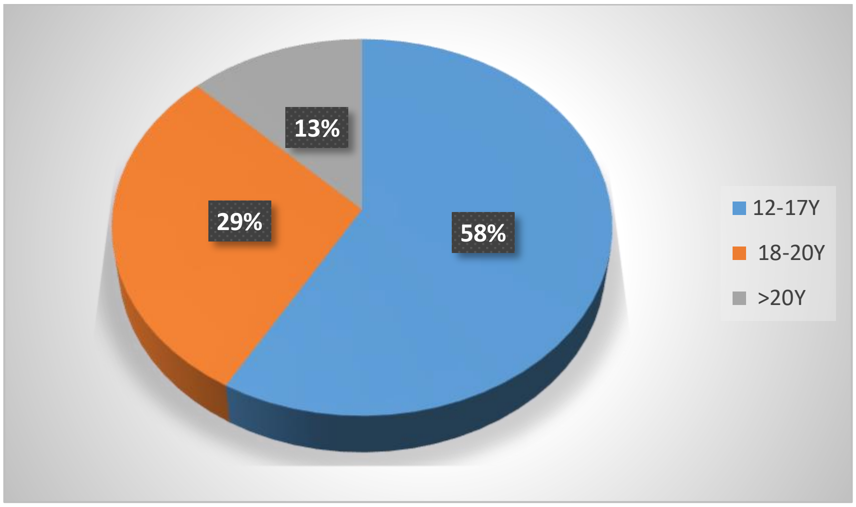

Figure 3.2: Percentage of bond failure rate in relation to different age ranges.

As well as, a higher failure rate occurred in Cl I malocclusion (58.3%) which is 14 cases of total 24 cases, whereas Cl II only 10 cases (41.7%), while in Cl III malocclusion, no data found, Table 3.3.

Table 3.3: Percentage of bond failure rate in relation to type of malocclusion.

Type of malocclusion	Bond failure (n=24%, 100%), n%
Cl I	14 (58.3%)
Cl II	10 (41.7%)
Cl III	0

Despite of low bond failure rate occurred among study sample, 41 molar teeth in 24 de-bonded cases exhibited de-bonded molar tubes. Among 41 de-bonded molar tube, a high failure rate was observed in the right side (63.4%) in comparison to the left side (36.6%). On the other hand, a high failure rate was observed in the mandible (53.7%), rather than in maxillary arch (46.3%), Table 3.3. Regarding molar type, 1st molar has a higher failure rate (85.4%) which is 35 tooth of a total 41 teeth than 2nd molar (12.2%) which is 5 tooth of a total 41 teeth and only 1 3rd molar (2.4%), as shown in Table 3.3.

Table 3.4: Bond failure with location of de-bonded tooth.

Location	Bond failure (n=41, 100%), n%
• **Side**	
Right	26 (63.4%)
Left	15 (36.6%)
• **Arch**	
Maxilla	19 (46.3%)
Mandible	22 (53.7%)
• **Molar type**	
1st molar	35 (85.4%)
2nd molar	5 (12.2%)
3rd molar	1 (2.4%)

Chapter Four: Discussion

Bond failure rates of orthodontic attachments are the frequency and pattern of bond failure, which differ with age and gender of the patient, the location of the arch, and tooth type **(Rasool *et al*., 2013)**.

Studies have reported varied bond failure rates of molar tubes ranging from 6% to 33.8% **(Millett *et al*., 1999; Linklater and Gordon, 2003; Aikins and Ututu, 2017; Roelofs *et al*., 2017)**. In this study, bond failure rate of molar tube is 6.5%, which is within the range of these studies (6% to 33.8%).

However; in this study, the bond failure rate of molar tube is 6.5% which is lower or minimal than other study **(Aikins and Ututu, 2017)**. Ae well as, other study shows approximately the same results or minimally lower or increased failure rate of molar tube **(Jung *et al*., 2014; Vercelino *et al.*, 2011; Gange, 2015; Roelofs *et al.*, 2017).**

In this study, there is an increased failure rate in male (54.1%) than female (45.8%). This similar to the results of a previous researcher **(Roelofs *et al.*, 2017)**, but difference with others who demonstrated a much higher prevalence in males (**Moninuola *et al.*, 2010; Aikins and Ututu, 2017)** and others in females **(Therneau *et al*., 2003; Khamnei et al., 2019)**.

