# Clinical Comparison on Detection of Dental Caries by Decayed, Missed and Filled Teeth (DMFT) System and International Caries Diagnosis and Assessment System (ICDAS) on Some Dental Students in Benghazi City.

**By**

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بسم الله الرحمن الرحيم

{وَقُلْ رَبِّ زِدْنِي عِلْمًا}

[طه: 114]

صدق الله العظيم

# *Dedication*

***To***

*My lovely family for their support, love, patience and encouragement, my supportive husband* ***Dr Mahmoud Abo Hurira,*** *who is always by my side when I needed him the most, and to my lovable children,* ***Mohamed, Noor*** *and* ***Ellen*** *who served as my inspiration.*

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*First, I thank **Allah** the most gracious for helping me to accomplish this research.*

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*Finally, thanks to my brother and my sisters for their love and support.*

***Gatrelnada Mohamed Elsharkasi***

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| | |
|---|---|
| **DC** | Dental caries |
| **DMF** | Decayed Missing Filled |
| **D** | Decayed |
| **M** | Missing |
| **F** | Filled |
| **WHO** | World Health Organization |
| **DMFT** | Decayed Missing Filled Teeth |
| **DMFS** | Decayed Missing Filled Surface |
| **ICDAS** | International Caries Detection and Assessment System |
| **CARS** | caries associated with restorations and sealants |
| **DEJ** | Dentin Enamel Junction |
| **SiC** | Significant index Caries |
| **PUFA** | Pulp-Ulcer-Fistula-Abscess |
| **CAST** | Caries Assessment Spectrum and Treatment |
| **FPMs** | First Permanent Molars |
| **dmft** | decayed missing filled teeth |
| **dmfs** | decayed missing filled surface |
| **FDI** | Federation Dentaire International |

# LIST OF APPENDICES

# Clinical Comparison on Detection of Dental Caries by Decayed, Missed and Filled Teeth (DMFT) System and International Caries Diagnosis and Assessment System (ICDAS) on Some Dental Students in Benghazi City.

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## ABSTRACT

**Background and Aim:** The common method of caries status evaluation is the number of decayed, missed and filled teeth (DMFT) index. Recently the International Caries Diagnosis and Assessment System (ICDAS) has been introduced for a detailed evaluation of the dental caries. The aim of this study was to evaluate the caries status with this new system while comparing it with the DMF index as a common method for caries evaluation.

**Materials and Methods:** A descriptive cross- sectional design study was performed to evaluate the caries status. The participants were conveniently selected from 500 dental students attending the Faculty of Dentistry, University of Benghazi, Libya. A single trained and calibrated examiner using a dental mirror and a WHO probe per the DMFT, ICDAS index systems, performed the examination. The numbers of decayed (D), missing (M) and filled (F) teeth were recorded in DMFT form. In the ICDAS, the evaluation of teeth status was carried out in pit and fissure surfaces in dry and wet situations according to the codes of this system. Paired t test and Pearson correlation test were used to compare between DMFT and ICDAS indices.

**Results:** All participants had caries experience (DMFT>0). The ICDAS index showed that participants had some form of caries in different phases of caries progression and extension. No statistically significant differences in numbers of missing teeth due to caries (p=0.854) or filled teeth (p=0.166). On the other hand, ICDAS index revealed significantly higher numbers of decayed teeth and the overall

score than DMFT Index ($p \leq 0.001$). The correlation test revealed statistically significant correlation between numbers of carious, filed teeth and missing teeth according to DMFT and ICDAS index ($p \leq 0.001$).

**Conclusion**: The inclusion of non-cavitated lesions during the caries evaluation by ICDAS represents a challenge in diagnosis, which allows for control of this process before the evolution of these lesions to cavitation and promotes advanced preventive therapies. DMFT index underestimates lesions that do not require any invasive treatment.

# 1. Introduction Chapter 1

Dental caries (DC) is a dynamic disease process caused by acids from bacterial metabolism of fermentable carbohydrates diffusing into the dental hard surface to demineralize and destroy the tooth [(1)]. The caries process is a dynamic interaction resulting from many cycles of demineralization and remineralization [(2)] and affects a major number of population throughout the world as a multifactorial disease resulting from a chronic imbalance between multiple risk and protective factors [(3)]. Therefore, all individuals are susceptible to this disease throughout their lifetime [(4)].

Dental caries is a widely prevalent disease problem globally [(5)]. It remains a public health problem in several countries due to differences in behavioral and sociodemographic conditions that interact with the etiology of dental caries [(3)]. It is also the main cause of tooth loss and pain around the world [(6)].

Caries detection and evaluation have an epidemiologic importance among more accurate diagnostic procedures; therefore, for caries control or prevention, a reliable project of measures in a population is needed and this step can only be obtained if a valuable caries assessment index is achieved [(7)].

Indices that allow assessment of the severity of the disease and the effects of treatment on disease are essential to show and compare levels of disease in different population and at different points of time. It trials to determine populations at high and low risk and to define the specific problem under examination [(8)]. Therefore, among the different epidemiological indexes used to assess dental caries manifestation, the Decayed Missing Filled (DMF) index was developed by Klein and Palmer in 1938 to determine the prevalence of coronal caries, it is one of the simplest and the most commonly used indices in epidemiologic surveys of dental caries [(9)].

According to WHO, 2013 [10] , the DMFT index measures dental health status based on the number of decayed (D), missing (M) and filled (F) teeth, which are evaluated and reported according to the number of teeth (DMFT) or surfaces (DMFS) involved**.** WHO has approved this index in its oral health assessment form for conducting national oral health surveys, because it is simple to use, valid and reliable, which explains why it is still being used for assessment and comparison of caries status of the population groups around the world [11].

Mehta, 2012 [12] reported that DMF index is used for caries diagnosis at a cavitation level result in a significant underestimation of the actual caries experience and severity in populations as it records only cavitation lesions and it ignores the incipient carious lesions . These incipient lesions can be reversed by application of various preventive measures like fluorides if detected at earlier stages. Therefore, an index should be able to record these lesions to apply primary preventive measures in a population [13].

