Facial prosthetic adhesives effect on maxillofacial silicone elastomers biology e...

Maxillofacial prosthetic discipline plays an important part on patient treatment that has suffered facial disfigurement caused by accidental trauma, tumour, cancer, diseases and congenital malformation (Sanchez-Garcia et all 2010). The sucess of maxillofacial silicone elastomer depends on factors such as stability, support and retention (Dahl and Polyzois, 2000; Sanchez-Garcia et al., 2010). The retention and its methodology is of primary importance and is based upon four categories (Dahl and Polyzois, 2000) : skin adhesives, mechanical (Magnets, spetcles) (Lemon et al., 1995 ; Goiato et all, 2009), anatomical (undercuts) and implants (Dahl and Polyzois, . 2000).

Adhesive retention is communly used in U. K which was identified by Hatamlesh et al (2010) by use of questionnaires. Of the 220 working maxillofacial prosthetic technologists surveyed, has been found that in 1193 prosthetic contructed, adhesives communly retained 48% of orbital prosthetics and 45% of nasal prosthetics (Hatamlesh et al 2010). However its use was influenced by adhesive chemical constituition and the patient skin condition (Sanchez- Garcia,. et al, 2010). Nevertheless, by refering to patient satisfaction and quality of life (Goiato et al, 2009), adhesive retention of facial prosthetic has a negative impact, due to difficulties of removable which results in skin irritation (Dahl and Polyzois , 2000) or damage to the prosthetics, compared to implant retained prostesis (Goiato et al, 2009), which is costlly (Cheng el al , 2002), however, despite of costs, 70% auricular implant are commonly made (Hatamlesh et al , 2010) to retain the prosthetics.

1. 1 Definition of adhesive-adhesion

An adhesive is an essence that holds materials together trough surface attachments (Holland and Turner, 1983). During surface interaction between an adhesive and subtracts is termed adhesion. When the two subtracts comes in contact by a third substance on its interface is termed adhesive joint (Hulland and Turner, 1983) (Figure 1. 0) or bond, which is depend upon the wetting and the spread of the adhesives (Thomas, 2003). According to Wu (1982 cited in Nenakhov, 2008 p 20) adhesion is where two different materials comes in close contact interfacially, so that a load could be transferred between adherent and substrate to the adhesive joint.

Flexible adherent

Subtract

Fig1. 0 The adhesive Joint

However, many issues are responsible for adhesion which is described by the skin factors and many underlying general theories.

Facial prosthetics retention factors

Skin is the largest organ of the human body and has many heterogeneous and anisotropic tissue layers. The three main tissue layers are: epidermis, dermis and hypodermis or adipose fat tissue. This tissues work in support to each other and differ in thickness by function of age and the area where is found (Pailler-Mattei et al, 2008; Pailler-Mattei, and Zahouani, 2006; Wood and Bladon, 1985). The epidermis is found at the outer layer of the skin and subsequently subdivided by differentiated five sub layers, called stratified squamous epithelium (fig 1. 1) which varies in thickness by 30 ums and 4 mm (Wood and Bladon, 1985). It contains blood vessels, diverse types of cells and keratin protein (Wood and Bladon, 1985). The outer sub layer of the epidermis (stratum corneum) contains dead cells which is water resistant. The dermis is found beneath the epidermis and it is further divided into two parts (Wood and Bladon, 1985):

Papillary region – The outer area that contacts the epidermis, and is composed by loose areolar connective tissues;

Reticular region- The deep area that contacts the hypodermis, and is composed by irregular connective tissues trough it, weaves collagen and elastic fibers.

The dermis functions to reduce the pressure and tension of the body under exterior excitation (Pailler-Mattei, and Zahouani, 2006). The hypodermis is found below the dermis and is consisted by loose connective tissue and elastin fibers. Its main function is to attach the upper layers to muscles and bones and to supply blood vessels and nerves (Wood and Bladon, 1985).

Generally different components can be found in the surface of the skin: fingernails, toenails, hair follicle, sweet glands and sebaceous glands.

