Skin Colour Analysis of Iraqi Kurdish Population

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Abstract

Objective: Skin colour measurement and analysis was performed for Iraqi Kurdish population in Sulaimani city. The purpose of this study was to produce a dedicated skin shade guide for precise colour reproduction and colour matching of maxillofacial prostheses with the patient's original skin colour.

Methodology: A skin colour measurement was undertaken for 140 subjects (73 female and 67 male). A method of capturing their (L* a* b*) colour values from nine body parts was performed using a Minolta CM-2600d spectrophotometer and a colour Data Software. The study sample aged between 18 to 50 years from Sulaimani city representing a Kurdish population of the north of Iraq. A comparison was made between (L* a* b*) colour values of the face and arm and between male and female shades. Data analysed using Independent-samples T-Test. Furthermore this study aimed at employing the performed data for suggesting a dedicated skin shade guide for the population examined in this study.

Results: A significant difference between facial and arm colour was identified. Facial colour found to be more reddish and colourful but darker than arm colour. Furthermore, collected data showed lighter female colour than males. Variations in skin colour of the study population were detected, body area differences and gender differences found to have a significant effect on the skin colour formulation of the study population. Based on colour data obtained, a skin shade guide was suggested for the population examined in this study.

Conclusions: A consistent colour shift in Kurdish population between facial and arm colour in which facial colour found to be reddish, more colourful, and darker than arm colour. Females are found to have a lighter colour than males. A dedicated skin shade guide was developed and suggested for Kurdish population based on a comprehensive colour gamut that was determined in this study.

Skin Shade Guide, (L*A*B*) Colour Values, Maxillofacial Prostheses, Colour Gamut

Introduction

Colour matching and colour differences between the maxillofacial prostheses and the surrounding skin is a prime concern of the maxillofacial prosthodontist and the patient. Failure of achieving the patient's exact skin colour lead to aesthetic failure (Lontz, 1990). Colour discrepancy is extremely evident in the maxillofacial region especially when the colour of the prosthesis is not accurately blended into the patient's skin colour. Thus, a properly fitted prosthesis and anatomically accurate prosthesis will be refused by the patient if its colour is not appropriately matching the adjoining tissues (Gut- tal et al., 2008). Skin colour varies according to various locations in the body, these differences may create aesthetic problems for the patient after micro-vascular surgery (Shaw and Ahn, 1992, Feldman, 1990). The desired results may not be achieved as a result of site differences of the transplanted tissue. Several factors affect the human skin colour, include, the thickness of epidermis layer and the amount of blood supply. Variation in natural skin color is mainly due to genetic factors (Walters and Roberts, 2008). However, the greatest source of colour in human skin is the types and amount of melanin pigments, which is responsible for colour variation among different ethnic groups (Thong et al., 2003, Ito and Wakamatsu, 2003).
Human skin colour also influenced by exposure to sunlight that cause tanning of skin. The exposed parts of the skin exhibit darker colour than non-exposed skin. Today, maxillofacial technicians depend on visual assessment which is based on visual acuity for reproducing the patient’s colour (Polyzois, 1999, Seelaus R and RJ, 2000).

Digital colour capturing devices (Camera, spectrophotometer, and colorimeter) identify and present colour in 3 dimensions by using 3D colour models (Coward et al., 2008a, Hunter, 1987). Today, RGB colour model and CIE LAB are the most widely used colour models. Colorimeter and spectrophotometer are used to improve the accuracy of colour matching by measuring the skin colour numerically in three dimensions (Koran et al., 1981).

In order to measure objectively the skin colour appearance and evaluate skin colour differences, CIE Colorimetry has been widely used for specifying skin colours into CIELAB uniform colour space.

Human skin tone is confined to a limited zone within the whole colour space, which is referred to as skin colour gamut (Stone et al., 1988). Recognition of colour gamut of human skin provides clear information about the distribution/location of the colour value among the whole colour space. Knowing the colour gamut of a population makes developing a shade guide for that population. To date, no comprehensive global database for skin colour among the main ethnic groups is available. Generation of a global skin shade guide requires conducting a comprehensive measurement of skin colour among groups of people from different ethnic backgrounds and different geographic locations around the world. Skin colour measurements have seldom been conducted among individual ethnic groups (Over et al., 1998, Coward et al., 2008b, Xiao et al., 2012, Han et al., 2006) and some of these were performed only for limited purposes. On searching databases, no published articles were found providing colour information for the Kurdish population in the Kurdistan region. Therefore, the purpose of the present study was to conduct colour measurement procedure and to assemble colour information from a group of Kurdish population from Sulaimani city – Iraq. Moreover, the current study was conducted to determine the skin colour range of Kurdish population and to suggest data for developing a dedicated shade guide for their skin colour.

**Methodology**

1-Ethical approval has been obtained from the University Research Ethics Committee (School of Dentistry – University of Sulaimani) for measuring skin colours for a group of volunteers included students and the school employees. An information sheet, including all information and details about the colour measurement procedure has been produced for the volunteers. A consent form to be read and signed by the volunteer was also produced.

2-140 Volunteers from the School of Clinical Dentistry - University of Sulaimani, 73 female and 67 male were participated in this study. The participants included staff and students of the dental school within an age group 18-50 years. A total of 1260 (140 x 9) skin colour data was collected. For each subject, skin colour of a total of nine body parts obtained, forehead, tip of nose, cheek, ear lobe, chin, back of hand, palm, forearm outer and forearm inter (Figure 1). Moreover, each subject also provided his basic information including age and gender.

3-A Konica Minolta CM-2600d spectrophotometer using SpectraMagic NX Colour Data Software was employed to measure the skin colour in CIELAB tristimulus values with a 2 degree standard observer. Colour instruments (colorimetry) generate tristimulus values in an X, Y and Z coordinate system. Depending on the specific instrument, these tristimulus values are converted to Hunter L, a, b or CIELAB L*, a* and b* units. The difference between the two systems is the mathematical manipulation of the basic tristimulus values (Poly-One, 2005). The illuminate was set to the CIE standard D65 to simulate skin colour in daylight conditions. During the measurement, a viewing geometry of d/8 (diffuse illumination, 8-degree viewing), was used by the specular component included and the aperture size was set to 3mm.

4-Independent-samples T-Test was conducted to present the results and to analyse the differences of the three colour attributes (L*, a* and b*). The L*a*b* is described as the vertical (L*) axis which represent lightness, ranging from 0-100 and two other horizontal axis values (a*) and (b*). Each has an “axis” that can range from (−a) to (+a) and (−b) to (+b). More specifically, (−a) represents green and (+a) represents red, whilst (b+) is represented by yellow and (b−) is represented by blue, as is shown in Figure 2 (Hunter, 1948, Honiball, 2010).

5-Based on colour data obtained in this study a suggestion was made for developing a skin shade guide for the study population as follow: Ten selected shades were used to develop a dedicated shade guide based on the higher and lower measurements detected for each of the three colour attributes (L*, a* and b*) among 1260 measurements - the total (L*a*b*) measurements. The process of selection carried out by taking one measurement below the lower margin, and then graduating to a higher level for each shade, the graduation continued up to shade number 10, this was one measurement above the higher margin of the total records for each colour attribute.
Results:

Table 1 presents the average and standard deviation of \((L^*, a^*\text{ and } b^*)\) values of skin tone and the higher and the lower skin tone range for each colour attribute of the total sample. An average \((L^*, a^*\text{ and } b^*)\) values reported \((56.4, 10.2\text{ and } 15.8)\) respectively.

Table 1 also details the \((L^*a^*b^*)\) colour distribution according to gender and body parts. It can be seen that females have significantly \((p<0.05)\) lighter skin shades as 2 tailed independent samples t-test showed.

A great variation in \((L^*)\) values (lightness) between male and female, statistically a significant difference \((p<0.05)\) of \((L^*)\) Value were recorded between male and female \((59\text{ against } 54.3)\) respectively. A significant difference \((p<0.05)\) of \((a^*)\) Value was also recorded between male and female \((9.9\text{ against } 10.5)\) respectively, whereas, no significant differences \((p>0.05)\) was reported among the sample of \((b^*)\) values between male and female \((15.6\text{ to } 15.9)\) respectively. However, males showed slightly more colorful skin than female and this is represented by higher \((a^*)\) values for males against female. Differences in the lightness, \((L^*)\) values were the greatest between female and male’s chins, \((59\text{ against } 49.2)\) respectively.

Figure 1 presents the average and standard error for \((L^*, a^*\text{ and } b^*)\) values differences between face and arm among the total sample. In general, the results demonstrate a clear trend that face is significantly \((p<0.05)\) darker and reddish than arm. This is presented with a significantly lower \((L^*)\) and a higher \((a^*)\) values \((55.2, 11.9)\) of the face against the arm \((58.4, 8.1)\) respectively. However, there were no significant differences \((p>0.05)\) in the \((b^*)\) values between face and arm shades \((15.9\text{ against } 15.7)\) respectively.

Variations of \((L^*a^*b^*)\) colour attributes in the ‘colour gamut’ among the sample is presented in Table 1 and Figure 4. The average value for each attribute \((L^*), (a^*)\text{ and } (b^*)\) and the highest and lowest values for these components were marked in order to determine the range of colour distribution for the sample. There was a great variation in \((L^*)\) value, which ranged from \((32)\) to \((70.7)\) with a mean value of \((56.4)\). This indicates that the skin of the Kurdish population is a combination of light and dark skin tones. Figure 5 presents the suggested \((L^*a^*b^*)\) values for a skin shade guide for Kurdish population which was developed according to the protocol mention in the previous section. Colour attributes of these 10 shades \((L^*\text{, } a^*\text{ and } b^*)\) followed a linear distribution on a plotted histogram. This collection can be suggested as a dedicated skin shade guide for the study sample.

### Table 1: Average \(L^*a^*b^*\) Values – Total average and upper and lower range values of \(L^* a^* b^*\) for different body parts according to gender

<table>
<thead>
<tr>
<th>Body Position</th>
<th>(L^*)</th>
<th>(a^*)</th>
<th>(b^*)</th>
<th>(L^*)</th>
<th>(a^*)</th>
<th>(b^*)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Face</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forehead</td>
<td>57.2</td>
<td>10.4</td>
<td>15.7</td>
<td>54.8</td>
<td>12.2</td>
<td>17.1</td>
</tr>
<tr>
<td>Nose</td>
<td>57.9</td>
<td>13.2</td>
<td>15.9</td>
<td>54.5</td>
<td>14</td>
<td>16.1</td>
</tr>
<tr>
<td>Cheek</td>
<td>60.4</td>
<td>11.7</td>
<td>15.6</td>
<td>55.6</td>
<td>11.7</td>
<td>16.1</td>
</tr>
<tr>
<td>Ear</td>
<td>51.8</td>
<td>10.4</td>
<td>15.2</td>
<td>51.6</td>
<td>12.3</td>
<td>15.7</td>
</tr>
<tr>
<td>Chin</td>
<td>59</td>
<td>13.5</td>
<td>15.9</td>
<td>49.2</td>
<td>9</td>
<td>13.1</td>
</tr>
<tr>
<td><strong>Arm</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backhand</td>
<td>60</td>
<td>7.9</td>
<td>16.6</td>
<td>55</td>
<td>9.2</td>
<td>16.3</td>
</tr>
<tr>
<td>Palm</td>
<td>61.4</td>
<td>9.1</td>
<td>14</td>
<td>59</td>
<td>10.7</td>
<td>14.1</td>
</tr>
<tr>
<td>Outer Arm</td>
<td>59.9</td>
<td>6.8</td>
<td>16.5</td>
<td>50.9</td>
<td>7.8</td>
<td>17.6</td>
</tr>
<tr>
<td>Inner Arm</td>
<td>63.4</td>
<td>5.7</td>
<td>15.4</td>
<td>57.9</td>
<td>7.4</td>
<td>17.3</td>
</tr>
<tr>
<td><strong>Total-AV&amp;SD</strong></td>
<td>59±3.3</td>
<td>9.9±2.7</td>
<td>15.6±0.8</td>
<td>54.3±3.2</td>
<td>10.5±2.3</td>
<td>15.9±1.5</td>
</tr>
</tbody>
</table>

Figure 1: position for skin measurements

Figure 2: \(L^*a^*b^*\) colour model
Human skin colour shows variations throughout life, and human skin undergoes several structural and functional alterations caused by intrinsic aging and independent environmental insults (Roh et al., 2001). This often results in hypopigmentation or hyperpigmentation spots by erratic melanocyte activity as a result of cumulative UV exposure. Structurally, the aged epidermis likely becomes thinner and less coloured than the young epidermis. With age, human skin loses colour and presents a significant reduced in (a*) and (b*) values (Fullerton and Serup, 1997). In order to collect more valid clear and representative skin colour data, the majority of data was collected from a younger age group – mainly students aged from 20-25 years.