Castro *et al* ., 2018 [14] showed that caries lesion detected by DMF index was lower than that detected by other methods (ICDAS ,CAST) because this index does not include enamel lesion, and DMF does not distinguish between severities of caries lesion, which is important for health planning . Furthermore, caries prevalence should not be based on the dmf/DMF index but on cavitated dentine carious lesions (d/D component) as the M- and F-component do not refer to a disease stage.

In recent decades, to overcome the limitation of the DMFT index, a wide variety of new methods have been developed to measure caries in a population. A new visual and tactile dental caries detection system was developed by Banting *et al*., 2005 [15] for international use, designated the International Caries Detection and Assessment System (ICDAS). According to Ismail *et al* ., 2007 [16] ICDAS has a clinical visual scoring system, which provides clinicians and researchers with diagnostic criteria that show clear stages of the caries process to enable them

to decide at which stage of disease (cavitated or non-cavitated) and severity and histological depth of the carious lesions depending on surface characteristics .

Pitts , 2009 [17] found that system was accurate and reproducible and was very helpful in the diagnosis of early carious lesions as well as long-term evaluations based upon visual examination of the teeth in a clean dry and accurate environment. Therefore, there is an increased chance of detecting incipient carious lesions that includes stages of carious lesion progression in the enamel.

Ferreira *et al.*, 2010 [18] conducted a study in different countries indicating a super correlation of the results of ICDAS with histology of the evaluated lesions, with a good reproducibility for permanent and deciduous teeth, their results proved the validity and reliability of this system especially for clinical trials assessing effectiveness of caries preventive control agents.

ICDAS is designed to meet the following concepts of content validity that is represented by measure the stages of the carious process rather than just the decayed stage as well as provide detailed exclusion criteria of non-carious lesions as staining, fluorosis, opacities in addition to define the terms and descriptions used to measure the caries process [19].

Few limitations of ICDAS have been recorded as a complicated index due to the recording of non-primary caries lesion related conditions, does not correlate well with the detection and assessment of the conditions and various types of restorations and may lead to an overestimation of the seriousness of dental caries experience [20].

According to the Coordinating Committee, ICDAS criteria are divided into two categories: coronal primary caries and root caries. Caries detection coding and caries activity coding should be done separately. ICDAS systems have two-digit coding for detection criteria of primary coronal caries. The first one is related to

the restoration of teeth and has a coding that ranges from 0 to 9. The second digit ranges from 0 to 6 that is used for coding the caries [21].

There are slight differences between the signs related to each code depending on a number of features. A full description of each of the codes is given under the following titles: Pits and fissures, smooth surface (mesial or distal), free smooth surfaces and caries associated with restorations and sealants (CARS). In this study, the first code description will be taken on pits and fissures to detect and record caries [22].

Therefore, this study was conducted to evaluate the caries status using this new system (ICDAS) and comparing it with the (DMF) index as a simplest and the most common method for evaluation of the caries status.

# 2. Literature Review Chapter 2

## 2.1. Overview of dental caries

Dental caries (DC) is a biofilm-mediated, diet modulated, multifactorial, non-communicable, dynamic disease involving cycles of demineralization and remineralisation of dental hard tissues and it is determined by biological, behavioral, and environmental factors [(1)]. The early stages of this process are reversible by modifying or eliminating etiologic factors such as plaque biofilm and diet and increasing protective factors such as fluoride exposure and salivary flow [(23)].

Dental caries is a multifactorial disease known to result from a chronic imbalance between multiple risks and protective factors, therefore; the balance between pathological and protective factors influences the initiation and progression of caries [(24)]. If the protective factors predominate, caries does not develop or are arrested. However, if the pathogenic factors predominate, the disease progresses [(25)].

Dental caries remains to be one of the most common diseases affecting humans [(26)]. Moreover, the most common chronic disease amongst all oral conditions [(27)]. It is the main cause of tooth loss and pain around the world; all individuals are susceptible to this disease throughout their lifetime [(28)]. It was reported by Alsumait *et al* ., 2015 [(29)] that dental caries can occur at any age of an individual's life leaving a negative influence on health-related quality of life, it plays a major role in causing pulpal inflammation and infection.

## 2.2. Prevalence of dental caries

Dental caries is a widely prevalent disease worldwide, its severity and distribution varies across different regions and countries due to differences in behavioral and sociodemographic conditions that interact with the etiology of dental caries [30]. Kassebaum *et al*., 2015 [31] reported in their systematic review that untreated caries in the permanent dentition was the most prevalent disease in people for the past decade, and untreated caries in the deciduous dentition was rated the tenth.

In a systematic analysis for the global burden disease prepared in 2017, which was performed to estimate oral disease affecting 3.5 billion people worldwide, it was reported that caries in permanent teeth was the most common condition as it was found that 2.3 billion people suffer from caries of permanent teeth and more than 530 million children suffer from caries of primary teeth [32].

Ingafou *et al*., 2003 [33] performed a study to estimate the prevalence of caries in 685 preschool children in Benghazi. Their results showed that 58% of the children had dental caries. Which indicated a high prevalence of dental caries among Libyan schoolchildren. Hence, they advised oral health knowledge and education on regular tooth brushing using adequate time should be supported to avoid dental caries among children in schools. Huew *et al* ., 2011 [34] carried out a study to determine the prevalence of DC among Libyan schoolchildren in which data available from this limited epidemiological studies in Libya found that the prevalence of dental caries was 57.8% among 12-year-old schoolchildren in Benghazi .

The World Health Organization (WHO, 2012) [35] reported that 60-90% of children worldwide had dental cavities, which demonstrates that dental caries is still a major health concern.

## 2.3. Etiology of dental caries

Dental caries occur because of the interaction of multiple factors, which are dental plaque community, host, diet, and time factor, which is significant for the beginning, and progress of caries in teeth [36].