Skin is consisted by: water, protein, lipids, and different minerals and chemicals. It has a variety of functions, (Wood and Bladon, 1985) such as:

It protects from bacterial invasion by keeping our insides (muscles bones ligament and internal organs) intact ;

Evaporation control – provides a semi permeability barrier to fluid loss;

Storage for lipids and water ;

Absorption- Oxygen, nitrogen and carbon dioxide can diffuse into the epidermis in small amounts;

Isolation by regulating the temperature and sensation.

Fig 1. 1 schematic illustration of skin (Ivyrose , 2003)

Hair

Pore

Epidermis

Stratified squamous epithelium

Stratum corneum

Stratum lucidium

Stratum granulosum

Stratum spinosum

Stratum basal

Stratum corneum

Stratum lucidium

Stratum granulosum

Stratum spinosum

Stratum basal

Stratum corneum

Stratum lucidium

Stratum granulosum

Stratum spinosum

Stratum basal

Dermis

Hair follicle

Sebaceous gland

Blood capillaries

Sweat glands

Nerve endings

Sensory receptors

Hypodermis

Artery and vein

Capillaries

Adipose tissue

Therefore for adhesion process to proceed, it is important to have an account of skin factors such as, hair follicles, (Kiat- Annuay et al 2008) perspiration, skin lipids and the sebum, which are the main culprits for the difficulties that the adhesive may encounter when in contact with the epidermis of the skin (Wood and Bladon, 1985).

Also these factors may vary between the different ethical groups (Kiat-Annuay et al 2008). However, In order to understand the adhesive behavior on health applications, human skin is modeled as viscoelastic material (Pailler-Mattei, and Zahouani, 2006; Renvoisea et al, 2009). Still for accepting it as an elastic, mechanical tests has been performed, and the results showed that its young modulus varies between, 0. 42Mpa -0. 85 Mpa for torsion, 4. 6 Mpa – 20 Mpa for tensile, 0. 05 Mpa -0. 015Mpa for suction and between 0. 0045 Mpa -0. 008Mpa for indentation (Pailler Mattei, and Zahouani, 2006). Therefore it can be thought that the skin is highly deformable up to a limit. Skin deformation should be minimized when testing adhesives.

Theories of adhesion

The theories of adhesion have been classified into three categories (Hulland and Turner, 1983):

Mechanical bonding – The theory is based on the factor that all the surfaces to be bonded are rough at microscopic level. The low viscosity adhesive will flow and penetrates into the cracks, crevices or pores of the rough subtract surfaces. As the adhesives hardens it keys into those surfaces and a strong bond results. However, the bond joint strength between the adherent and substrate is limited, both by the adhesive strength and the roughness of the surface (Hulland and Turner, 1983).

Chemical bonding – the theory is based on the formation of primary chemical bonds between the adhesive and the surface of the substance which invokes the formation of covalent, ionic and hydrogen bonds also secondary bonds may influence by van der walls forces in the interface (Hulland and Turner, 1983)

Physical bonding – Adhesive bond formation may be attributed trough the energy on the interface between adhesive and the substance which in turn is determined by physical process during contact :

Electrostatic -is based on difference in electro negativity between the two subtracts when in contact. Adhesive strength is given by: the transfer of electrons across the interface resulting in a negative and a positive charge, creating double layers thus attracting one another (Hulland and Turner, 1983).

Diffusion -is based on adhesion that is formed trough diffusion of molecules in the adhesive and adherent. However the theory is only applicable when both the adhesive and adherent are soluble and having similar long-chain molecules that are capable of kinetics (Hulland and Turner, 1983).

Absorption – is based on adhesion which results from molecular contact between an adhesive and the adherent known as wetting. The wetting is considered in terms of free surface energy and is determined by measuring the surface contact angles (fig1. 2). Thus, high surface energy a near Zero angle of contact may occur, so the liquid wets efficiently over the subtract surface. However, at low surface energy a higher contact angle may be produced which results in inefficiently surface coverage by the liquid (Hulland and Turner, 1983).

Fig 1. 2 – The effects of surface energy of a subtract on contact angles of a liquid

droplet (Hulland and Turner, 1983, p 403).