The current study aimed to formulate a comprehensive skin colour database and skin colour information based on CIELAB tristimulus values for males and females volunteers. Skin colour gamut for the sample, and colour variations according to gender and body part were also determined. The results provided some important evidence about the skin colour of the population investigated in this study. This evidence suggested that Kurdish shad is a combination of dark and light tones. Furthermore, females exhibited lighter skin shade than males, while males exhibited redder skin colour than females: the redness can be attributed to the greater blood volume in the male’s body (Fortney et al., 1981). This study result agree with a previous study performed to collect Skin colour data onto the population of Nowshahr City, northern Iran, which revealed significant differences between the males and females on the upper inner arm and the forehead, and within each sex between the sites (Mehrai and Sunderland, 1990). However, the lightness is probably due to genetic factors, such as the male having more melanin in his skin or the fact that most outdoor labor is undertaken by males. Also, females are more likely to use makeup, which provides some protection from sunlight (Brown et al., 1962, Frost, 2006). The data also revealed that faces are of darker and more colorful shades than the arms. This is probably due to the fact that the face is an uncovered part of the body and exposed to more sunlight than the covered parts. The natural skin colour can darken as a result of tanning due to exposure to sunlight. Either the UV-radiation creates oxidative stress, which in turn oxidizes existing melanin and leads to rapid darkening of the melanin or there is an increase in production of melanin to provide protection to the skin (Agar and Young, 2005). Differences in the lightness, (L*) values were the greatest between female and male’s chins (59 against 49.2) respectively, this is probably because of thick subcutaneous hair follicles on some male’s chin as the table shows.

It is very important to consider these facts when applying data acquisition or manufacturing processes to skin colour reproduction. Human skin shades can be digitally represented using cameras (2D or 3D) and then physically reproduced using manual - handmade or digital - additive manufacturing techniques. Layered fabrication techniques such as 3D colour printing is recently adopted for fabrica-
tion of Soft tissue facial prostheses (Zardawi, 2013). For this process to be successful, the appropriate skin colour gamut has to be used as a true reference in order to achieve an accurate skin colour reproduction and/or translation between different media.

Another important advantage of skin colour measurement is to provide each population/ethnic group with a dedicated skin shade guide instead of one shade guide representing the entire skin colour range. If, for example, one wants to produce a prosthesis for a patient in China, all that is needed is to refer to the Chinese skin shade guide. This will allow much more focused and more accurate colour matching. One skin shade guide for the entire population of the world cannot be as accurate as a range of dedicated skin shade guides. If we look at any ethnic shade, for example, it is possible to produce a skin shade guide for an ethnic group, perhaps comprising no more than eight to ten skin shades. This could not accurately fit the selected population properly, there might be some individual variations, not all individuals fell in the selected colour range dedicated for a specific population, some individuals might have a different skin colour fell out of the shade guide’s range. However, the closest colour match could be achieved and modified to fit the required shade properly. Moreover, the suggested skin shade guide should be produced and its validity and accuracy should be tested on human skin in order to perform the required improvement to achieve a more inclusive skin shade guide for the selected population. This kind of a very simple shade guide can be created for the purpose of producing prosthetic devices matching the patient’s skin colour properly.

Conclusions

Consistent colour shift in Kurdish population between facial and arm colour in which facial colour found to be reddish, more colourful, and darker than arm colour. Females are found to have a lighter colour than males.

A comprehensive colour gamut was developed and a dedicated skin shade guide for the study population, which requires further testing and clinical validation.

References


POLYZOIS, G. L. 1999. Color stabil-
Evaluation of Diagnostic process in Oral Surgery Department
A cross-sectional Study for 5th Year Dental Students at Mustansiriya University

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Abstract
Introduction: Diagnosis is one of the important skills for dental students. During their clinical training dental students make diagnostic mistakes, which are expected because of limited knowledge and experience. Despite the fact that these diagnostic problems are usually addressed during the clinical training in the final two years, the exact reasons for diagnostic inaccuracies made by students have not been investigated thoroughly in Iraqi dental schools.
Aim: The aim of the study is to identify factors influencing the appropriateness of diagnostic procedure by students performing dental extraction.
Material and methods: Eight Selected items from the case sheet of the Department of Oral Surgery were used to evaluate the student’s accuracy of surgical diagnosis. Seventy eight dental students were included in the study. After completion of surgical (dental extraction) procedure, each student was asked about the reason behind the diagnosis.
Results: Documentation of selected items reported as follows: chief Complaint (CC) field was neglected in 9%; history of present illness has been neglected in 73 case sheets (93.6%). Chi square test, however, showed no significant relationship between history taking (CC and HPI) and the accuracy of diagnosis. Extraoral clinical examination included lymph node (LN) examination, which was reported in 42 cases (53.8%); and facial swelling, which has been reported in 45 (57.7) cases. Intra oral examination items reported as follows: cavity probing was documented in 33 (42.3%) cases; tooth percussion for tenderness documented in 50 (64.1%) cases; examination for tooth supporting structure reported in 46 (59%) cases. Chi Square Test did not show significant relationship between both extra and intra oral examination and the accuracy of diagnosis (p>0.05, df=12). 56 students, however, made their diagnosis by guess rather than accurate diagnosis process. How about the differences you observed by gender?
Conclusion: There is an obvious lack of documentation in both history taking and clinical examination. This might negatively influence proper diagnostic procedure.

Keywords: Dental Students, Diagnostic Procedure, History Taking, Intra-Oral Examination and extra-oral examination

Introduction
The Clinical teaching process represents an interactive environment between the student, patient and clinical trainer. This environment helps the students to acquire the proper clinical skills (Groenlund and Handal, 2013). Teachers and researchers in the past decade have discussed how to improve clinical learning abilities within this environment, which results in continuous review of dental curricula (Sodestorm et al., 2012) (Albino et al., 2008; de-Azevedo-Vaz et al., 2013; Fincham and Shuler, 2001; Hendricson et al., 2006). Oral diagnosis is one of the important skills for dental students (Trowbridge et al., 2013). It is the skill dentists need in every aspect of their clinical practice. Management and treatment planning mandate accurate diagnosis. Performing diagnosis involves range of systematic procedures which aid in diagnostic decision making (Hendricson et al., 2006; Pretty and Maupome, 2004).
Gordon et al divided diagnosis process into seven steps: (1) presentation, (2) history taking, (3) clinical examination, (4) testing, (5) assessment, (6) referral, and (7) follow-up (Schiff et al., 2005). This will provide the dental student the skill of clinical reasoning, as recent perspective in medical education is to prepare successful clinician through effective knowledge management (Graber et al., 2009).

The major goal of clinical trainer is to teach the student to follow the accurate diagnostic steps, to help him/her acquiring necessary knowledge and clinical problem solving skills, in addition to ensuring professional behaviour (Cox et al., 2010) (John H. Kleffner, 2007). During their clinical training dental students make diagnostic mistakes, which is expected because of limited knowledge and experience (Graber et al., 2009). In fact diagnostic errors are often committed by medical residents and practitioners in general, which may reach up to 15% (Graber, 2013; Schiff et al., 2005; Schiff et al., 2009; Singh et al., 2014; Trowbridge et al., 2013).

Each clinical department in the College of Dentistry- Mustansiria University, including Oral Surgical Department, provides students with patient case sheet, in which he/she documents the case history and clinical findings. This protocol aims to help the student to reach the precise diagnosis and informed treatment decision. Part of the task of the clinical trainer in the department is to spot errors in the steps to reach diagnosis and treatment process (Berner, 2009) (Hendricson et al., 2006).

Despite that teaching process received more attention in the recent years, there was no particular emphasis on diagnostic errors (Singh, 2013). Diagnostic inaccuracies continue to represent a challenge for dental students, especially in their final study year. Despite the fact that these diagnostic problems are usually addressed during the clinical training in the final two years, the exact reasons for diagnostic inaccuracies made by students have not been investigated thoroughly in Iraqi dental schools.

**Aim**

The aim of the study is to identify factors influencing the appropriateness of diagnostic procedure by students performing dental extraction.

**Materials and methods:**

This study has been approved by Mustansiria Dental College Scientific Committee. This study was conducted at the Department of Oral Surgery, College of Dentistry, Al-Mustansiria University/ Baghdad during the first three weeks of the academic year 2014-2015.

Selected items from the case sheet of the Department of Oral Surgery were used to evaluate the student’s accuracy of surgical diagnosis. These items were:

- A-Case history
  1- Chief complaint.
  2- History of present illness.

- B-Extra-oral examination which includes:
  1- Lymph nodes examination.
  2- Swelling (if present).

- C-Intra-oral examination
  1- Probing of the accused tooth.
  2- Percussion of the accused tooth (lateral and vertical).
  3- Tooth supporting structures (gingiva, periodontal ligaments, alveolar bone).

These items were chosen because they were directly related to diagnosis of accused tooth condition. Other items are related to patient’s medical history and other teeth conditions.

D- Investigations, which has not been considered for statistical analysis as it was not required in most of the referred cases for extraction.

Each answered item scored 1, not answered or incompletely answered scored 0. Correct diagnosis scored 2, correct diagnosis by guess scored 1, wrong diagnosis scored 0.

If the student did not write the result of the examination, the score was also scored 0.

Each case sheet was reviewed and diagnosis was assessed before starting the extraction procedure. After completion of surgical procedure (dental extraction), each student was asked about the reason behind the diagnosis. Certain cases the students had already made a diagnosis in their mind, in retained roots cases in particular. Hence they skipped the required steps to reach the diagnosis, these cases were given a score 1 for diagnosis by guess. Seventy eight dental students were included in the study. The sample size was determined by the number students in the 5th class. Statistical analyses were performed by SPSS version 20. As study variables are nominal variables Chi square test was performed to determine the statistical relationship.

**Results**

Seventy eight dental students from the fifth year participated in this study. Twenty six (33.3%) of participating students were males and 52 (66.7%) were females. Chi-square test showed no significant relationship between accuracy of diagnosis and the sex of student (p>0.05, df=2).
Seventy eight patients participated in this study, 53 (77.9%) patients were referred from the Prosthodontic Department for extraction of either retained roots, or for extraction of single isolated teeth interfering with denture construction. The remaining 25 (32.1%) patients were referred from Oral Diagnosis Department for unrestorable teeth.

Figure 1: Documentation for history taking and clinical examination (n=78)

Figure 1 demonstrates a general trend of inadequate documentation of relevant information fields in the case sheet. Apart from Chief Complaint (CC) field where only 9% of the cases were empty, most the remaining relevant case sheet items exhibited noticeable lack of information, ranging from 28 (35.9%) to 36 (46.2%) of the cases. History of present illness (HPI) has been neglected in 73 case sheets (93.6%). Only 5 case sheets (6.4%) documented information regarding HPI. Chi square test, however, showed no significant relationship between history taking (CC and HPI) and the accuracy of diagnosis.

Relevant extraoral clinical examination involved documentation of lymph node (LN) examination and the presence of facial swelling with comparable percentage of record. LN examination was reported in 42 cases (53.8%) leaving 36 cases with no documentation. Facial swelling item has been reported in 45 (57.7) cases.