### 2.3.1. Main determinants of etiological factors of DC

#### *2.3.1.1. The host*

Kotsanos and Darling 1991 [37] reported that the location, morphology, structure, composition, and post-eruptive age, have great effects on the caries process. Caries susceptibility is high immediately after tooth eruption and it decreases with age due to re-precipitation of minerals which are less soluble than the original minerals that present in the tooth structure and for that resistance of teeth to caries increased with ageing.

Furthermore, Featherstone in 2004 [38] reported that the shape, size and the proximity of crystals in enamel play a key role in caries resistance. The presence of fluoride triggers remineralisation by acting as a catalyst for calcium and phosphate diffusion to form a more stable, and acid-resistant, structure which is called Fluor hydroxyapatite .

Dodds *et al*., 2015 [39] reported in a review of literature that composition and flow rate of the saliva are important factors in reducing dental caries. Saliva plays a significant role in maintaining oral health, helping to build and maintain the health of soft and hard tissues. When saliva flow is reduced, oral health problems such as dental caries and oral infections can develop.

The pH of dental plaque is a key factor in the balance between acid demineralization of the teeth and the remineralisation of the initial caries lesion.

Plaque pH falls each time when acid accumulates in the plaque due to bacterial acid production following the consumption of fermentable carbohydrates mainly sugars in foods and drinks. When the saliva pH or the plaque pH is below a 'critical value' of about 5.5, the saliva or plaque becomes unsaturated with respect to tooth mineral. As a result, tooth enamel can begin to dissolve. However, when the pH is above this value, the saliva and plaque are supersaturated with respect to tooth mineral. The calcium and phosphate ions in saliva then start to repair any damaged mineral crystals in the enamel during the process of remineralisation [40].

Featherstone in 1999 [25] described how fluoride inhibits demineralization process and the role of fluoride when present at the crystal surface at the time of acid attack. If the fluoride is, present in the plaque fluid at the time that the bacteria produces acid, the fluoride will travel with acid into the subsurface of the tooth, bind to the crystal surface and protect it against being dissolved.

#### *2.3.1.2 .Cariogenic microorganism*

Although oral cavity contains a wide variety of bacteria, a few species are believed to be linked to dental caries, such as Streptococcus Mutans (S. Mutans) and Lactobacilli species, which form the bulk of the bacteria present in dental plaque, and play a major role in the initiation and progression of coronal and root caries in both children and adults [41].

According to Selwitz *et al*., 2007 [3] the site in which microorganisms occupied and provided food is called ecological niche. This site protects the biofilm and, if the patient is not able to clean this area, the caries process will progress.

#### *2.3.1.3. Diet*

Sheiham and James 2014 [42] reported in their study that lack of dental hygiene and increase of a sugar consummation are the most important factors associated

with the development of D.C. Jensen, 1999 [43] found that sucrose is the most cariogenic sugar because of the ability of S.Mutants to metabolize sucrose and produce intracellular and intercellular polysaccharides. In addition, sucrose is the source of energy for most cariogenic bacteria. In addition, the mechanical properties of food such as adhesiveness, hardness, cohesiveness and viscosity have a role in the cariogenicity of food.

Sheiham and James 2015 [44] suggested a significant relationship between sugar consumption and caries incidence rates, even with the use of fluoridated drinking water and fluoride-containing toothpastes. Approximately 90% of food sugar or starch allows bacteria in plaque to produce acids in 20 min after intake, leading to loss of minerals in the enamel, and resulting in caries.

The WHO and Food and Drug Interactions, 2015 [45] had initially recommended that sugar consumption should be less than 10% of the total energy intake per day. However, they currently recommend a reduction to less than 5% of the total energy intake per day, which is equivalent to approximately 25 grams (about six teaspoons) of sugar per day for adult.

Bernabe *et al*., 2016 [46] performed a longitudinal study involving adults who participated in at least two of three surveys in Finland exploring the dose-response association between sugar intake and caries. The findings suggested a linear relationship between the two variables, with the amount being more important than the frequency of intake.

In Brazil, Peres *et al*., 2016 [47] carried out an investigation of the effects of sugar-related feeding practices on changes in dental caries from early childhood to young adulthood. Feeding practices were assessed at 4, 15 and 18 years of age. The results showed that high and upward sugar consumers had a higher prevalence rate of dental caries when compared to low sugar consumers. The adjusted analysis presented that the increase in dental caries between ages 6 and 18 years was 20- 66% higher in upward and high sugar consumer groups when

compared to low consumers. Thus, higher sugar consumption throughout the course of one's life translates to a greater increase in the occurrence of dental caries.

#### *2.3.1.4. Time*

Higham, 2012 [48] pointed out that a significant amount of time is needed to develop tooth decay. Due to the slowness of the demineralization process, a significant amount of time is needed for demineralization to lead to the development of white-spot and/or carious lesions. Therefore, prevention is the most indicated source to fight against tooth decay through correct oral hygiene and periodical visits to a dental clinic.

Declerck *et al*., 2008 [49] mentioned that certain oral behaviors such as poor oral hygiene, plaque, and sugar-containing drinks, and improper tooth brushing habits are likely to increase the risk of caries. Von der Fehr *et al* ., 1970 [50] showed that the lack of oral hygiene, during 23 days, associated with a high sugar exposure, produced clinically detectable caries lesions. The reversal of the lesions was also reached when oral hygiene was done associated with daily mouth rinses with fluoride solutions.

## 2.4. Caries Pathogenesis

Dental caries is a dynamic process due to the de- and re-mineralization activities according to pH fluctuations in dental plaque on tooth structure, which may result in loss of mineral, and overtime the cavitation may stop or reverse depending on the physiological balance [51].

Selwitz *et al*., 2007 [3] reported that the balance between pathological and protective factors determines whether the lesion progresses to cavitation, remains the same or arrests. In addition, they reported that demineralization could be reversed by calcium and phosphate in the presence of fluoride, which acts as a catalyst for the diffusion of both minerals forming a new crystalline structure

(fluoridated hydroxyapatite and Fluor apatite) which is much more resistant to acid attacks than the original structure.