High surface energy so lower liquid contact angle indicated by the arrow

Low surface energy so higher liquid contact angle indicated by the arrow

(Hulland and Turner, 1983 , p 403).

Surface wet ability of a prosthetic material

The prosthetic material that contacts the skin must have a good wettability (high surface energy- hydrophilic) for efficient adhesion, however according to Water et all (1999) when comparing silicone elastomers used in maxillofacial with that of an acrylic denture base resin, statistically found that the silicone elastomers has a lower surface energy, thus resulting on surface that is poor wetted (low surface energy- hydrophobic). Nevertheless, no significance statistically difference has found between the silicones elastomers, but only demonstrating a quantitative difference contact angle mean raging between 79. 31 to 83. 18 degrees and the surface energy raging between 25. 11 and 28. 45. In addition to that, the researchers concluded, the low wettability found may cause friction and micro trauma to the supporting tissues, as the wettability did not achieve the lubrification needed (Water et all, 1999). However, the surface of the silicone elastomer may be modified to improve wetting without affecting the material bulk and mechanical properties as Aziz et all (2003) demonstrated. The experimenters concluded, that if the silicone elastomer was treated with argon plasma and followed by chemosoption of ethyneopoxy functional silanes it proved an effective way to improve wetability demonstrated by the reduction of contact angle (Aziz et all, 2003).

Requirements of medical adhesives

Adhesives that are used in the facial prosthesis are pressure sensitive adhesives (PSA) which needs a slight pressure to adhere at room temperature and it possess two essential requirements which are:

That they should stick firmly to a difficult subtract (skin) (Chivers, 2001; Webster 1998), which varies in dryness and wetness.

That they should be easily removed from subtract without causing any damage by stripping the skin, or leaving adhesive residue (Chivers, 2001; Webster, 1998) during de-bonding process.

With this two requirements in mind, PSA is proposed to show an adhesive failure when the skin is a subtract, however to verify this requirements a peel test at different angles, usually at 900 or 1800 degrees, is employed which is one of the standards used to evaluate the strength of adhesive bonds, therefore the higher the test value (energy per unit area), the stronger the bond.

Assessing Pressure sensitive adhesives

1. 6. 1Pressure sensitive adhesive factors

During assessing the mechanical properties according to Chivers (2001) the requirements in 1. 5 are constantly in conflict, so to resolve it, he approaches trough using chemical means and physical procedures during peeling of PSA that is used for dressing of wounds.

The chemical means consist of an adhesive that contains a mix of a hydrophilic base polymer (alkyl vinyl ether) with a water soluble tackifying agent (ethoxylated alkyl phenol part of polyethelne glycol) in 1: 1 or 1: 2 ratios which gives on a dry state its tackiness (Chivers, 2001). However by wetting with water the peel strength has seen to be reduced by 90%. Also he explains if an additive of a crystallisable polymer side chain is incorporated into the making of a PSA adhesive the effect of strength may be reduced by increasing the temperature so melting the additive above its use temperature. Though, Mcguiggan and et all (2008) demonstrated that the peel strength of the PSA decreases with increasing temperature consecutively the peeling rate is decreased at peeling angles of 900 and 1800 degrees. Also PSA may be activated by visible light or to a low ultraviolet light on a “ switch of mechanism” to lower peeling strength, so that it does not traumatize the skin (Webster, 1999). By activating by this mechanism cross-linking process occurs with the free radical exposure of the side groups, thus the adhesive polymer will produce a bond of the prosthetic material to the skin (Chivers, 2001).

The physical procedures that Chivers (2001) mentioned showed that, if the angle of peel of polyester backed PSA on a stainless steel subtract is increased up to 1350 degrees, the peeling force will automatically decrease.