Intra oral examination items also showed noticeable levels of negligence in documentation, as follows: cavity probing was documented in 33 (42.3%) cases; tooth percussion for tenderness documented in 50 (64.1%) cases; examination for tooth supporting structure was reported in 46 (59%) cases. Five patients (6.4%) required additional investigations. These cases required periapical radiographs to confirm the presence of facial swelling item has been documented in 42 cases (53.8%) leaving 36 cases with no documentation. Facial swelling item has been reported in 45 (57.7) cases.

Figure 2: the percentage of documentation of case history items by male and female students

The diagnosis. Chi Square Test did not show significant relationship between the degree of documentation for both extra and intra oral examination and the accuracy of diagnosis (p>0.05, df=12).

Figure 2 shows the degree of documentation for the items of case history (two items) between the students (71.8%) reached the correct diagnosis. Only 8 (10.3%) students (17.9%) made the wrong diagnosis. Chi square test (P<0.05, df=2).

Figure 4: diagnostic accuracy for the study sample (n=78)

has been statistically confirmed by Chi square test (P<0.05, df=2).

It is obvious from Figure 3 that male students involved in clinical examination more than female students, apart from the examination of tooth supporting structure. The most obvious difference is noticed in tooth probing which was only performed by 25% of female students compared to about 77%

Figure 3: the percentage of documentation of clinical examination items by male and female students

male and female students. There is relative difference in the degree of documentation for related question about the case history. Female students are keener to document the information than male students. The difference is more obvious in HPI item. This of male students who performed the test. There was a significant relationship (P<0.01, df=6) between the sex of the student and the clinical examination (intra and extraoral items)

Figure 4 reveals the level of accuracy in diagnosis for the collected sample. The majority of the students (71.8%) reached the diagnosis by guess. 14 students (17.9%) made the wrong diagnosis. Only 8 (10.3%) students reached the correct diagnosis through following the accurate clinical reasoning process.

Discussion

The instrument used to assess students’ clinical skill is the patient case sheet. The reason for choosing Oral Surgery Case Sheet is that it represents the most comprehensive case sheet in the dental school. It has 56 items (questions) covering current and past dental history; both extra and intra oral examination, medical history, family history and habits.

Reaching clinical diagnosis is a
culminate process of information gathering from patient’s interview and clinical examination as agreed in most dental curricula. Inaccuracies or deficiencies in following clinical diagnostic protocol with misinterpretation of provided information might lead to wrong treatment decision (John et al., 2012). On the other hand proper history taking and examination with accurate report of collected information help the student in his clinical reasoning process to reach accurate diagnosis, especially for beginner dentists (Crespo et al., 2004).

As the study results suggest, most of the students have reached the accurate diagnosis. However, Most of these diagnostic decisions were by guess, since most of the cases are referred for extraction of teeth for prosthetic reasons. Such cases are presented with retained roots, which are mostly diagnosed as teeth with chronic periapical lesions. Despite the fact it has been stressed by the academic teaching staff that proper case sheet documentation is essential, it seems that students try to save time by neglecting proper registration of information. Saving this time, as students explain to the researchers, helps to increase the number of dental extraction to achieve the requirement for the final exam entry. The second reason for this negligence could be that students are more concerned about the technical aspects of dental extraction procedure rather than reporting the history and clinical findings, even when these students are in the 5th year and they should have gained some confidence from the dental extraction procedures they performed during the 4th year. However, some of them might not sure about their technical extraction skills.

Graber et al found that students commit cognitive errors, such as failure to gather adequate history information or perform proper physical examination (Graber et al., 2009). This agrees with the finding of this study. However, this study data suggests that proper history taking and documentation is not necessarily related to correct diagnosis. This could be explained by the fact that most of the cases which have been referred from prosthodontic department for extraction of retained root are diagnosed based on prejudice judgement. Students are taught by their clinical tutor that asymptomatic retained roots are almost always diagnosed as chronic periapical lesions. For such cases, students usually jump to diagnosis ignoring proper patient interrogation and clinical examination.

Majority of published studies about diagnostic errors belong to the medical field, whereas there is paucity of studies concerning dental field. It might be expected that some level of difference in diagnosis and treatment planning between the two disciplines (John et al., 2012). However, this study’s results agree with the fact that mistakes in clinical reasoning process in both disciplines may result from inadequate data collection and interpretation (Graber, 2013). It seems that students in this study sample are not fully aware of the importance of proper case sheet filling. This in turn could negatively influence the organisation of ideas with missing the clinical key message provided by the clinical findings. This in turn will jeopardise their diagnostic procedure (Crespo et al., 2004).

It should be remembered, however, that the number of case sheet items might represent a burden for the student. Intra and extraoral examination items in the current case sheet in Oral Surgery Department are 22. Nine items in the case sheet are dedicated for extraoral examination, whereas 13 items are devoted for intra-oral examination. In addition there are 8 items specified to detect dental problems including: missing teeth, fillings, carious teeth, calculus, retained roots, bridges, crowns and defected fillings. Such a number of items for students in the clinic has its burden, especially, if we consider that students’ main concern is to master different local anaesthesia and extraction techniques. This could be another reason for only 2 (2.6 %) students completed the chosen fields in the case sheet, which is an important finding that needs considerable attention.

The study results not only revealed a lack of students’ enthusiasm to report their clinical findings, but also showed a difference between male and female students concerning the case sheet filling details. There are published studies that found certain differences between men and women clinical performance in general, especially in their attitude toward risky tasks (Park et al., 2010).

A comparative study between male and female dental students in Jordan found that female students are better in the theoretical than clinical courses. In Oral Surgery, however, the study did not find significant difference between both genders (Sawair et al., 2009). These findings refer to the fact that female students are more theoretically oriented in general; whereas male students are better in manual aspects of practice (do you have a reference to support this?). This might explain to some extent the current study results. As the study data suggests, female students seem more interested in verbal communication with the patients than male students and reluctant to be manually involved in clinical examination during the...
diagnostic process compared to their counterpart male students. This, certainly, represents a problem in clinical training, as it is important to integrate theory and practice in dental clinical education (Crespo et al., 2004; Kelleher, 2014).

To address this problem it might be suggested to teach students a time-saving strategy or to reduce the number of case sheet items. It could be suggested to address this problem by either teaching student a time-saving strategy for case sheet filling, or reducing the case sheet fields to help students to focus on more important aspects of patient’s information. The clinical trainer, in addition, can use these findings to direct students’ attention during clinical demonstration to this problem. Training process needs to encourage each student to avoid the expected error in his/her diagnostic performance. Clinics are challenging environment for the student and the trainer as well. There is a diversity of theoretical, clinical competencies and ethical behaviour for students to demonstrate (Gerzina et al., 2005). Improper case sheet filling seems to represent a trend in students’ behaviour. It does not, necessarily, mean that students do not ask, but it might reflect students’ unwillingness to fill out every field in the case sheet paper.

The main shortcoming of this study is the number of male students, which was the total number of male students in 5th year. This may affect the power of statistical analyses. It however, reflects the tendency toward feminisation of dentistry in general (Silva et al., 2010), as the number of female students always dominates male number in Iraqi dental schools.

The findings of this study raise an important question about students’ attitude about patient’s case sheet and its role in establishing proper diagnosis. This will be addressed with a qualitative study. It is hoped that this study will provide the teaching staff with possible tactics to improve diagnostic process performed by dental students.

**Conclusion**

There is an obvious lack of documentation in both history taking and clinical examination. This might negatively influences proper diagnostic procedure.

**References**


The Influence of Mandibular Third Molar Position on Distal Caries in Mandibular Second Molar

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Abstract

Introduction: Distal caries of mandibular second molars has been documented to be associated almost exclusively with impacted third molars. The level of involvement of second molars in distal caries is influenced by the angulation of the occlusal surface of mandibular third molars and third molars depth. In spite of the importance of these factors on the occurrence of distal caries, their influence on prophylactic extraction decision of asymptomatic impacted molars for Iraqi population did not get enough attention.

Aim: of the study: To determine the influence of mandibular third molar impaction, as identified by panoramic radiograph, on distal caries incidence in second molar in Iraqi population.

Materials and Methods: Panoramic radiographs of impacted mandibular third molars prior to surgical extraction were retrieved from the database of Al-Karamah Secondary Dental Care Centre in the period 2004-2013. Demographic data were collected for all cases. Each panoramic radiograph was examined for the presence of distal caries of mandibular second molar and for the level of depth and degree of angulation of adjacent impacted mandibular third molar.

Results: One hundred forty-eight panoramic radiographs of 214 pre-surgically extracted impacted mandibular third molars were reviewed. Eighty-four (56.8%) of the cases were for males and sixty-four (43.2%) were for females. Chi-Square Test showed significant relationship between age group, impaction angulation, impaction depth and incidence of mandibular second molar distal caries. It also showed highly significant relationship between angulation and depth of impaction.

Conclusion: Horizontally impacted mandibular third molars close to the level of occlusion increases the chance of distal caries incidence in adjacent mandibular second molars. Close monitoring for such cases would be a suitable option. Further prospective studies should be conducted to study the influence of other factors on distal caries incidence.

Key words: impacted mandibular third molar, distal caries of mandibular second molar, panoramic radiography.

Introduction

Impaction of mandibular third molar is a common problem (Ozec et al., 2009), often associated with various complications. The complications identified in relation with impacted third molars are: dental caries, root resorption, periodontal problems, pericoronitis, infections, cysts, dental crowding and neoplastic lesions (Falci et al., 2012a; Fuster Torres et al., 2008; Juodzbalys and Daugela, 2013; RCS(Eng), 1997; Salehi and Danaie, 2008).

Accordingly, prophylactic extraction has been recommended (AAOMS, 2011; Mc Ardle and Renton, 2005). However, the decision to extract asymptomatic impacted mandibular third molars as a preventive measure continue to be a debatable issue (Allen et al., 2009; Boughner, 2013; Fuster Torres et al., 2008; Mettes et al., 2012; Pitekova and Satko, 2009). Distal caries of mandibular second molar is a frequently noted complication of impacted mandibular third molar tooth. It has been found to be associated almost exclusively with impacted third molar teeth (Oderini et al., 2012). The incidence of distal caries has been reported up to 42% (Allen et al., 2009; Ozec et al., 2009). The level of involvement of second molar in distal caries has been found to be influenced by the depth of impacted third molar and the occlusal angulation between the impacted tooth and the occlusal surface of the second molar (Ahmed et al., 2011; Hupp, 2008).

In spite of the significance of
mandibular third molar position on the incidence of distal caries and its possible influence on prophylactic extraction decision, there is shortage of related data regarding Iraqi population.

**Aim**

To determine the influence of impacted mandibular third molar, as identified by panoramic radiograph, on distal caries incidence in second molar in Iraqi population.

**Materials and Methods**

This study has been approved by the Scientific Committee of College of Dentistry, Al-Mustansiria University. Panoramic radiographs of cases with impacted mandibular third molars were retrieved from the database of Al-Karamah Dental Centre for secondary care. These radiographs were taken using Planmeca machine (PM 2002 CC Proline Pan/Ceph) in the period between 2004 and 2013. The panoramic radiographs were reviewed to determine their eligibility for the study. Inclusion criteria were panoramic radiographs where both mandibular second and third molars are present. Exclusion criteria were panoramic radiographs with missed and/or filled mandibular second molars. Demographic data in addition to reasons for extraction were recorded.

Each panoramic radiograph was examined for the presence of radiolucency in the distal surface of mandibular second molar on the digital screen and for the determination of both: the angulation of impacted mandibular third molar according to Winter’s classification (Winter, 1926) and the depth of impaction according to Pell and Gregory’s classification (Pell and Gregory, 1993).

The printed copy of the radiograph was used to measure the angle between mandibular occlusal plane and occlusal surface of the mandibular third molar using a tracing paper. The angles between the two tracing lines were categorized into four types of impaction as follows: <0° for disto-angular impaction, 0-30° for vertical impaction, 31-60° for mesio-angular impaction, and 61-90° for horizontal impaction (Figure 1).