Rosier *et al*., 2015 [52] explained the three microbial hypotheses. The first hypothesis called the specific plaque hypothesis, which indicated that only a few species of the total micro flora are actively involved in disease. The second one is the non-specific plaque hypothesis that suggests that caries are the consequence of the overall interaction of all the groups of bacteria within the plaque. Finally, the ecological plaque hypothesis resigned the main points in the previous two hypotheses and suggested that caries is the result of an imbalance in the micro flora due to ecological stress, resulting in a development of certain disease-related microorganisms.

## 2.5. Enamel caries

Enamel forms the anatomical outer layer of the crown of a tooth and it is considered as a highly mineralized structure since it comprises approximately 96% inorganic apatite crystals and 4% organic material and water. These enamel crystals are tightly packed together in alternating parallel pattern forming and bonded together by interprismatic enamel structure [30].

Black, 1932 [53] postulated that the initial site of enamel demineralized showed an increase in the micro porosity under microscopic examination and there were no surface changes on clinical examination at this stage.

According to Robinson *et al*., 2000 [54] enamel showed several distinct zone under microscopic examination which are superficial layer which is an intact zone that remains mineralized until further destruction occurs which results in a cavitation, then the body of the lesion which shows the greatest level of demineralization, followed by dark zone represents 90% of the lesion and finally translucent zone with 1-2% mineral loss. In addition, they reported that these

zones form a cone shape or a triangular pattern with the base towards the tooth surface and the apex towards dentine-enamel junction (DEJ).

## 2.6. Dentin Caries

Dentin is a vital and dynamic tissue that forms throughout life. It is covered in the crown by enamel caps and in the root, it is covered by cementum. Dentin is a brittle and less mineralized, 70% of its weight composed of minerals and 20% of collagen [55].

According to Soamas and Southam 2005 [56], histologically caries in dentin is described in four-zone:

**a) Zone of destruction:** The dentin is necrotic and liquefied. Clinically, this zone is yellow and soft when the caries is active and in the rapid phase. As the progression slows down, it becomes hard brown structure.

**b) Zone of bacterial invasion:** When bacteria invade the tubules, it multiplies and the proteolysis, which becomes softer, and the collagen starts to dissolve by the bacterial acids.

**c) Zone of demineralization:** this result from bacterial acids, but no bacteria is present in this region. Clinically, it is difficult to differentiate between the demineralization zone and the bacterial invasion zone.

**d) Zone of sclerosis:** When the acid starts to penetrate the dentinal tubules, a defense reaction occurs within them. This reaction helps to slow down the progress of the lesion by laying down a calcified material to occlude the tubules, giving the pulp a protection against acid invasion.

On the proximal and buccal surfaces, histologically, the lesion appears as a wedge shaped defect with the base at the enamel surface and the apex at the enamel-dentin junction following the direction of the enamel prisms. The opposite

is seen in the occlusal caries, where the caries lesion becomes wider as it approaches underlying dentin following the direction of the prisms [57].

## 2.7. Pit and Fissure Caries:

De Santé , 2005 [58] described a pit as a small depression on the surface of the tooth whereas fissures are the grooves that naturally occur on all biting surfaces of teeth, which usually presents in occlusal surfaces of posterior teeth and sometimes on the buccal surface of the tooth and at lingual surfaces of anterior teeth .

Beauchamp *et al* ., 2008 [59] reported that anatomical grooves or pits and fissures on occlusal surfaces of permanent molars are more prone to caries development than a smooth surface, which contributed to the morphological complexity of these surfaces that can trap food particles and promote the presence of bacterial biofilm, increasing the risk of developing caries lesions.

Caries in the pits and fissures follows the direction of enamel rods and characteristically forms a triangular or cone-shaped lesion with its apex at the outer surface and its base towards DEJ [60]. According to Nango, 1961 [61], the fissures were described based on the alphabetical description of shape as follows: **(Fig .1)**

- **U-type:** They constitute 14% of fissures and consist of similar width, shallow and wide, tend to be self-cleaning and somewhat caries-resistant and non-invasive technique is recommended.
- **V type:** Wide at the top and gradually narrowing towards the bottom (34%) tends to be self-cleaning, shallow and wide, somewhat caries resistant and non-invasive technique is recommended.
- **I-type:** Extremely narrow slit constitutes (19%). It is deep, narrow and quite constricted resembling a bottleneck, carries susceptible and requires invasive technique.

- **IK- type:** Seen as narrow slit associated with a larger shape at the bottom (26%), requires invasive technique, very susceptible to caries.
- **Inverted Y type:** 5% to 10%