1. 6. 2 Comparison of adhesives bonds on different subtracts

A number of studies were published to compare adhesives bond strength on facial prosthetics elastomer to the skin (Wolfaardt et all, 2005; Kiat-Annuay et all 2004; Polyzois, et all 1993) , and one of the studies was to compare four types of adhesives (Dow Corning 355 medical adhesive, PSA 1, Daro and 9874 3 M) with five room temperature vulcanized silicone facial elastomers (Silskin II, MDX4- 4210, Cosmesil, Cosmesil HC2 and RS 330 T-room temperature Vulcanized (Polyzois, et all 1993). Polyzois , et all (1993) prepared the elastomers strips specimens of 50x 50 x 3 mm dimension on stone moulds. These specimens were tested on the inner aspect of the right forearms of one subject. And before each test, the attachments sites were cleaned with ethyl alcohol. A total of 160 peelings were carried out on the universal testing peeling machine that was previously calibrated to a 4 N load and the rate of 1mm/ minute of peeling. With this experiment the researchers concluded, that the tensile bond strength is depended upon both the elastomers and the skin adhesives and the results showed that the Down corning 355 adhesive had the highest bond and the 9874 3M the lowest (Polyzois, et all 1993). The MDX 4 4210 silicone elastomer had the strongest bond and the RS 330T-RTV had the weakest in all adhesives (Polyzois, et all 1993).

The material used for adhesives are based on silicones and resin formulation. Benedek (2000) explained that the resin adhesives exhibited from low to higher adhesion to skin and silicones from low to moderate skin adhesion.

However, the adhesives used may have caused damage to the skin but according to Kiat -Annuay, et all (2000) if a skin protective dressing is used then trauma will be reduced. Nevertheless, the researchers experimented the protective dressing and a remover manufactured by Smith and Nephew on two adhesives, (Daro epithane 3 (E-3) water based and factor II secure medical adhesive (SMA) silicone based with the backing of MDX 4 4210 silicone elastomer. They applied to 20 subjects on the volar surface of the arms, and at 900 degrees of peeling observed the adhesives on its own, without the dressing and found that SMA was 4 times more retentive (adhesion mean = 96. 3 Nm) than E-3 (adhesion mean = 24. 1 Nm), however with the prep, E-3 increased by 27% in contrast SMA increased only 15%. Also it was observed a residual adhesive on prosthetics (skin interface) and the skin (prosthetic interface) (Kiat -Annuay, et all 2000). However the remover did not affected the bonding but helped only cleaning the skin.

Though, Kiat – Annuay, et all (2001) indicated if a second application of adhesive was applied over the existing paste within a time period between 0 and 4 hours to secure the prosthetic, then at 4 hours interval the peeling bonds strength increased for SMA. Although it was observed the bond strength of silicone elastomer to the skin was decreased over an 8 hours interval. Anyways, when investigating a single and multi adhesive layering at 900 degrees of peeling, on 30 subjects has found the combination of SMA/ E3 had significant higher adhesion to the skin followed by SMA alone, E3/SMA and E3 alone (Kiat – Annuay el all 2004). The investigators agreed that if a sandwich of adhesives was used then the margins of the prosthetic will not be visible (Kiat – Annuay et all 2004) therefore improving esthetics (Karayazgan B et all 2003). However when peeling the device out, the margins may tear, so by incorporating of tulle it would improve its strength (Karayazgan B et all 2003).

According Kiat-Annuay, et all (2008), when evaluating the strength of SMA and E-3 adhesive on silicone MDX 4 4210 with urethane liner and the chlorinated polyethylene elastomer, backed with skin prep, found that there were no significant interaction differences between silicones, however they observed that the adhesive failure occurred at the interface. Nevertheless of the 26 subjects tested it was found significant statistically difference in bond strength for gender, amount of hair in volar surface of testing subjects and ethnicity. However, age of the volunteers did not affect the bond strength of the adhesives. Volunteers with no Hair had a higher bond strength compared with subjects with arm hair. In addition, the mean adhesive bond strength of strips applied to the African -american subjects (n= 8) was statistically greater than of the Hispanic, white and Asian volunteers (Kiat- Annuay et all 2008).

Thought by reviewing the literatures, peeling experiments still is carried out on Humans volunteers which conflicts with the ethical issues, and on stainless steel which gives false adhesion values, as it does not relate to skin. So for this reason Nussinovitch, A. et all., (2008) and Renvoise, et all (2009) produced artificial skins to test adhesion of adhesives, anyways adhesives should be chemical clear before testing on humans.