![Figure 1: Tracing paper measurement for the occlusal angle of impacted mandibular third molar.](image-url)
These measurements were performed using a half circle protractor marked in degrees (180°). The depth of impaction was classified into three levels: A, B and C. In level “A” the occlusal plane of the impacted tooth is within the same level as the adjacent tooth while in level “B” the occlusal plane of the impacted tooth is between the occlusal plane and the cervical line of the adjacent tooth and in level “C” the occlusal plane of the impacted tooth is apical to the cervical line of the adjacent tooth (Figure 2).

The studied predictors were: age groups (17-24, 25-32 and 32-54), impaction angle between the occlusal plane and occlusal surface of mandibular third molar, and impaction depth.

Statistical analyses used were descriptive statistics and Chi-Square Test. The Chi-Square Test was used to determine correlation between each study variable and incidence of mandibular second molar distal caries. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 20. P value < 0.05 was considered in this study to detect statistically significant relation between study variables.

Results
Panoramic radiographs for 148 patients with 214 pre-surgically extracted impacted mandibular third molars were reviewed. Sixty-six patients had bilateral impactions. The reasons for surgical extraction of lower third molars were: pericornitis, periodontitis, mandibular second molar caries, orthodontic referral and for prophylactic reasons.

Radiographic evidence of distal caries found in 40 cases (18.7%) whereas 174 cases (81.3%) were free from distal caries.

Eighty-four of the cases were for males (56.8%) and 64 were for females (43.2%). Chi-Square Test showed no statistically significant relationship (p>0.05) between patients’ gender and incidence of distal caries as appeared in the radiographs.

Right sided impaction was found in 112 cases (52.3%) leaving 102 cases (47.7%) with left sided impaction. No statistical significant relationship (p>0.05) was found between the side of impaction and incidence of distal caries.

The age range was 17-54 years (Mean=24.5, SD=±5.8). As shown in Table 1, about two thirds of the study sample lies within the age range 17-24 years, whereas the age group above 32 years old represents the smallest number of included cases. The age groups 25-32
and above 32 years showed the highest number of distal caries in both males and females with similar percentages. The statistical relationship between age group and distal caries incidence was highly significant (p<0.01, df=2).

As demonstrated in Table 1, apart from the distal angulation, the number of cases becomes less with the increase of impaction angulation. Vertical impactions were the highest incidence (33.2%) whilst the disto-angular impactions were the lowest incidence of impaction (8.9%). Level B impaction depth was recorded as the highest number of cases (49.1%), followed by level A (39.2%), then level C (11.8%). There was highly significant relationship between tooth angulation and its impaction depth (p<0.01, df=6). Most of the cases in each category were clear from distal caries in all study variables (58.5%-93%). The highest percentages of cases with distal caries, however, were found in association with both level A and horizontal impactions.

Apart from the distal angulation, the percentage of mandibular second molar distal caries increases with the increase of occlusal angle of impaction. The incidence of caries was the highest in horizontal impaction (38.9%), followed by mesio-angular (17.1%), then vertical impaction (7%). Only two cases with disto-angular impaction were found associated with distal caries in mandibular second molar. This relationship between impaction angulation and distal caries incidence was statistically confirmed (P<0.001, df=2).

Table 1: Incidence of distal caries according to age groups, Winter’s Classification and Pell and Gregory Classification.
The data in Table 1 show that the lesser the depth of mandibular third molar the more the incidence of distal caries. The statistical relationship between tooth occlusal level and distal caries incidence was statistically significant (p <0.01, df=2).

Table 2 caries incidence in each impaction category (angulation and depth of impaction)

<table>
<thead>
<tr>
<th>Horizontal impaction</th>
<th>No. of cases</th>
<th>Caries incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level A</td>
<td>37</td>
<td>17 (45.9%)</td>
</tr>
<tr>
<td>Level B</td>
<td>10</td>
<td>2 (20%)</td>
</tr>
<tr>
<td>Level C</td>
<td>7</td>
<td>2 (28.6%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mesio-angular impaction</th>
<th>No. of cases</th>
<th>Caries incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level A</td>
<td>15</td>
<td>6 (40%)</td>
</tr>
<tr>
<td>Level B</td>
<td>39</td>
<td>6 (15.4%)</td>
</tr>
<tr>
<td>Level C</td>
<td>16</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vertical impaction</th>
<th>No. of cases</th>
<th>Caries incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level A</td>
<td>28</td>
<td>2 (7.1%)</td>
</tr>
<tr>
<td>Level B</td>
<td>41</td>
<td>3 (7.5%)</td>
</tr>
<tr>
<td>Level C</td>
<td>2</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disto-angular impaction</th>
<th>No. of cases</th>
<th>Caries incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level A</td>
<td>4</td>
<td>1 (25%)</td>
</tr>
<tr>
<td>Level B</td>
<td>14</td>
<td>1 (7.1%)</td>
</tr>
</tbody>
</table>

Table 2 details the caries incidence in each impaction category according to Winter and Pell and Gregory’s classifications. The lesser is the impaction depth in each angulation type, the more caries incidence is noticed. Caries incidence was mostly associated with level “A” horizontal (45.9%) and mesio-angular (40%) impactions. Disto-angular impaction showed the least incidence of distal caries.

Discussion

The focus of the current study is to determine the value of mandibular third molar position, as identified in panoramic radiograph, in distal caries incidence in mandibular second molar in the Iraqi population. This may inform the clinician’s decision for prophylactic extraction of asymptomatic mandibular third molars. The ability to predict the incidence of impacted mandibular third molars complications has been the subject of continuous argument (Costa et al., 2013; RCS(Eng), 1997). It has been suggested that the reason for such opinion conflict is related to the flaws in some of the published studies, such as inadequate sample size, insufficient monitoring time or methodological errors (Costa et al., 2013). Despite the fact that over the last two decades there was no sufficient evidence to support either extraction or retention options for asymptomatic impacted mandibular third molar (Allen et al., 2009; NHS, 1998; Steed, 2014), it is generally agreed that asymptomatic mandibular third molar with the potential risk for developing complications needs to be extracted. However, there is no consensus about what should be considered the high risk factors (McArdle and Renton, 2005; Network, 1999; NICE, 2000). Surgical decision, as far as distal caries incidence concerned, is no exception (BDA, 2013). The incidence of mandibular second molar distal caries as well as adjacent impacted third molar was reported in the literature to range from 0.5% to 42.5% (Sandhu and Kaur, 2008; Sheikh et al., 2012). Distal caries incidence in this study sample falls within this range and is comparable to what has been reported by Ozec et al. (2009) study (20%). Patients’ age, as this study suggests, has significant influence over mandibular second molar caries incidence. This is expected because increased patient’s age can give more chance for bacteria to cause dental caries. Almendros-Marques et al. (2006) reported that younger age group (16-30 years) was associated generally with more mandibular third molar complications. The authors, however, found no statistically significant relationship between age and impaction complications, which disagree with the finding of the current study. This disagreement may be attributed to the wider age range for “young group” in Almendros-Marques et al. study, which could influence statistical analysis Results.
Patients’ gender in this retrospective sample was found to have no influence on the incidence of distal caries. Similarly, Almendros-Marques et al. (2006) found that gender has no influence on mandibular third molar complications.

This study showed that the horizontal impaction was associated with the highest incidence of distal caries in comparison with the mesio-angular impaction which concurs with Falci et al. (2012b). This study, also, showed that the greater the occlusal angle the higher the chance of distal caries incidence. This is probably due to more chance of food impaction (Ahmed et al., 2011; Motamedi and Kavandi, 2013). However, the available evidence mandates especial consideration for mesio-angular rather than horizontal impaction (NICE, 2000). Many studies found that mesio-angular impaction was associated with the highest incidence of distal caries (Allen et al., 2009; Ozec et al., 2009; Sheikh et al., 2012). In their clinical and radiographic study on Turkish population, Ozec et al. (2009) reported that 47% of cases with distal caries of second molars were associated with mesio-angular impacted third molars (31-70 degrees). The authors, therefore, suggested prophylactic removal of asymptomatic partially erupted mandibular third molar with 30-90 degree angulation to prevent distal caries development (Ozec et al., 2009). Sheikh et al. (2012) also recommended prophylactic removal or close monitoring for asymptomatic mesio-angular impacted third molar because half of these cases in their study were associated with distal caries of adjacent second molars.

In this study, level B impaction depth was the highest incidence of impaction, which agrees with other studies (Almendros-Marques et al., 2006; Meh dizadeh et al., 2014) followed by level A. This study showed that the highest occlusal level of mandibular third molar (level A impaction depth) is associated with a greater chance of distal caries in adjacent second molar. The highest the level of impacted teeth means more exposure of the tooth crown to the oral environment. This provides bacteria with better access increasing the possibility of causing caries in the distal surface of second molar (Almendros-Marques et al., 2006; Hupp, 2008). The deeply impacted third molar, however, may also provide access to bacteria leading to bacterial accumulation around the distal surface of second molar, even with no obvious communication between the impacted tooth and the oral cavity (BDA, 2013; Hupp, 2008).

The highest incidence of distal caries was found in level “A” horizontal impaction followed by level “A” mesio-angular impaction. This concurs with the finding of Polat et al. (2008) study. Accordingly, it can be argued that level “A” horizontally impacted mandibular third molars require particular attention.

The number of cases with distal caries incidence in all study variables, however, was less than the cases without distal caries. This implies that tooth position alone might not be the only influential predictor for distal caries incidence. Other factors, such as individual susceptibility to caries and improper oral hygiene maintenance may play more important role (Falci et al., 2012b).

Recently, numerous published studies from different parts of the world are involved in the debate around the issue of prophylactic extraction decision of asymptomatic impacted third molar (Allen et al., 2009; BDA, 2013; Costa et al., 2013; McArdle and Renton, 2005; Steed, 2014). However, the predictive value of mandibular third molar position on distal caries incidence, in Iraqi population, did not get similar attention. As far as Iraqi studies are concerned, the only published Iraqi study on extraction of impacted mandibular third molar showed that prophylactic extraction is not uncommon practice (Al-Bahrani et al., 2012).

Despite the fact that symptom free impacted mandibular third molar is not necessarily risk free, it should be remembered that the decision to remove an asymptomatic mandibular third molar for predictable complication is usually weighted against expected surgical difficulties, postoperative complications and surgery cost (Godfrey, 1999; Mettes et al., 2012; Steed, 2014). Accordingly, prophylactic removal of impacted tooth is not a straightforward decision (AAOMS, 2011; Friedman, 2007). It needs to be considered after thorough clinical and radiographic examination.

In addition, the decision should not ignore the patient’s opinion when the tooth is asymptomatic. Mettes et al. (2012) on the basis of absence of strong evidence for prophylactic removal of symptom free impacted third molar, suggest that this decision is influenced by patients informed agreement in addition to surgeon’s experience.

To the best of study authors’ knowledge, this is the first study conducted in Iraq trying to determine, on the basis of radiography, the value of impacted third molar position using this number of cases. The study, however, had some limitations. First, the panoramic radiographs may not be the best investigative tool to detect proximal carious lesions (Kamburoglu et al., 2012). This study limitation is understood within the context of retrospective studies in general. In retrospective studies the authors have no control over the data. Second, the radiographic assessment was performed by a singular examiner with possible related bias. Third, the
sole reliance on radiographic findings alone may not provide a strong base for prophylactic extraction decision. Nevertheless, the impacted tooth position, as this study suggest, may have a role in developing distal caries of adjacent tooth and should be taken in consideration before making a decision to extract or retain an asymptomatic impacted tooth.

Conclusion
Horizontally impacted mandibular third molar close to the level of occlusion increases the chance of distal caries incidence in mandibular second molar. Close monitoring for such cases would be a suitable option. Further prospective studies should be conducted to evaluate the influence of other factors on distal caries incidence.

Conflict of interests:
No conflict of interest in this study.

References


Network SIG (1999). Management of Unerupted and Impacted


Comparative Evaluation of Shear Bond Strength of Flowable Composite Bonded to Teeth Enamel with Laser Surface Treatment.