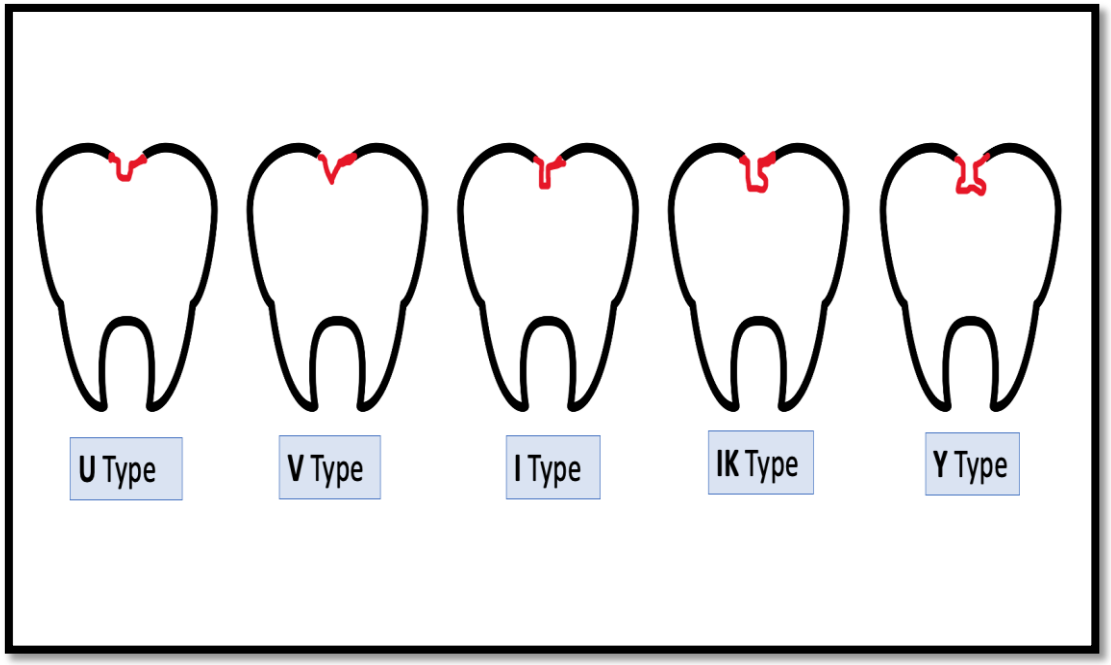



**Figure 1: Relation between the Form of Pit and Fissure and the Primary Lesion of Caries.**

## 2.8. Caries Diagnosis

For diagnose of dental caries, the detecting and finding a caries lesion are not enough, but deciding if the lesion is active, progressing rapidly or slowly, or already arrested are of great significance because without this information, a logical decision about treatment is difficult [(62)]. Kidd *et al*., 1993 [(63)] considered the diagnosis of caries as an integral part of the epidemiologist's role when conducting cross-sectional caries prevalence surveys for planning and evaluation of services provided.

Nyvad, 2004 [(64)] defined the diagnosis of caries as" the art or act of identifying a disease from its signs and symptoms". It is also mentioned that the

identifications of these signs and symptoms are related to the term caries detection.

The diagnosis and detection of caries is important for risk assessment, treatment planning, epidemiological research and clinical trials [65]. There are several methods for caries diagnosis such as visual and visual-tactile examination, radiographic examination and Laser fluorescence devices [66].

## 2.9. Dental Indices

Indices are designed to permit and facilitate comparison with other population and are classified by the same criteria and methods [8]. One important requirement for epidemiological investigation is the ability to quantify the incidence, prevalence, severity and understanding of the disease process, which most commonly relies on index [8].

### 2.9.1. Ideal properties of an Index

Saxer *et al*., 1977 [67] explained that the index should have some properties to give a better and more accurate recording. These properties are:

- **Clarity, simplicity and objectivity:** So the examiner should be able to carry the rules of the index in his mind. Indexes should be easy to apply.
- **Validity:** It should measure what it is planned to measure. It should reflect the clinical stage of the disease.
- **Reliability:** It should be able to measure consistently at different times and under a variety of conditions.
- **Quantifiability:** The index should be amenable to statistical analysis.
- **Sensitivity:** The index should be able to detect reasonably small shifts, in either direction in the condition.
- **Acceptability:** The use of the index should not be painful or demeaning to the subject.

## 2.9.2. Purposes and Uses of an Index:

According to Smith, 2001 [68], the purposes and uses of an index are follows:

- Described for individual patients and in community health. In the case of individual patients, it provides individual assessment to help a patient recognize oral problem.
- Exposes the degree of effectiveness of the present oral hygiene practices, motivates the person in preventive and professional care for the elimination and control of oral disease.
- Evaluates the success of individual and professional treatment over a period by comparing index scores.

## 2.9.3. Historical Background of Dental Caries Indices

A summary of historical background of dental caries indices of dental caries indices is presented in **table 1**.

Bodecker in 1933 [69] described the caries index as sensitive but too complex for use in epidemiological surveys. Bodecker modified caries index later, with addition to counting the surfaces decayed, an extra count was selected for those surfaces that can experience multiple caries attack.

In 1934, Mallanby [70] described the carious lesions depending upon the degree of severity, numerically expressed as Slight caries, Moderate caries, and Advanced caries.

Klein and Palmer in 1938 [9] developed the DMF index. It has been widely used in epidemiological surveys of oral health and considered the key measure of caries experience in dental epidemiology for several decades.

The WHO (1977) [11] recommended this index for measuring and comparing the experience of dental caries in population. It expressed the mean number of

decayed, missing and filled teeth in a group of individuals. This index will be discussed detail in paragraph (2.12.1).

In 1949, Stone [71] introduced Stone's index, this index based on the severity in which each tooth was graded. (**Table 2)**

In 1956, Ponsova and Matena [71] introduced the Czechoslovakian Caries Index to compare experience in one group with that of other groups with a similar population density but living in different environments.

In 1960, Tank and Strovic [71] developed the Caries Severity Index to study the depth and extent of the caries surfaces and the extent of pulpal involvements. (**Table 3)**

Richardson, 1961[72] introduced a Caries susceptibility index, which was based on the number of tooth surfaces at risk and amount of caries developed during the observational period. Each tooth is divided into various surfaces, five posteriors and four for anterior, each surface was examined for caries and filling.

In 1973, Moller and Poulsen [73] developed Moller's index system, which was used in diagnosing, recording and analyzing dental caries in pits and fissures and smooth surfaces.

### *2.10. The criteria of diagnosis for pits and fissures*

- Grade I: area is dark by the incident and transmitted light; the lesion is confined to a small dark line.
- Grade II: in addition to Grade 1, a white zone can be seen along the margins of the fissure, which appears dark in transmitted light.

### *2.11. Buccal and lingual smooth surfaces*

- Grade I: a white opaque spot that keeps its luster after a 3 sec short period of drying.

- Grade II: after being dried, the area appears white and chalky.
- Grade III: There is the smallest perceptible break in the continuity of the enamel.

Nyvad *et al*., 1999 [74] created the caries detection criteria "Nyvad's diagnostic system" that differentiated between active and inactive caries lesions. If the lesion is active and cavitated, operative treatment is recommended and if it is active and non-cavitated, non-operative and preventive treatment is recommended. Limitations of this system were the difficulty to make an exact diagnosis of the precipitated active lesion over the occlusal surface than over the facial surface. This system has been shown to have good reliability and constructive and predictive validity for the assessment of caries activity. (**Table 4)**[75] .