1. 6. 2. 1 The rational of Biocompatibility

Therefore biocompatibility is of prime importance (Dahl and Polyzois, 2000). For the clinical clearance of adhesives, patch tests have been developed to scrutinize, the constituents of the adhesives such as solvents and takifying agents, which may irritate the skin (Dahl and Polyzois, 2000). According Dhal and Polyzois (2000) they suggested a new in-vitro test by use of hen's egg test chororioallatoic membrane method. The researchers concluded that the organic solvent ethyl acetate contained into the adhesive gives severe irritation reaction. For this reason, a new PSA adhesive was formulated by Sanchez -Garcia, et all (2010), and it was based on acrylic monomers. They found that the formulation B3, synthesized by water based emulsion, presents a good alternative for patients that have suffered severe facial damage.

1. 6. 3 Adhesive failure

Most of adhesive boding joint failures can be placed into 4 groups (Messler, 2004) they are:

Substrate Failure: Substrate fails before the adhesive and this depends on the adhesive strength

Cohesive Failure: Adhesive fails down in the middle, adhesive remains on both substrates.

Interfacial Failure: Adhesive fails from one of substrate.

Mixed failure : characterized by interfacial and cohesive failure

Fig 1. 3 Subtract failure Fig 1. 4 Cohesive failure Fig 1. 5 interfacial failure

Fig 1. 6 Mixed failures

Figures 1. 3 , 1. 4, 1. 5 and 1. 6 (Messler, 2004)

1. 7 Research objectives

The objective of this study was to measure the force needed to remove strips of room vulcanized silicone elastomer from a rigid material such as stainless steel, treated with acetone. Four different skin adhesives were measured on a universal testing machine (Hounsfield H50KS Universal Testing Machine) at 1800 peel (Figure 1. 7) according to ISO 8510-2-2010 standard.

Figure 1. 7 – Schematic diagram 1800 peeling (ISO 8510-2-2010)

Material and Methods

Twenty silicone abacus strips 250 x 25. 0 x 2mm were processed from a mix of 50% stone/gypsum moulds. The surfaces of the moulds were treated with an alginate separator before pouring a mix of 100 grams of silicone abacus and 10 grams of the activator, as of manufactures instructions. See table 2. 1, for the materials used in this study. The elastomers strips were allowed to cure at a room temperature for 24 hours before testing. For the rigid material five stainless steel sheets 250 x 25. 0 x 1. 6mm were cut. The surface attachment of the stainless steel was cleaned with the acetone and allowing to dry before each test. The Hounsfield H50KS Universal Testing Machine was calibrated with a load cell of 8N at a crosshead speed of 100mm/min (Fig 2. 2). Four types of adhesives were studied. The spray (Down corning B, Hollister 7730) and the liquid adhesives (Pros- aide and

PSA 1b) were applied to 120 mm area in length, in a thin layer of each of the twenty silicone elastomers, and allowed to dry according to each specific adhesive manufacturing instruction (Down corning B- 1 minute; Hollister 7730- 5 minutes; pros aide -3 minutes; principality- 3minutes). The elastomer specimen was attached to the stainless steel and a thumb pressure to the silicone was applied for 30 seconds. The unattached silicone elastomer was placed into the grip of the universal testing machine and the peeling at 1800 was carried out. A total of twenty (five of each adhesive type) peeling was made. The point of adhesive failure (cohesive, mixed or interfacial failures) was noted. The average maximum, minimum, normal average force and the energy of peeling were recorded as a function to the distance peeled. SPSS Statistical package software version 17. 01 was performed to analyze the data through a combination of a paired T test of adhesives and the maximum force of peeling data was used to conduct it.