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Abstract
Background: Acid etching of enamel appears to improve retention by selectively eroding certain hydroxyapatite formations and facilitating penetration by the development of resin tags. Aim of study: To evaluate shear bond strength (SBS) of flowable composite to non-lased and lased groups, compare the (SBS) of flowable composite between Total and Self-etch in non-lased and lased groups, and failure mode analysis.Materials and Methods: Forty bovine incisors were used, enamel surfaces was grounded by silicon carbide paper and samples were randomly assigned into two main groups (Group A: Non lased n=20, Group B: lased prepared n=20). Each main group was subdivided randomly according to the adhesive systems that used which are: total-etch adhesive and self-etch adhesive, which were applied to the prepared enamel surface according to manufacture instruction. Composite rod applied over the bonded area and cured. Samples were stored in distilled water at 370 for 24 hours. The evaluation of shear bond strength was employed by the use of universal testing machine. Results: The results of Student’s t-test showed that there was no significant difference between the lased and non-lased enamel groups (P= 0.311). One–way ANOVA test and Duncan's Multiple Range test that compare shear bond strength between total and self-etch adhesives showed no significant difference in both lased and non-lased enamel groups. Conclusion: The mean shear bond strength and enamel surface etching obtained with an Er,Cr:YSGG laser was not comparable to that obtained with non- lased enamel surface.

Keywords: Bovine Enamel, Er,Cr:YSGG laser, adhesives, composites, Shear bond strength.

Introduction
Despite improvements to resin composite formulations over the years, polymerization shrinkage of the resin is still considered highly relevant to the failure of direct resin composite restoration (Goracci et al. 1995). Therefore, pretreatment of the tooth surface is essential for establishing a strong bond between the resin and both the enamel and dentin (Swift et al. 1995).

Acid etching has been the standard approach for enamel pretreatment since the publication of Buonocore’s report. Effective adhesion to enamel has been achieved with relative ease and has repeatedly proven to be a durable and reliable clinical procedure for routine applications in modern adhesive restorative dentistry (Buonocore 1955).

A recent laser system which considered effective for the ablation of dental hard tissues is the Er,Cr:YSGG laser (waterlase YSGG;BIOLASE Technology), which emits light in the mid-infrared region at 2.78μm with the assistance of an air and water spray (Dela et al. 2004).

The results of previous studies on the application of laser etching for increasing bond strengths of restorative materials have been controversial. Investigation of enamel surface roughness showed that laser irradiation yielded a comparable or smaller amount of surface roughness than acid etching (Hess 1990, Arcoria et al. 1993). With regard to bond strengths of restorative materials, some studies indicated that acid-etched teeth had significantly more bond strength than laser-Laser_etch teeth (Ariyaratnam et al. 1997), whereas other demonstrated that laser etching (Melendez et al. 1992, Walsh et al. 1994, Shahabi et al. 2014,Lorenzo et al. 2015). These variations could be attributed to the different types of lasers or different irradiation parameters used because the laser-hard tissue interaction is dependent on wavelength and irradiation energy.
because the laser-hard tissue interaction is dependent on wavelength and irradiation energy. With the advancement in adhesive dentistry, various adhesive systems were introduced. Total etch adhesive system is one of the commonest adhesive systems used. It contains hydrophilic/hydrophobic primers with the ability to penetrate into the demineralized enamel and dentin created after phosphoric acid etching and smear layer removal. Further development led to what is called self-etch adhesive system to overcome drawback associated with total etch system due to collapse in collagen fibrils following dryness. This system supplied in either one or two step of application. Current two-step self-etching primers or single-step self-etching adhesives (all-in-one systems) produce simultaneous conditioning and priming effects on dental tissues (Loguercio et al. 2008).

The hypothesis tested in this study is that there is no significant difference in shear bond strength between Er,Cr:YSGG lased and non-lased enamel, different adhesives when enamel is etched by Er,Cr:YSGG laser, and different adhesives in non-lased group.

**Aim of the study**

The aims of this study were to: (1) Evaluate shear bond strength (SBS) of flowable composite to non-lased and lased groups. (2) Compare the (SBS) of flowable composite between Total and Self-etch in non-lased and lased groups. (3) Evaluate the failure mode of experimental groups.

**Material and Methods**

Forty bovine incisors, frozen to maintain freshness and defrosted immediately before specimen preparation, were used. Roots were sectioned 2mm below the cemento-enamel junction and the teeth were embedded in acrylic resin (Ivoclarvivadent, Liechtenstein) with the labial surface of the crown exposed and parallel to the base of the resin mold. The labial surfaces of bovine incisors were polished with 320-600 grit size wet silicon carbide papers using a grinding/polishing machine (Struers, Denmark), under a continuous stream of water to obtain flat enamel surface. The teeth were randomly divided into two groups (non-lased and lased) according to the surface treatment. For group (A) non-lased enamel and (B) lased enamel, flowable composite resin (DMG, Hamborg, Germany) used. Then for each group two types of adhesive system used (10 samples for each type): self-etch adhesive (Contax, DMG, Hamborg, Germany) and total etch adhesive (Teco, DMG, Hamborg, Germany).

In all samples of non-lased and lased groups adhesive tape with a central hole of 4mm diameter was attached to the flattened enamel surface. For the lased groups the laser system used was Er,Cr:YSGG (Waterlaseiplus, BIOLASE Technology, USA) in department of oral surgery, Mosul university. The laser energy was delivered through fiber-optic system to a sapphire tip terminal (MZ6) with 600 μm in diameter. Samples were lased for 20 seconds in the non-contact mode perpendicular to the flat surface with a 1-mm fixed distance from the laser tip. A sweeping motion was used to achieve an even coverage of the tested surface by overlapping the laser impacts. The following parameters (2780 nm wavelength, a pulse duration 200 μs, a pulse repetition rate of 10 pulses per second (10 Hz), 2.5 W power, energy: 250 mJ, 60% air spray and 80% water spray) were used. After that the adhesive agents were applied to a standardized enamel bonding site for all samples followed by light curing unit (LEDition, Ivoclarvivadent; Austria) according to the manufacturer’s instruction. After bonding, a translucent standardized plastic straw with an internal diameter of 4mm and height of 4mm was positioned exactly over the hole of the adhesive tape and fixed with a sticky wax. The straw was filled with resin composite (Table1) and light cured for 40 seconds.
Samples were stored in distilled water at 37°C for 24 hours then subjected to a thermal cycling of 500 cycles between 5°C (±2°C) and 55°C (±2°C) using water baths with 30 seconds in each bath. After which, shear bond strength (SBS) test was carried out using a Universal Testing Machine (WP universal material tester, gunt-Hamburg, Germany) at a cross-head speed of 1.0 mm/min. The load was applied to the composite/tooth surface interface. Maximum load to failure was recorded (digitally) in newton (N) for each sample and then shear bond strength was expressed in megapascals (MPa), in order to respect the unit commonly used in similar research, which is derived by dividing the load at failure (Newtons) by the bonded surface area (12.56 mm²) (Bahrami et al., 2011).

\[
S = \frac{F}{A}
\]

Where: 
- \( S \) = Shear bond strength (Mpa),
- \( F \) = load at failure (N)
- \( A = \pi \cdot r^2 \) (12.56 mm²), \( \pi = 3.14 \)
- \( r \) = radius of bonding area (2mm)

Following testing procedure, the mode of failures between composite and enamel surface were examined with optical microscope of the enamel surface at X40 magnification using a Stereomicroscope (Motic, Italy). The failure modes were classified as follow: Adhesive failure (enamel exposed); Cohesive failure (composite or adhesive observed on enamel); and Mixed failure (combination of adhesive and cohesive).

### Statistical analysis:
1) Descriptive statistics include, mean, standard deviation, standard error, minimum value, maximum value.
2) One-way ANOVA test was used, followed by Duncan’s Multiple Range test to find the difference in shear bond strength among different adhesive types for non lased and lased prepared group.
3) Student’s t-test was used to test the difference in shear bond strength between non lased and lased prepared group for each individual adhesive type.

### Table 1. Adhesive systems and composite resin composition, batch numbers, and the application modes, according to manufacturer’s instructions.

<table>
<thead>
<tr>
<th>Material</th>
<th>Composition</th>
<th>Application Mode</th>
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<tbody>
<tr>
<td>Teco one bottle 2-step total-etch Adhesive; DMG German; Batch#: 684040</td>
<td>Bis-GMA-based resin matrix, starter, additive, pigments, DMG Etching Gel: O-phosphoric acid in water (37%), aerosol.</td>
<td>Acid etching (20 seconds). Rinse (15 seconds) and air-dry. Apply two coats of adhesive. Air-dry (15 seconds). Light-cure (20 seconds).</td>
</tr>
<tr>
<td>Ecosphere-Flow composite Resin; DMG, Germany Batch#: 698833</td>
<td>Dental glass in an optimized matrix of Bis-GMA; 63% by weight – 41% by volume inorganic filler (0.02-3 µm).</td>
<td>Straw filled with resin composite. Light cured for 40 seconds.</td>
</tr>
</tbody>
</table>

Bis-GMA = Bisphenol A-Glycidyl methacrylate
Results
The results of SBS means and standard deviations in non-lased and lased groups are shown in (Table 2) and (figure 1). Student’s t-test revealed that there was no significant difference between the non-lased and lased enamel groups (p=

<table>
<thead>
<tr>
<th>Groups</th>
<th>Type</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std Mean</th>
<th>T</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>Contax</td>
<td>7.64</td>
<td>10</td>
<td>3.94</td>
<td>1.25</td>
<td>-1.665</td>
<td>9</td>
<td>(0.132) N.S.</td>
</tr>
<tr>
<td></td>
<td>Teco</td>
<td>10.83</td>
<td>10</td>
<td>3.87</td>
<td>1.22</td>
<td>9</td>
<td>(0.106) N.S.</td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>Contax</td>
<td>6.45</td>
<td>10</td>
<td>2.61</td>
<td>0.83</td>
<td>-1.794</td>
<td>9</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>Teco</td>
<td>9.48</td>
<td>10</td>
<td>4.12</td>
<td>1.30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Contax= Self-etch; Teco=Total etch; N.S.= Not significant.

Table 2. The results of Paired Samples t-test for SBS.

Figure 1. Results of SBS (MPa) of test groups
There was no significant difference between self-etch (Contax) and total-etch (Teco) adhesives in non-lased enamel group (p = 0.132). There was no significant difference between self-etch and total-etch adhesives in lased enamel group (p = 0.106). Student’s t-test showed no significant difference in self-etch adhesive between non-lased group and lased enamel group (p = 0.435) and no significant difference in total-etch adhesive between non-lased and lased enamel group (p = 0.459).

One-way ANOVA and Duncan's Multiple Range test did not indicate any significant differences among the non-lased and lased enamel groups (F = 2.769, p = 0.056). Total etch (Teco) showed the highest bond strength in both non-lased and lased groups.

Fracture mode: The analysis of bonding sites after shear strength tests revealed that, for non-lased fractured specimens, cohesive failure mode was predominantly observed followed by adhesive failure mode. The total-etch systems showed a limited number of in enamel (8%), which were not observed for the self-etch system. However, for lased fractured specimens, mostly mixed failures occurred. For the self-etching system, a significant number of cohesive failures in enamel was observed (28%).

**Discussion**

According to ISO 11405/TS bovine incisors can be used as a substitute for human enamel. Unlike bovine dentine, which is not recommended as a substitute for human dentine, (Retief et al. 1990) bovine enamel exhibits very similar bonding characteristics to human teeth (Oesterle 1998) and has often been used as a replacement (Chung et al. 2000, Czochrowska 1999).

Laser etching of enamel surfaces is popular because of the potential disadvantages of acid etching. Acid etching results in chemical changes that can modify calcium-toposphorus ratio, reduces the carbonate-to-phosphate ratio, and leads to the formation of more stable and less acid-soluble compounds. As a result of this demineralization, enamel becomes more susceptible to caries attack (Sungurtekin, Oztas 2010, Martinez-Insua et al. 2000). Recently, Er:YAG and Er:Cr:YSGG lasers were introduced in dentistry. For physical and medical reasons, they are used for the treatment of hard tissue. The advantage of an Erbium wave is that it is well-absorbed by water and dental hard tissue. These lasers can also be used for etching of enamel surfaces for the purpose of bonding the composite resin to enamel surface (Yazici AR et al. 2013).