Bratthall, 2000 [76] proposed the Significant Index Caries (SiC) to overcome the limitation of the mean DMFT in the distribution of dental caries in a population. Therefore, using DMF and SiC together helps to highlight oral health variations more accurately among different population groups within the community in order to identify the need for special preventive oral health interventions.

The coordinating committee in 2005 [15] developed an International Caries Detection and Assessment System (ICDAS) for use in clinical practice, research, epidemiology and dental education, which allows calibration of data collection and enables comparability between studies. It also provides clinicians and researchers with diagnostic criteria that show clear stages of the caries process to enable them to decide at which stage of disease (cavitated or non-cavitated), severity and histological depth of the carious lesions depending on surface characteristics. This index will be discussed in detail in paragraph (2.19).

Acharya, 2006 [77] proposed Specific Caries Index with the objective to develop a reproducible index that would provide qualitative and quantitative

information about untreated dental caries in an individual based on clinical examination. The drawbacks of this index are:

- It employs the same caries detection criteria as DMF or DMFS.
- In cases of large lesions, which cover more than one surface, only an assumption can be made regarding the originating lesion;
- The inability of this index if used alone to arrest information useful for treatment planning; and the lack of provision for assessing root cavities. **(Table 5)** [78].

Monse *et al* ., 2010 [78] developed PUFA ( pulp-ulcer-fistula-abscess ) index to overcome DMF failure to provide information on the untreated dental caries such as pulp abscess, which may be more serious than the carious lesions themselves. This index records the advanced stages of untreated carious lesions. It is expressed in uppercase letters (PUFA) when used for permanent dentition and lowercase letters (pufa) when used for primary dentition. The scoring criteria for the PUFA index are illustrated in **Table 6** [79].

Anu *et al*., 2018 [80] reported that this index is simple to use. It can be applied for primary and permanent teeth and the results can be presented alongside with the DMF index. On the other hand, there are certain limitations that appeared after a recent study highlighted a few subjects with score u (ulcer) and assessment of abscess and fistula can be combined into one code. Hence, the reliability and validity of this index need further investigation.

Frencken *et al*., 2011 [81] developed Caries Assessment Spectrum and Treatment (CAST) index because of the need to find a reliable reporting system that is based on the strengths of PUFA and ICDAS indices and provide a link to the widely used DMF index (M and F component). It covers the total dental caries spectrum from no carious lesion, through caries protection (sealant) and restoration to carious lesions in enamel and dentine, and the advanced stages of caries lesion progression in pulpal and tooth surrounding tissue. Some limitations

were on using this; it does not record active and inactive carious lesions. It has not been validated to provide data on treatment or preventive measures required for each code. **(Table 7)**[82].

Among all the previously mentioned indices, DMFT and ICDAS are the most commonly used indices in caries assessment. In this study, we aim to compare those two indices in terms of caries prevalence and severity. Detailed explanation of these two indices will be given in the next paragraphs.

## 2.12. The Decayed, Missing, Filled (DMF) Index

Klein and Palmer in 1938 [9] developed the DMF index, which is used for assessing dental caries. It has been widely used in epidemiological surveys of oral health.

### 2.12.1. The Decayed, Missing, Filled, Tooth Index (DMFT)

DMFT index quantifies dental caries status in terms of the number of decayed teeth with untreated caries lesion (D) and the number of teeth, which have been lost due to caries (M) as well as the number of filled teeth due to caries (F) [83].

Features and calculation of DMFT will be discussed in Material and Method in paragraph (4.4.1.1).

### 2.12.2. Advantages of DMFT index

Mehta, 2012 [12] reported that DMFT is a simple index to use, valid and reliable, and for that, it is still being used for assessment and comparison between caries experience (past & present). Prevalence of an individual and community can also be found out, which gives a broad overview of caries experience in a population over a period.

### 2.12.3. Disadvantages of DMFT Index

Mehta, 2012 [12] also reported that DMFT records only cavitated lesions and ignores incipient carious lesions because it does not account for the consequences of untreated cavitated dentin lesions and does not register carious lesions in enamel. Therefore, for that reason this index provides an underestimation of the prevalence and severity of caries.

### 2.12.4. Major limitations of DMF Index

According to Vijender in 2016 [83], the limitations of DMF index were summarized as following:

- DMF values are not related to the number of teeth at risk.
- It assesses only cavitated lesions extended into dentin.
- DMF index is invalid in the elderly population, as teeth can be lost for reasons other than caries.
- Cannot be used to assess root caries.
- Rate of caries progression cannot be assessed,
- Does not give account for treatment needs.
- DMF index gives equal weight to missing, untreated decayed and well-restored teeth.
- DMF index does not account for sealed teeth since sealants and other cosmetic restorations did not exist in the 1930s when this method was devised.
- There are several limitations on DMFT Values that do not show the number of teeth at risk. DMFT index can overestimate caries experience in teeth in which preventive fillings are made. It gives only little study about root caries. The index associates a disease state with a healthy state by assigning the same score for a decayed tooth as well as for a filled healthy tooth.