Age effect on bond failure rate of molar tubes showed difference among studies. Higher failure rate occurred in younger patients (their ages range between 12-17 years) than adult patients which show lower bond failure rate of molar tubes. This is similar to other studies that demonstrated a higher bond failure in the younger patients **(Millett *et al.*, 1999; Jung, 2014; Aikins and Ututu, 2017)**.

This outcome may be attributed to a lower level of motivation and adherence to dietary and oral hygiene advices and self-motivation in kids while experiencing orthodontic therapy when compared to adults **(Therneau *et al.*, 2003; Sukhia *et al.*, 2011)**.

Also according to the number of molar tube de-bonded cases (24 cases), a slightly higher failure rate occurred in Cl I malocclusion and crowding teeth than Cl II malocclusion, whereas in other study showed that there were no significant differences **(Millett *et al.*, 1998)**, and other study did not investigate failure rates according to type of malocclusion **(Jung, 2014)**.

Regarding location of bond failure, the right side of the jaw showed a higher failure rate in comparison to the left side. But yet in literature the bond failure on the right and left side equivocal **(Pandis *et al.*, 2005; Manning *et al.*, 2006; Moninuola *et al.*, 2010; Aikins and Ututu, 2017)**. The side of the jaw that the patient uses more during eating can affect the side where bond failure occurs.

A higher failure rate in the mandible (53.6%) in comparison to the maxilla (46.3%) was found in this retrospective study. This is in similar to a study carried out in patients undergoing orthodontic therapy in Nigeria **(Moninuola** et al.**, 2010; Aikins and Ututu, 2017)** but differences with other studies carried out by **Manning *et al.*, (2006) and Rasool *et al*., (2013**) which showed a higher failure rate in the maxilla.

The higher failure rate detected in the mandible in this study may be because of fail to obtain a dry field during bonding, **(Rasool *et al.*, 2013)** as well as chewing forces.

Molar type also evaluated, 1st permanent molar shows higher failure rate in molar tube (85.3%) than 2nd molar. **Pandis *et al.* (2005)** reported on failure of molar tubes, they found that 2nd molars had the highest failure rate, which is different from this study.

While in **(Gupta and Mahanta, 2018)** showed that there was no significant difference on failure rate between 1st and 2nd molars. Higher failures with tubes could be probably due to moisture contamination, lower adaptation on the buccal surface of the tooth, high occlusal force or occlusal interference of the opposite tooth.

Chapter Five: Conclusions and Suggestions

5.1. Conclusions

1. High bond failure rate in the males than females.
2. Increased bond failure rate in the younger patients (12-17years) than adult patient.
3. High bond failure rate in Cl I malocclusion and crowding cases than Cl II and other type of malocclusion.
4. High bond failure rate in the right side than left side
5. High bond failure rate in the mandible than maxilla.
6. High bond failure rate in the 1st molars than in 2nd molars.

5.2. Suggestions

1. A prospective study is suggested instead of a retrospective.
2. Studying the relation of tooth surface status before and after bonding.
3. Studying the relation of tooth alignment at the time of study commencement.
4. Studying the effect of type of bonding adhesive system used for attachment bonding.
5. Studying the bond failure rate for different types of orthodontic attachments such as brackets and buttons rather than tubes.
6. Studying the failure rate in relation to archwire gauge at which de-bond occur.

Limitations of the Study

This is a retrospective study, that some data can't be reached or lost as it was not listed in case sheet for patients. Also, in the case sheet there was any information regarding the type of material of orthodontic attachments (brackets and tubes) to know which type of material showed high bond failure rate than other. As well as, post graduate students need to write down type of bonding adhesive system that used for bonding and de-bonded attachment to evaluate their relation to failure rate.

A photograph at de-bonding time of molar tube (and other attachments), which is useful in future studies to know if the cause of bond failure is caries, white spot lesion or healthy tooth.

Also, one of the limitation of this study is that the data collected is not stored in an electronic format that lead to data loss and save time. Furthermore, the stage of postgraduate students in case sheets need to be listed, to know in which stage that bonding failure rate is high to evaluate the relation of the operator practice and failure rate.

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