Table – 2. 1 some of the material used in this study and its drying time

Type

Material

Drying time

Manufacturer

Silicone facial elastomeric + activator

Abacus

24 hours room temperature

Abacus Silicon Technology Pte Ltd

Skin adhesives

Dow Corning medical adhesive B

1 minutes

Down corning corporation, midland, USA

Hollister 7730 medical adhesive

3 minutes

Hollister limited, aurora Ontario

Pros -aide Adhesive

3 minutes

Pros-Aide®, a division of ADM Tronics Unlimited, Inc. Northvale, New Jersey 07647 USA

PSA 1b Adhesive

3 minutes

Principality Fx Newport U. k

Results

The maximum, minimum, mean, standard error and standard deviation of the maximum bond strength in Newton per millimeter (N/mm), measured by four adhesives (Dow Corning, Hollister, Pro aide and PSA1b) backed with silicone elastomer strips, at 1800 degrees peel on a stainless steel subtract, is shown on table 3. 1. Five peelings (N= 5) of each adhesive was performed and a total 20 pulling was made. The mean value varied from 4. 12 N/mm to 10 N/mm and the standard deviation ranged from 1. 62 N/mm to 4. 40 N/mm. The bar chart /error bar on figure 3. 2 shows graphically, that PSA 1 b had highest maximum bond strength comparatively to Dow Corning, Hollister and Pro aide adhesives, thus Dow Corning and Hollister adhesives had lower bond strength of peeling and the pro aide an intermediate. Acetone use to remove the adhesive did not influence the bonding, however De- bonding of adhesives was at stainless steel level as the residues was left on the prosthetic strips, however one specimen of Down corning adhesive had de-bonded on the prostheses strips so the majority of residues was left on the metal substructure (table 3. 2) (Fig 3. 1)

Fig 3. 1 Dow Corning adhesive had mixed failure cohesive and interfacial (residue left on

prosthesis and on the metal)

Fig 3. 2 Maximum adhesive bond strength mean and the standard error of the means

Dow Cor

Maximum adhesive bond strength to the stainless steel

Table 3. 1 The maximum bond descriptive statistics

Descriptive Statistics

N

Minimum

(N/mm)

Maximum

(N/mm)

Mean (N/mm)

Std. Deviation

(N/mm)

Statistic

Statistic

Statistic

Statistic

Std. Error

Statistic

P/M

Dow Corning B

5

2. 50

6. 62

4. 12

. 72567

1. 62

4/1

Hollister 7730

5

2. 48

5. 72

3. 91

. 53729

1. 20

5/0

Pros Aide

5

3. 10

8. 45

5. 22

. 96437

2. 16

5/0

PSA 1B

5

5. 11

14. 95

10. 00

1. 96904

4. 40

5/0

Valid N (leastwise)

5

Key: P/M residue left on the prosthetic P or in the stainless steel M

A paired t test from SPSS Statistical analytical software tool, table 3. 2 revealed that there was a statistical difference between the pairs : Dow Corning and PSA 1b; Hollister and PSA 1b as the Sig(2tailed) value = pâ‰¤0.

05 at 95 % of chance. Adding on, no statistical difference was found between: Dow Corning and Hollister; Dow Corning and Pro aide; Hollister and Pro Aide; Pro aide and PSA 1b as the sig (2 tailed) value = P > 0. 05 at 95 % chance.

Table 3. 2 SPSS statistical analysis of Paired t test between adhesives groups

Paired Samples Test

Paired Differences

t

df

Sig. (2-tailed)