**Table 1: a summary of the indices used in caries recording**.

| year | authors | Name of index |
|---|---|---|
| **1938** | Knutson JW, Henry Klein and Carole Palmer | DMFT/DMFS index |
| **1944** | Gruebbel A.O | Def/dmfs index |
| **1949** | Stone H. H, Lawton F. E, Bransby E. R. & Hartley H.O | Stone's index |
| **1956** | Ponsova Novak and Matena | Czechoslovakian Caries Index |
| **1960** | Tank Gertrude and Storvick Clara | Caries severity index |
| **1961** | Richardson A | Caries susceptibility index |
| **1966** | Miller I.J and Poulsen S | Molars index |
| **1983** | Joseph Z and Anaise | Modified DMFT index |
| **1987 ,1997 ,2013** | World Health Organization | WHO modification of DMFT Index |
| **1999** | Nyvad et al | Nyvad's System |
| **2000** | Bratthall D | Significant caries Index (SCI) |
| **2002,2005** | Baltimore, Maryland | International Caries Detection and Assessment System (ICDAS) |
| **2006** | Acharya S | Specific Caries Index |
| **2010** | Monse et al | Pulpal Ulceration, Fistula, Abscess Index (PUFA) |
| **2011** | Frencken JE | Caries Assessment and Treatment Instrument (CAST) |

**Table 2: Stone`s index criteria**.

| score | criteria |
|---|---|
| **1** | One or more cavities in the same tooth present in enamel only |
| **2** | One or more cavities in the same tooth extend into dentin |
| **3** | Over 1/4th of the crown is involved |

**Table 3: Caries severity index criteria.**

| SCORE | CRITERIA |
|---|---|
| **1** | Superficial (caries in enamel) |
| **2** | Moderate (caries in enamel and superficial dentine) |
| **3** | Moderately severe (enamel undermined) |
| **4** | Severe (approaching pulp, enamel, collapsed) |
| **5** | Pulpitis (caused either by deep-seated caries or by trauma without caries) |
| **6** | Death of pulp (caused either by deep-seated caries or by trauma without caries) |
| **7** | Periapical infection (caused either by deep-seated caries or by trauma without caries) |

**Table 4: Description of the diagnostic criteria used by Nyvad et al (1999)** [75]

| Score | Category | Criteria |
|---|---|---|
| **0** | Sound | • Normal enamel translucency and texture |
| **1** | Active caries (intact surface) | • The surface of enamel is whitish, intact fissure, lesion extending along the walls of the fissure.<br>• No clinically detectable loss of substance. |
| **2** | Active caries (surface discontinuity) | • Localized surface defect in enamel only.<br>• No undermined enamel or softened floor detectable with the explorer. |
| **3** | Active caries (cavity) | • Enamel/dentin cavity is detectable<br>• There may or may not be pulpal involvement. |
| **4** | Inactive caries (intact surface) | • Surface of enamel is hard and smooth.<br>• No clinically detectable loss of substance. |
| **5** | Inactive caries (surface discontinuity) | • Localized surface defect in enamel only.<br>• No undermined enamel or softened floor detectable with explorer. |
| **6** | Inactive caries (cavity) | • Enamel/dentin cavity is detectable<br>• No pulpal involvement. |
| **7** | Filling(sound surface) | |
| **8** | Filling+active caries | • Caries lesion may be cavitated or non-cavitated. |
| **9** | Filling+inactive caries | • Caries lesion may be cavitated or non-cavitated |

**Table 5: The specific caries index and criteria Score [78].**

| Score | criteria |
|---|---|
| **0** | Non carious lesion detected |
| **1** | Carious lesion occurring on the occlusal, buccal pits and fissures of molars and premolars and the lingual pits of the anterior teeth |
| **2** | Proximal caries affecting the molars and premolars |
| **3** | Carious lesion situated on the proximal surface of the anterior teeth and not involving the incisal angle |
| **4** | Carious lesion situated on the proximal surface of the anterior teeth, involving the incisal angle |
| **5** | Carious lesion situated on the cervical region of the tooth |
| **6** | Carious lesion situated on the occlusal cusp tips of molars and premolars and on the incisal edges of incisors |
| **6A** | Grossly decayed tooth /root stumps indicated for extraction |

**Table 6: PUFA criteria [79].**

| CODE | CRITERIA |
|---|---|
| **P/p** | • Pulpal involvement is recorded when the coronal tooth structure has been destroyed<br>• No probing is performed to diagnose pulp involvement |
| **U/u** | • Ulceration due to trauma from sharp pieces of tooth is recorded. |
| **F/f** | • Fistula is scored when the pus releasing sinus tract related to a tooth with pulpal involvement is present |
| **A/a** | • Abscess is scored when a pus containing swelling related to a tooth with pulpal involvement is present |

**Table 7: CAST codes and description** [82].

| Characteristics | Code | Description |
|---|---|---|
| **Sound** | 0 | No visible evidence of a distinct carious lesion |
| **Sealed** | 1 | Pit and / or fissures are at least partially sealed with a sealant material |
| **Restored** | 2 | A cavity is restored with a (in) direct restorative material |
| **Enamel** | 3 | Distinct visual change in enamel only. A clear caries is without localized enamel breakdown visible with or |
| **Dentin** | 4 | Internal caries related discoloration in dentin |
| | 5 | Distinct cavitation into dentin. The pulp chamber is intact |
| **Pulp** | 6 | Involvement of pulp chamber |
| **Abscess /fistula** | 7 | A pus containing swelling or a pus releasing sinus tract with pulpal involvement related to a tooth |
| **Lost** | 8 | The tooth has been removed due to dental caries |
| **Other** | 9 | Does not correspond to any of the other categories |

## 2.12.5. Validity of DMFT index

Becker *et al*., 2007 [84] conducted a study to evaluate how much the DMFT index underestimates the need for restorative care. A dental screening was based on clinical examination and bilateral bitewing radiographs to 376 people. DMFT index was calculated with and without radiographs to compare DMFT scores. The average DMFT was 1.42 higher with radiographs than without (6.35 vs. 4.93, respectively), and the D component was 1.75 higher. The Pearson correlation between DMFT indices was 0.899 ($p<0.0001$) and 0.759 between the D components ($p<0.0001$). Between the M component 1 ($p<0.0001$) and between the F component 0.953 ($p<0.0001$). The findings indicated that assessing treatment needed for a population based only on DMFT screening was inadequate and incomplete without radiographs.

Silva *et al*., 2014 [85] conducted a study to estimate the prevalence of dental caries based on clinical examinations and self-reports as they compared differences in the prevalence and effect measures between the two methods among 18-yrs old (n = 4041). The prevalence of clinical and self-reported caries was 66.5% and 60.3%. Self-reports underestimated the prevalence of dental caries by 9.3% in comparison to clinical evaluations. This study concluded that self-reported information on dental caries using the DMFT index requires further studies prior to its use in the analysis of risk factors, but it is valid for population-based health surveys. All mean values of the DMFT components demonstrated the underestimation of self-reported information in comparison to the clinical evaluation.