The structural changes of the enamel tissue as a result of laser treatment using Er:YAG and Er:Cr:YSGG is ablation process without formation of the smear layer. This results in surface irregularities and enamel prisms exposure. These changes are thought to increase the bond strength of resin composites (Keller et al. 1993) but in fact, these morphological changes created by laser ablation do not have the same ideal pattern obtained by acid phosphoric application. Therefore; this heterogeneous structure in lased enamel affects the bond strength of resin composite (Christensen et al. 1996). Parhami et al. (2014) reported that Er:YAG laser treatment reduced shear bond strength of flowable resin composite to enamel compared to the ones treated by conventional technique using a bur previous to acid etching.

The parameter used in this study was 2.5 W output power with water according to the manufacturer of Er:Cr:YSGG lasers that recommended 2.25 to 2.5 W for laser etching but other studies used 2 to 3 W referring from their results of a pilot study to obtain the proper effects (Galskanydjm et al. 2010).

A plethora of flowable composite products are commercially available as bonding agents because of these favorable properties: non-stickiness and injectability (Elaut et al. 2002). There are some studies evaluating the shear bond strength of resin composites to lased dentin, (Visuri et al. 1996, Armengol et al. 1999) but there are not enough studies about the shear bond strength of flowable composite to lased enamel. Therefore this study was aimed to evaluate and compare the shear bond strength of flowable composite to enamel etched with Er:Cr:YSGG laser.

Pretreatment with 37% phosphoric acid increases bond strength because thick outer enamel layer may prevent the permeation of self-etch primers and bonding agents, thus leaving some areas partially unetched. This then results in formation of shorter and poorly defined resin tags. Removing the outer enamel with phosphoric acid etching, longer resin tags are formed and thus bond strength is increased (Kanemura et al. 2009, Scougall et al. 2009). On the other hand, self-etch primers and bonding agents have some advantages over the phosphoric acid etchant. Self-etch primers simplify the clinical handling of adhesive systems by combining the conditioning and priming agents into a single product (Bishara et al. 2004). Self-etch bonding agents prevent aggressive decalcification and bulk enamel loss which are characteristics of phosphoric acid etching (Arhun et al. 2006). This means that they reduce the risk of enamel damage due to their reduced ability to sufficiently etch and penetrate the enamel surface (Eminkahyagil et al. 2005). Most self-etch adhesives did not etch enamel as deeply as the phosphoric acid etchants did, but the shallow etching pattern compromised bonding to enamel (Kim et al. 2005).
It has been reported that the morphological changes of the intact and ground enamel surfaces after interaction of the self-etching adhesive depend on the pH classification of the self-etching adhesives (Chakmakchi. 2005). Demineralization effects of self-etch primers and bonding agents are proportional to their acidity. The lower the pH, the higher the acidity, the deeper the etch; and the pH values of self-etch adhesive systems are higher than that of phosphoric acid etchant (Di Frances et al. 2007).

In this study, although there was no significant differences between Er,Cr:YSGG lased and non-lased enamel groups, the lower bond strength was achieved when enamel surface etched by Er,Cr:YSGG laser, and this finding presented in both types of adhesive systems that used ( Teco, two step total etch and contax, two step self etch adhesives). Therefore the null hypothesis is that there is no significant difference between lased and non- lased etched enamel was accepted. Several of the findings concerning the use of lasers for enamel etching are contradictory. Von Fraunhofer et al. (1993) and Usumez et al. (2003) have stated that laser irradiation is not capable of etching enamel. In contrast, Visuri et al. (1996) and Hossain et al., (2003) who reported that laser irradiation may be used to etch enamel. These contradictory findings are due to the different outputs and experimental designs of the studies.

Our results disclosed that the irradiation of enamel surface with an Er,Cr;YSGG laser prior to the application of self-etching and total-etch adhesive systems, adversely affected the interaction pattern of the adhesive systems with the lased enamel and yielded a decrease in bond strength. Similar results were reported in other studies. Martines-Insua et al. (2000) found weaker adhesion forces in an Er: YAG laser-etched enamel surface than an acid etched enamel surface. This was related to sub-surface cracks observed in SEM images. Dunn et al. (2005) reported a decrease in bond strength to Er: YAG laser irradiated dental hard tissue. Sungurtekin and Oztas (2010) noted that Er,Cr;YSGG laser etching did not eliminate the need for acid etching. Moreover, they found that when a Er,Cr:YSGG laser and acid etching were combined, Er,Cr:YSGG was as effective as the conventional acid etching technique. However, the laser irradiation of enamel surfaces produced surface fissures and a union or blending of a distinctive etch pattern normally seen in acid-etched enamel. This blending effect likely prevented the penetration of resin into enamel, resulting in lower enamel bond strength values. Delme et al. (2006) who postulated that the acid-etching procedure is essential after laser ablation. Some researchers stated that laser applications give similar results to acid-etching techniques. Ozer et al. (2008) investigated the SBS of brackets that they applied on enamel prepared with 0.75 W Er, Cr: YSGG, 1.5 W Er, Cr: YSGG, 37% Orthophosphoric acid or self-etching primer. They found that the 0.75 W laser-applied group was significantly less in regard to SBS than all other groups, although there was no statistically significant difference among the other groups. Lee et al. (2007) etched enamel surfaces with acid, a laser, and acid and a laser together and investigated the SBS of the orthodontic brackets. They did not find statistically significant differences in the laser- and acid-etched surfaces. Further, they reported that the application of both could enhance the bond strength. However, acid etching after laser irritation is not able to eliminate the laser-modified layer completely.

In the present study, Total-etch adhesive produced bond strength higher than self-etch adhesive in non-lased enamel and lased enamel groups. The results of present study showed that acid etching pretreatment alone is more effective than Er,Cr;YSGG laser etching followed by acid etching. This is in agreement with Ceballos et al (2001) that proposed acid-etching alone yields shear bond strength values that are significantly higher than those achieved with laser ablation alone, or in combination with acid-etching. The self-etching primer adhesive system yielded the lowest bond strength in the Er,Cr;YSGG-lased group and confirmed the outcomes of previously reported studies (Eguro et al. 2002, De Munck et al. 2002). Contreas-Bulnes et al. (2013) found that Er, YAG laser irradiation could not de an option for enamel conditioning.

As regards the types of failure observed in the fractured specimens, an adhesive-failure mode was predominantly observed in the non-lased specimens. These findings indicate that failure after testing mostly occurred at the interface between the adhesive system and enamel surface. The total-etch systems showed a limited number of cohesive failures in enamel (8%), which were not observed for the self-etch system. In contrast, in the laser-irradiated specimens, there was an alteration in the fracture pattern, with a greater number of mixed failures and a significant increase in the number of cohesive failures in enamel. For the self- etching system, a significant number of cohesive failures in enamel was observed (28%).
Conclusion
Within the limitations of this laboratory study, the following conclusions were drawn:
1. No significant differences were noted between non-lased and Er,Cr:YSGG lased enamel for each adhesive tested.
2. Er,Cr:YSGG laser pretreatment followed by acid etching or self-etch adhesives did not enhance the adhesion of composite resin to enamel surface compared with acid etching.

References
Galişkan MK, Parlar NK, Oruçoğlu H, Aydin B (2010). Apical microleakage of root-end cavities prepared by Er, Cr:
Multi-clinical Applications of Er:YAG Laser in Oral and Maxillofacial Surgery

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Maha Salah Al-Din, MSc. Alwasity Teaching Hospital for reconstructive surgery, Baghdad, Iraq.

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Abstract
Introduction: Laser application in dentistry is the latest innovative modality which has been used in different dental and surgical fields. Among the different types of lasers, the Er:YAG laser is used for soft tissue surgery in numerous ways.

Methods: Forty five patients, who had various oral conditions, were referred to the Department of Oral and Maxillofacial Surgery in Alwasity teaching hospital and selected to be treated by Er:YAG Laser. The subjects were divided into six groups based on the clinical diagnosis. Group1 for 17 subjects with polyps, Group2 for 6 subjects requiring implant exposure, Group3 for 16 subjects requiring frenectomy, Group4 for 1 apicectomy, Group5 for 2 subjects with aphthous ulceration and Group6 for 3 subjects with pyogenic granuloma.

Results: Our study confirmed that soft and hard tissue surgery by Er: YAG laser had less oedema, post-operative bleeding and pain, good cutting and coagulation effects, easily tolerated and rapid uncomplicated healing processes in comparison to the conventional surgical methods of treatment.

Conclusion: With laser surgery, treatment times and post-operative healing periods are much shorter. Using Er: YAG lasers in soft-tissue surgery means that sutures are rarely needed, and with the laser’s simultaneous disinfection effects, healing is faster with fewer post-operative complications.

Introduction
Dentistry has a new weapon in the fight against tooth decay. This “lightsaber” of dentistry is the Erbium laser. The dental laser is the latest in modern innovations for the 21st Century. The Erbium laser has proven to be safe and effective for the removal of tooth decay and cavity preparation, in addition to many soft tissue and hard tissue surgical procedures. The FDA approved the Erbium laser for marketing in the United States as of 1997 (Nash 2002).

Er:YAG lasers are solid-state lasers whose erbium-doped yttrium aluminium garnet (Er:Y3Al5O12) is the lasing medium. Er:YAG lasers classically emit light with a wavelength of 2940 nm, which is infrared. If compared with Nd:YAG or Er:Glass, Er:YAG laser is intensely absorbed by water which is considered to limit its use in surgical procedures or any other applications where water is present. Er:YAG lasers have been used for laser resurfacing, which includes treating acne scarring, deep rhytides, and melasma. In addition to water, Er:YAG laser energy is also absorbed by hydroxyapatite, which makes it a very good laser for cutting bone as well as tissue. Many studies have described the use of Er:YAG in different oral and maxillofacial surgical procedures (Bornstein 2004, Stubinger et al. 2008, Schwarz et al. 2007).

Er:YAG laser was applied in the treatment of different oral conditions. Pyogenic granuloma is one of the laser treated conditions. It is a common tumour-like growth of the oral cavity which is unrelated to infection and represents an exuberant tissue response to local irritation or trauma. Clinically, it is a smooth or lobulated mass that is usually pedunculated and some lesions are sessile. The surface is characteristically ulcerated and ranges from pink to red to purple depending on the age of the lesion (Epivatianos et al. 2005, Bhaskar & Jacoway 1966).

Er:YAG was also applied in implant exposure (Matsuyama et al. 2003, Kreisler et al. 2002) and various frenectomy
Materials and Methods

Forty-five subjects from the Department of Maxillofacial Surgery at Alwasity Teaching Hospital were selected for this study. All the recruited subjects required laser therapy to address different oral conditions. The subjects were divided into six groups based on the clinical diagnosis (Table 1).

Written consent forms were signed by the subjects prior to the laser treatment. The treatment was conducted by the same surgeon. The laser machine used in this study is Kavo K.E.Y laser 3, 1243. Its technical data is the following, as shown in the catalogue:

Therapy laser
Laser type Solid-state Er:YAG laser
Laser class 4
Wave length 2.94μm (infrared)
Pulse energy at exit of laser contra-angle hand piece 2060 10-600
Adjustable in the range
10-200mJ in 20 mJ steps
200-600mJ in 50 mJ steps
Pulse frequency 1-25 Hz

Pilot laser
Laser type Red laser diode
Laser class 2/max. 1mW
Wave length 655nm red
At the time of operation, we gave general anaesthesia for some patients, local anaesthesia for others, and the remaining patients were given topical anaesthesia. With regards to laser, we provided particular energy and frequency for each patient, as will be shown in the results section.

**Results**

After the selection and diagnosis of the cases by the maxillofacial surgeon, 45 cases were operated on by Er:YAG laser. Depending on the diagnosis, we operated on the following cases with different management, as shown in Table1. These cases were:

1. Fibroepithelial polyps: (Fig. 1)

The number of cases was 17, six of them were male while the females were eleven (Mean age = 42). The cases were operated on either with local anaesthetic infiltration or topical anaesthesia. There was no need for suturing.