Mean

Std. Deviation

Std. Error Mean

95% Confidence Interval of the Difference

Lower

Upper

A – B

. 21040

2. 29084

1. 02450

-2. 63406

3. 05486

. 205

4

. 847

A – C

-1. 10380

1. 97320

. 88244

-3. 55386

1. 34626

-1. 251

4

. 279

A -D

-5. 87980

4. 73267

2. 11651

-11. 75619

-. 00341

-2. 778

4

. 050

B – C

-1. 31420

3. 11820

1. 39450

-5. 18595

2. 55755

-. 942

4

. 399

B – D

-6. 09020

4. 10128

1. 83415

-11. 18261

-. 99779

-3. 320

4

. 029

C – D

-4. 77600

5. 84121

2. 61227

-12. 02881

2. 47681

-1. 828

4

. 142

Key : A – Dow Corning B B – Hollister 7730 C – Pros Aide D- PSA 1b

Discussion

The approach of retention methodologies of facial prosthesis from pressure sensitive adhesives are important, so its development and research, to make a more compatible, toxic free and less irritable to employ it on skin contacts. Testing machines has been used to experiment adhesives for its tackiness such peel tests at certain degrees but its use remains controversy as it tests on volar surfaces of the arms or other type of substrates such stainless steel which gives misleading information. However, according Wolfaardt et all (1992) used a custom made machine to perform in vivo testing of tree facial prosthetic adhesives (PSA1, Pro- Aide, Dow Corning 355) on Cosmesil silicone elastomer. He tested the adhesives on one of the cheeks region of two subjects and obtained the data by repeating the experiment. A load of 900gm was applied for 20 seconds. Stretching, twisting and its combination tests were carried out. The data was analyzed trough the student Newman keuls statistical method and found that Down corning 355 had the strongest bond during stretching and twisting, however PSA 1 during stretching was the weakest nevertheless PSA1 and Pro Aide adhesive was found no statistical difference during twisting test methodology. Adding on, Polyzois and et all (1993) also found that Down corning 355 had a stronger bond strength during peeling at the volar surface of the arm during tension by use of ANOVA and Duncan statistical test methodology. Its results however varied between the types of silicone elastomer used. Nevertheless, Wolfaardt et all (1992) and Polyzois and et all (1993) experiments showed that Down Corning adhesives had higher bond strength but the methodology used was different from the present study, so a detailed comparison would be invalid or difficult. Adding to, the two researchers did not disclosed what angles that the peeling was performed and also the experiments was conducted in vivo. Despite of these facts, according to Benedek (2000), resin adhesives such as the PSA1 b and the Pro Aide water based formulation would exhibit a lower to higher adhesion and silicone from lower to moderate skin adhesion and this are all depended upon to its curing time and the number of applications. Indeed, according to Sanchez – Garcia, et all (2010) water based acrylic adhesives is the most effective for the patients with severe facial damage, thus this adhesive can stand a variety of loads consequently suitable for its use in maxillofacial prosthesis.

The research results in figure 3. 2 and table 3. 1 from peeling at 1800 degrees on a stainless steel subtract indicated that the PSA1 B had a maximum retention (mean = 10. 00 N. mm), approximately 2. 5 times more retentive than Down Corning (mean 4. 12 N. mm) and Hollister (Mean 3. 91 N. mm). Pro aid showed approximately 2 x lower retention (mean= 5. 22N. mm) than the PSA1B. Pro Aide had an intermediate retention between the adhesive tested.

Nevertheless to illustrate the most retentive adhesive a Paired T test (table 3. 2) indicated that the statistically paired combination of adhesives : Down corning (A) and Hollister (B) t(4)= 0. 205, p= 0. 847Down Corning (A) & Pro aide (C) t(4)= 1. 251, p= 0. 279; Hollister (B) & Pro Aide (C) t(4)= 0. 942, p= 0. 399 ; Pro Aide (C) & PSA 1B (D) t(4)= 1. 828, p= 0. 142 has found no significant difference as p values were > than 0. 05 at 95% chance difference. However, statistically paired combination of adhesives: Down corning (A) & PSA 1 B (D) t (4)= 2. 778, p= 0. 050; Hollister (B) & PSA 1 B (D) t(4)= 3. 320, p= 0. 029 has revealed statistically significant as P values is â ‰¤ than 0. 05 at 95 % of chance difference.

Also the use of acetone did not influence in the bonding. Furthermore, only one specimen Silicone/Dow Corning had a mixed failure (cohesive and interfacial) as some residue left on metal and the prosthetics. The rest of adhesives failed at metal interface (residue left on prosthesis). Thought the results was expected PSA 1 B and Pro Aide are based in water and resin emulsion therefore it gave a higher adhesion to the skin compared to Dow Corning and Hollister which are based in silicones (Benedek, 2000). However the higher peeling was depended upon the curing time (monomer cross linking)