![Figure 1.a](image1.png)

**Figure 1.a**

A. Fibro-epithelial polyp on the dorsum of the tongue

B. The same patient shown in Figure 1.a, after polyp excision by Er:YAG laser
2-Implant exposure: (Fig. 2)
The number of subjects was 6, four patients were males and two of them were females (Mean age = 31 years). 4 cases were operated on topical anaesthesia, while for the other two cases local anaesthetic infiltration were used. No sutures were performed.

3-Frenectomy: (Fig. 3)
The number of subjects was 16. This was divided into:

a-Labial frenum: 4 subjects, one of them was female and the others were males (Mean age =10 years).
b-Lingual frenum(tongue tie): 12 subjects, eight patients were males while females were four (Mean age = 9 months).

Either general anaesthesia or local anaesthetic infiltration was required in these cases. In most of the cases no sutures were performed.
4-Apicectomy
Only one male (thirty-two years old) was recruited. Local anaesthetic infiltration was used in this operation which ended with suturing of muco-periosteal flap.

5-Aphthous ulcer
Two females were diagnosed with Aphthous ulceration (Mean age 17 years). Subjects were treated with topical anaesthesia, there was no need for suturing in both cases.

6-Pyogenic granuloma: (Fig. 4)
The number of cases was 3. Two patients were females and other was male (Mean age 35 years). The excisions were done under local anaesthesia and sutures were performed.
The results of our study confirmed that soft tissue surgery by Er: YAG laser had less oedema, post-operative bleeding and pain, good cutting and coagulation effects on soft tissues in comparison to the conventional surgical methods of treatment such as scalpel and electrocautery. The procedure was easily tolerated and postoperative pain was low or absent.
Regarding dental and bone surgery (group 4), Among all other lasers, Er: YAG laser can be used in almost all steps of peri apical surgery: incision for flap, bone removal, removal of granulation tissues, apex resection and retrograde cavity because of its efficacy in soft tissue, bone and dental tissues removal. Er: YAG lasers are appropriate for the treatment of hard tissues without inducing discomfort, vibration or noise. Furthermore, risk of surgical field contamination and damage to the surrounding tissues is decreased when compared to the surgical drilling technique.
As result of that we ended with rapid uncomplicated healing processes in the majority of cases when compared to conventional surgical methods.

Figure 4.a

Figure 4.b

A. Pyogenic granuloma in the lower anterior edentulous ridge
B. Healing after 8 days from the complete excision for the same lesion shown in Figure 4.a by Er:YAG laser
Discussion
The therapeutic effect of Er:YAG laser is based on the photothermal interaction, where the biological effect of K.E.Y laser is not only thermal, but also mechanical and best described as a thermo-mechanical effect (Niernz 1996). The absorption spectrum of water shows that the wavelength of the K.E.Y laser of 2940 nm coincides with maximum absorption in water (Catone and JR 1997). During the surgical operations of all the cases considered in this study, no significant bleeding was noticed and that is because the K.E.Y laser seals the small blood vessels (Strauss 2000). For example, when we excised polyps, we found no bleeding at all because the clotting due to the laser application acts as a seal on the excised tissue, and for that reason no suture was performed.

With regards to pain, the laser lessens the pain threshold to an extent because the laser seals the nerve endings (Mancuso 1991). In some cases, for example polyps, implant exposure, aphthous ulcer and pyogenic granuloma, we did not use local anaesthetic infiltration in this research work, but if we did not apply the laser in these cases we had to inject local anaesthesia. This is one of the advantages of laser compared with the scalpel and by this we protect the patient from the side effects of local anaesthesia (Keon 1992).

We agreed with some authors who suggested that mild oedema was seen in the first few days after laser application before gradual shrinkage in this oedema and swelling (Rechmann et al. 1998). The oedema-reducing effects of the low-power laser results from increased micro vascularization (Rozenborn & Fiszerman 1995, Rozenborn 1995), accelerated lymphatic flow (Pontinen & Airaksinen 1989, Pontinen 1998), and enhanced tissue oxygen uptake. The number of nail bed and mesenteric capillaries increases after laser stimulation. Laser irradiation enhances blood flow to oedematous, ischemic or hypoxic tissues in general. The most marked increase in capillary density laser irradiation occurs at the dermal-epidermal junctions.

Conclusion
The conclusion drown form this study is; the Er:YAG laser is a good tool to use in oral surgery because of its advantages during operations and post-operatively. With laser surgery, treatment times and post-operative healing periods are much shorter. Using Er:YAG lasers in soft-tissue surgery means that sutures are rarely needed, and with the laser’s simultaneous disinfection effects, healing is faster with fewer post-operative complications.

References
Bornstein E (2004). Proper use of Er:YAG lasers and contact sapphire tips when cutting teeth and bone: scientific principles and clinical application. Dentistry today, 23(8), pp.84, 86–9; quiz 89.


In Vitro Comparative Assessment of Facture Resistance of Roots Restored With Everstick Fiber Reinforced Composite Post
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Abstract
Aims: To evaluate and compare the fracture resistance of maxillary central incisors received EverStick adaptable glass fiber reinforced composite posts and prefabricated glass fiber Luxa post and to determine the mode of failure.

Materials and Methods: Thirty extracted human permanent maxillary central incisor were decoronated, instrumented, and obturated. Post space was prepared in each root, randomly divided into 3 groups (n=10). Group (A): Control group; the roots remained without post space preparation. Group (B): The roots prepared to receive prefabricated translucent glass fiber posts (Luxa post). Group (C): The roots prepared to receive adaptable EverStick fiber reinforced composite post. After core built up, the specimens were thermocycled, mounted in a customized metal ring and fracture resistance was tested in a Universal Testing Machine. Data collected were analyzed statistically and the mode of failures was analyzed under stereomicroscope.

Results: Statistical analysis revealed highly significant difference at p≤ 0.001. Group (C) showed the highest mean of fracture resistance followed by Group (B). While Group (A) the control group show the lowest mean of fracture resistance. Fracture pattern indicated that specimens in Group: C represent 100 % favorable failure, followed by group: B which represent 80 % favorable failure, while the control group showed 80 % unfavorable failure.

Conclusions: EverStick adaptable glass fiber reinforced composite post showed significantly more predictable fracture resistance than prefabricated glass fiber Luxa post.

Key words: EverStick Posts, fracture resistance, glass fiber post fiber, reinforced composite post.

Introduction
It is assumed that the endodontically treated teeth are weaker and more prone to fracture because of desiccation or premature loss of moisture supplied by a vital pulp, complicated by substantial loss of coronal tooth structure. Therefore, endodontically treated teeth often require build up with varying post-core foundation materials (Adanir et al, 2008, Vidhya et al, 2009, Bijelic et al, 2011).

The fracture strength of the root-post-core assembly is very important to sustain the mechanical stability of the restoration and, therefore, high fracture strength is crucial for clinical success (Özcan and Valandr, 2009). The fiber reinforced composite (FRC) posts have been introduced because of the high root fracture risk with prefabricated metal posts (Garoushi et al, 2009). The use of such materials offer a number of advantages, including biocompatibility, esthetic properties, dentin-like rigidity, resistance to corrosion and fatigue, mechanical properties that closely match those of tooth and option of easy removal of post from the root canal. Among of these posts, glass fiber post is consider the most important one since their ability to chemical adhesion with bonding cement and composite resin cores, this advantage provides more conservative post hole preparation (Bitter and Kielbassa, 2007, Adanir et al, 2008, Abo El-Ela et al, 2008, Bijelic et al, 2011). In addition they can be transmitted light to deeper part of the canal so they can improve degree of polymerization for the resin cements (Kim et al, 2010).

Fiber-Reinforced Composite can be used in root canal as prefabricated posts and individually formed post. The reinforcing effect of the fiber fillers is based not only on stress transfer from the polymer matrix to the fibers, but also on the behavior of individual fiber as stress breaker (Adanir et al, 2008, Garoushi et al, 2009, Makarewicz et al, 2013)When posts are bonded well to root dentin, the post, cement and dentin form a monoblock. A similar
situation can be created in the crown portion of the tooth if the core build-up is made of bonded resin composite. The components of such a monoblock behave as one unit under functional forces, with better distribution of stress and enhanced resistance to fracture (Abo El-Ela et al, 2008, Makarewicz et al, 2013).

A novel glass fiber post (EverStick post, Stick Tech, Finland) was introduced. This post is made of flexible, resin-impregnated uncured glass fibers with an Interpenetrating Polymer Network (IPN). The post is supplied in a soft form and hardens upon polymerization with light (Abo El-Ela et al, 2008, Vidhya et al, 2009, Kim et al, 2010).

**Aim of the study**
To evaluate and compare the fracture resistance of endodontically treated maxillary central incisors restored with prefabricated and adaptable glass fiber posts, and to determine the mode of failure.

**Materials and Methods**
The materials used in this study are listed in Table (1).

<table>
<thead>
<tr>
<th>Materials</th>
<th>Composition</th>
<th>Manufacturer</th>
</tr>
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<tbody>
<tr>
<td>EverStick Post (supplied in a soft unpolymerized form sheet)</td>
<td>Silanized E-glass unidirectional fiber impregnated with PMMA and Bis-GMA</td>
<td>Stick Tech Ltd, Turku, Finland</td>
</tr>
<tr>
<td>LuxaPost (prefabricated translucent glass fiber post)</td>
<td>Pre-silanized glass fiber in a Bis-GMA based resin matrix</td>
<td>DMG, Hamburg, Germany</td>
</tr>
<tr>
<td>PermaCem 2.0 (Universal auto-mix dual-cure self adhesive resin cement)</td>
<td>Barium glass in a Bis-GMA based matrix of dental resins, pigments, additives and catalysts, filler content 69 wt.%</td>
<td>DMG, Hamburg, Germany</td>
</tr>
</tbody>
</table>

Table (1)

Thirty extracted human permanent maxillary central incisor were collected from Department of surgery, College of Dentistry, Mosul University, Iraq, with straight, similar root lengths and round canals, using two projections (bucco-palatal and mesio-distal) of dental radiograph taken by digital x-ray device (Digora® Optime Classic, Soredex, Sweden) and approximately with the same size (measured mesiodistally and faciolingually by means of a digital caliper) which were free of any caries, previous restorations, fractures and cracks were used. They were surveyed under a stereomicroscope (Motic, Taiwan) at magnification of X20. The teeth were examined radiographically to discard those with internal structural defect. All teeth scaled, polished, and stored in distilled water at 37˚C in an incubator until use. The anatomic crown of each tooth was cut horizontally to the long axis of the root 1 mm incisal to the cemento-enamel junction and at 15 mm from the root apex using diamond wheel saw (KG Sorensen SP, Brazil) under water coolant, then a size 10 K-file (Mani, Inc. Japan) was passed through each canal until being visible at the apical foremen and the working length was recorded as being 1 mm less than that length (14mm). All the canals were instrumented with ProTaper (NiTi) rotary instrument to size F3 (Endo-Mate DT, JAPAN). Sodium hypochlorite (2.5% NaOCl, 2 mL) was used for irrigation between each file size and as a final irrigation, then the canals were dried with ProTaper paper points, obturated using size F3 single cone gutta-percha and (AH plus) root canal sealer (Dentsply, Maillefer’s). Excess gutta-percha then removed with a heated instrument and cold vertical compaction performed with endodontic plugger. The canal orifices, then sealed with glass-ionomer cement (Voco, Germany), and the roots were stored in distilled water in 100% humidity at 37˚C for 72 hours. After that, each root surface was thinly
covered with a silicone impression material about 0.3mm thickness at 2mm apical to the cemento-enamel junction to simulate thickness of periodontal ligament.

Each root was then fixed from the cervical surface with paste to the arm of an adjusted dental surveyor, to imbedded in polyvinyl tube with (10×20) mm dimensions which was filled with self cure acrylic resin (BMS dental, Italy), then the vertical arm of the surveyor was lowered until the root was flush with freshly acrylic resin to 2mm below the cemento-enamel junction of the root and allowed to remain undistributed until chemical curing of the resin was completed. After that the roots were randomly divided into three groups. Group (A): control; 10 roots remained without post space preparation. Group (B): 10 roots prepared to receive prefabricated translucent fiber glass reinforced composite post (LuxaPost, 1.5mm size). Group (C): 10 roots prepared to receive EverStick fiber-reinforced composite post (EverStick Post, 1.5 mm size).

Consistent post space would be prepared by removing 10 millimeters segment of gutta-percha from each root canal obturation using Peeso drills (Dentsply, Maillefer’s) size 1-3 coupled with slow speed hand piece (W&H, Austria) leaving 4mm of gutta-percha, then the post spaces were prepared with Parapost drills (diameter 1.5 mm). A new drill was replaced after every 10 post preparation. Radiographs were taken to check the presence of any residual gutta-percha and sealer in the root canal walls along the prepared post space. Each post-space was irrigated with 5 mL of 17%EDTA for 15 Seconds following by 5 mL of distilled water, and then thoroughly dried with paper point. The soft unpolymerized EverStick sheet was cut to a premeasured length, inserted and shaped by condensing to the prepared post space (during this procedure the post must remained away from any light to prevent premature polymerization), then the shaped post was initially light polymerized inside the root canal for 20 Seconds. The shaped EverStick post then removed from the root canal and further light polymerized for 40 Seconds according to the manufacturer instruction.

Post cementation with (PermaCem 2.0) self-adhesive resin cement was used. Apply the auto-mixed paste in to the root canal with the aid of root canal elongated tip. Insert the post (LUXA post and EverStick) immediately into the canal; remove excess cement within 30 Seconds of insertion. The post was maintained under finger pressure until initial hardening of the cement had occurred (about 7 min. according to the manufacturer instructions). Then the material can additionally be light cured for at least 40 Seconds from each side. The seating procedures were performed by a single clinician.

All fiber posts were cut at a distance of 4mm from the coronal surface of the roots, seating of the post was verified radiographically. Core build-ups for all specimens were created incrementally from a light-polymerized hybrid resin composite (Tetric, Vivadent) using light curing unit (Astralis, Vivadent, Germany), which was applied for 40 Seconds per increment (Acid etching of post core with (37% phosphoric acid) for 15 Seconds, rinse with water spray for 20 Seconds, gently dry with air. Applied two coats of Excite bonding (Ivoclar, Vivadent), gently air dry, and light cured for 20 Seconds).

The crowns of the teeth were restored to their original anatomic form with the composite material and were finished with rotary instrument. In order to minimize variations in specimens, transparent anterior crowns (No. 1.910, TOR VM Ltd, Russia) of an ideally contoured crown was used to aid crown fabrication. After that leaving the samples for further polymerization for half an hour, then they were stored in distilled water at room temperature for 72 hours. All specimens were thermocycled in water (1000x, 5°C ± 2°C/ 55°C ± 2°C, dwelling time of 15 Seconds). During the entire procedure, the teeth were maintained in a wet environment and then stored in water at room temperature for 24 hours before testing.

A static load was applied to the restored teeth with the aid of computer controlled universal testing machine (TERCO, MT, Sweden) at a speed of 1.0 mm/min. The acrylic block containing the restored tooth was tightly fixed to the customized inclined metal base to provide a 45-degree angle between the palatal surface of the tooth and the loading tip (spherical head 2.0 mm) (Fig.1). The loading in Newton (N) until fracture for each tooth has been occurred was registered and the failure mode for each specimen was categorized to 2 typical types of failures: favorable type above the CEJ which has easy possibility to repair (portion of the core fractured, or failure occurred at core-tooth interface) and unfavorable type below the CEJ (vertical root fracture) with difficult chance to repair (Garoushi et al, 2009). Data of the fracture-load values were statistically analyzed using One-way analysis of variance (ANOVA) followed by Duncan’s multiple rang test at a significance level of 0.001 to determine the differences between the groups.
Results
The results of the mean fracture resistance values (N) and standard deviations obtained for each group are shown in Table (2).

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gp.A (control)</td>
<td>10</td>
<td>602.90</td>
<td>132.56</td>
<td>401</td>
<td>790</td>
</tr>
<tr>
<td>Gp.B (LuxaPost)</td>
<td>10</td>
<td>1247.60</td>
<td>155.44</td>
<td>1032</td>
<td>1563</td>
</tr>
<tr>
<td>Gp.C (EverStick)</td>
<td>10</td>
<td>1780.30</td>
<td>155.42</td>
<td>1581</td>
<td>2103</td>
</tr>
</tbody>
</table>

In all the tested specimens, Group: C exhibited the maximum mean fracture resistance (1780.30±155.42) in Newton, followed by group: B which represented (1247.60±155.44) in Newton, while Group: A exhibited the least fracture resistance mean (602.90±132.56) in Newton.

Significant differences were detected among groups by one-way ANOVA at (p<0.001) as shown in Table (3).

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>6952260.46</td>
<td>2</td>
<td>3476130.233</td>
<td>158.277</td>
<td>.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>592981.40</td>
<td>27</td>
<td>21962.274</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7545241.86</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Df: Degree of freedom  Sig: Statistically significant at P≤ 0.001

Duncan’s multiple rang test Table (4) revealed that the teeth restored with (EverStick Post) had higher fracture strength than teeth restored with prefabricated LuxaPost fiber post.

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gp.A (control)</td>
<td>10</td>
<td>1780.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gp.B (LuxaPost)</td>
<td>10</td>
<td>1247.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gp.C (EverStick)</td>
<td>10</td>
<td>602.90</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Different laters mean statistically significant differences.
Failure mode was summarized in Table (5).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Favorable Failures %</th>
<th>Unfavorable Failures %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Portion of the core fractured</td>
<td>Debonding at core-tooth interface</td>
</tr>
<tr>
<td>Gp.A (control)</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Gp.B (LuxaPost)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Gp.C (EverStick)</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

Table (5)

The mode of fracture was different among the study group. In group A, (80%) showed vertical root fracture. However, vertical root fractures were not observed in groups (C) which was shown about (60%) core fracture. While group (B) was shown 80% of favorable failure.

Discussion
It has been suggested that a post should have the same modulus of elasticity as root dentin to distribute applied forces evenly along the length of the post (Bijelic et al, 2011), which is an important factor for fracture resistance of weakened roots (Kim et al, 2010). Root fractures on root-filled abutment teeth are severe failures, often with fatal consequences for the involved tooth and prosthetic reconstruction (Özcan and Valandr, 2009, Bijelic et al, 2011,).

Lateral forces were applied to the incisal surface using a 45° angle between palatal surface of the tooth and the loading tip (Garoushi et al, 2009, Kim et al, 2010, Bijelic et al, 2011).

The teeth received EverStick® post was associated with the highest fracture resistance (1780.30±155.42) in Newton. This could be due to the multiphase polymer matrix of these types of posts consisting of both linear and cross-linked polymer phases (semi interpenetration polymer network, semi-IPN). The monomers of the adhesive resins and cements can diffuse into the linear polymer phase, swell it, and by polymerization, form interdiffusion bonding and a so-called secondary semi-IPN structure, this will reduced stress formation at post/dentin and post/cement interfaces (Le Bell et al, 2005, Mannocci et al, 2005, Abo El-Ela et al, 2008, Vidhya et al, 2009, , Makarewicz et al, 2013). Teeth with prefabricated glass fiber composite Luxa post revealed (1247.60±155.44) mean in Newton fracture strength. Luxa posts were supplied in a hardened form (with pre-polymerized monomer). It exhibit a highly cross-linked polymer matrix between the fibers; the monomers of the applied adhesive systems cannot penetrate into a cross linked polymer matrix and no free radical polymerization can occur, which might have reduced their potential for bonding to the resin cement and thus might have allowed relatively lower fracture resistance (Mannocci et al, 2005, Abo El-Ela et al, 2008, Kim et al, 2010).

The majority of root canals have an irregular, ovoid shape in their coronal and middle third. When using prefabricated fiber posts the consequent lack of adaptation of the post to the root canal walls may result in the inability of the luting agent to fill the post-tooth interface completely (Terry 2003, Bitter and Kielbassa, 2007, Vidhya et al, 2009, , Makarewicz et al, 2013).

EverStick Posts have the ability to adapted easily to the shape of the root canals, thereby possibly reducing the number of voids and then the canal completely filled with post for this reason the adhesive surface and the strength in the most critical part of the tooth are maximized (Terry 2003, Abo El-Ela et al, 2008, Kim et al 2010, Bijelic et al, 2011).

The teeth with no post received represent the lowest mean of fracture resistance (602.90±132.56) in Newton. Gutta-percha does not show increased resistance to internally generated stresses in root canal since it does not chemically bond...
to the dentin wall even with the use of resin-based sealers because the sealer does not bind to gutta-percha. Moreover, the sealer tends to pull away from it during setting (Teixeira et al, 2004).

Adanir et al, 2015, compare the resistance to vertical root fracture of root filled teeth restored with different FRC, as in the present study. However, the mean failure loads was less than obtain in the present study. This difference can be related to use the dynamic loading while in our study we use thermocycled and aging for 24 hours before testing. The observation of failure mode can indicate how the system is working and point out the weakest link (Mannocci et al, 2008).

In terms of failure mode, The teeth with no post received showed 80% root fracture (Fig.2), this can be originate from regions with excessive stress concentrations and propagate by exploring mechanically weak areas in the restoration (Bitter and Kielbassa, 2007, Garoushi et al, 2009).

Teeth using the adaptable EverStick Post, showed that most common failure were fracture portion of core (Fig.3), which have easy possibility to repair (Mannocci et al, 2008, Garoushi et al, 2009, Özcan and Valandr 2009).
Studies showed that an oxygen inhibition layer is formed on the coronal part of the post, which allows free radical polymerization between the post and core-built-up composite resin. This allows formation of secondary IPN bonding based on interdiffusion of the resin systems of post and composite resin core (Özcan and Valandr 2009, Garoushi et al, 2009, Makarewicz et al, 2013, Zaitter et al, 2011, Mannocci et al, 2005, Terry, 2003). While when using prefabricated Luxa post and composite resin core, the failure mode were 40% core fracture, 40% debonding at core-tooth interface (Fig.4) and 20% root fracture. The latter fractures could have originated from the adhesive interface between the core and root dentin, and propagated toward the post by suggesting weak dentin bonding (Garoushi et al, 2009, Bitter and Kielbassa, 2007, Mannocci et al, 2008, Le Bell et al, 2005).

Prefabricated FRC posts have been critized for their highly cross-liked polymer matrix, which is difficult to bond to resin luting cements and core materials (Bitter and Kielbassa, 2007, Mannocci et al, 2008, Vidhya et al, 2009, Kim et al, 2010). The debonding of the post from the core may be a clinically more favourable failure mode than fracture of the post (Mannocci et al, 2008, Özcan and Valandr 2009).

Teeth with EverStick Posts showed no root fracture and this is because the individually formed posts provide fiber location closer to the outermost surface of the root where the highest functional stresses are located. While roots with prefabricated Luxa posts revealed 20% root fracture, and this may be due to the location of these posts in the center of root in the neutral axis of tubular structure is not optimal to provide effective reinforcing effect by the fibers of the post for the root-core-crown system. In addition, by using the prefabricated FRC posts, the free space of the coronal root canal opening is filled only with weaker particulate filler composite resin cement (Terry, 2003, Zaitter et al, 2011, Makarewicz et al, 2013).

Conclusion
The individually formed (FRC) post improved the fracture load of the post-crown system and significantly contributed to the reinforcement and strengthening the restored teeth by supporting the tooth structure.

Prefabricated FRC post also have limitations in their properties, such as poor anatomical fit to the canal, poor bonding to luting cement and in thin posts low fracture resistance.

In case of endodontically treated with crownless teeth, the need for posts that have the same modulus of elasticity as root dentin to distribute applied forces evenly along the length of the post root appears to be mandatory. Further studies are required to compare other types of posts and its effect on the fracture resistance of endodontically treated teeth.

References


Conflict of interest
The authors confirm that this article content has no conflicts.