Silveira *et al*., 2016 [86] carried out a study to verify the validity of two simplified DMFT indices compared to the full DMFT. This study was done with a sample of 88 adult. The average total DMFT was compared with crossed quadrants and DMF of the right and left sides by age and sex. The analysis showed no statistically significant difference between the right and left sides between indexes. In view of that, it was concluded that the data obtained were consistent

with similar studies on the distribution of dental caries in quadrants, allowing simplifying the DMFT index for epidemiological estimates.

Pontigo *et al*., 2020 [87] presented a study to analyze whether a correlation exists between the caries status (DMFT Index) of the first permanent molars (FPMs) and that of the full permanent dentition of Mexican adolescents in a cross-sectional study of 1538 adolescents from 12 to 15 years old and to propose its use in large epidemiological studies of dental caries. After examination, they found that 56.8% of the sample of adolescents had no caries in their 4 FPMs whereas 4.9% experienced caries in all. The underestimation of caries prevalence (DMFT > 0) was 5.4% (48.6% vs 43.2%), while the DMFT Index was underestimated at 0.34 (1.15 vs 0.81). The authors concluded from the study that the decision to use DMFT Index protocol could serve to evaluate the benefits of reduced effort for data collection in the face of the possible loss of data. Therefore, because of its simplicity this evidence is useful when conducting large epidemiological studies.

## 2.13. Decayed missing filled surface index (DMFS)

When the DMF index is employed to assess the individual surface of each tooth rather than the tooth as a whole is termed as (DMFS index). Each tooth was recorded as four surfaces for anterior teeth and five surfaces for posterior teeth (10).

### 2.13.1. Calculating DMFS

According to WHO (2013) [10], the Calculation of DMFS is as follows:

1. Individual DMFS Index: DMFS score

Total number of decayed surfaces = D

Total number of missing surfaces =M

Total number of filled surfaces =F

2. Total surface count for a DMFS Index = D+M+F

When the index is applied only to tooth surfaces (five per posterior tooth and four per anterior tooth), it is called the DMFS index, and scores per individual can range from 0 to 128 or 148, depending on whether the third molars are included in the scoring.

If 28 teeth are examined (third molars are excluded)

16 posterior teeth (16×5) =80 surfaces and 12 anterior teeth (12×4) =48 surface. Total = 128.

If third molars are included: (4×5) =20 surfaces .Total = 148 surfaces

## 2.14. DMF in primary dentition

Gruebbel, 1944 [72] introduced the dmf index as an equivalent index to DMF for measuring dental caries in the primary dentition.

d – Indicates the number of deciduous teeth decayed.

m – Indicates deciduous teeth extracted due to caries

f – Indicates restored teeth without recurrent decay.

## 2.15. Calculating dmft and dmfs

The rules for recording d, m, and f are the same as for DMFT. The total count is 20 teeth. For dmfs, the teeth are not counted the same as for dmft. As with DMFS, there are five surfaces on the posterior teeth and four surfaces on the anterior teeth. The total count is 88 surfaces.

Total def =d+e+f

Total def = ds+es+fs (decayed surface +extracted surface +filled surface) [72].

Anaise, 1983 [88] developed a modified DMFT index involving the same operational procedures as the common DMFT index. The only difference is in the scoring criteria for (D) component of index, which is divided into 4 separate categories as follows: -

• C = Unfilled teeth that are carious

• CF = Teeth that are carious around the margins of restorations or primarily on a tooth surface other than restored one.

• IX - Carious teeth either filled or unfilled that in the examiners opinion are indicated for extraction

• IRC - Carious teeth either filled or unfilled that in the examiners opinion are indicated for pulp treatment or RCT.

### *2.16. Advantages of a modified DMFT index* [88]

1. The index remains simple and provides description of previous dental experience.

2. It further shows the extent of dental services needed by the population, which can be interpreted in terms of treatment hours and costs.

3. In addition to these four categories, the remaining two categories of DMFT index (F- filled teeth with no decay and M- Missing teeth) are recorded as usual according to the WHO criteria.

4. The DMFT score includes the summation of all six categories and the calculation of the individual components as well as sum remains essentially the same as the original DMFT index.

## 2.17. WHO modification of DMF Index (1986)

- It is postulated that: All third molars are included.

- Temporary restorations are considered as decayed
- Only, carious cavities are considered as ‘D', the initial lesions (Chalky spots. stained fissures, etc.) are not considered as ‘D'.
- Data presented include the percentage of the sample affected, the decayed, missing, filled teeth (DMFT) index and, if available, its decayed teeth (DT), missing teeth (MT) and filled teeth (FT) components [89].

### 2.17.1. WHO Modification of DMF Index (1997)

- The WHO probe should be used to confirm visual evidence of caries.
- Individuals 30 years and older, M component should include teeth missing due to caries and any other reason.
- More than 30 years M component includes missing due to caries only [90].

## 2.18. WHO modification of DMF Index (2013) [10]

This modification will be discussed on Material and Method in paragraph (4.4.1.1).

## 2.19. International Caries Detection and Assessment System (ICDAS)

Banting *et al*., 2005 [15] in the coordinating committee, an international system for caries detection was developed to allow a comparison of data collected in different locations as well as at different points of time. The ICDAS system was developed to bring forward the current understanding of the process of initiation and progression of dental caries to the fields of epidemiological and clinical research.

Ismail *et al* ., 2007 [16] considered ICDAS as a clinical visual scoring system, which provides clinicians and researchers with diagnostic criteria that show clear stages of the caries process to enable them to decide at which stage of disease (cavitated or non-cavitated), severity and histological depth of the carious lesions

depending on surface characteristics. The examination must be carried out in the presence of compressed air to detect the earliest signs of caries. Teeth should first be cleaned before examination with a ball-ended explorer to remove any remaining plaque. The use of sharp explorers for caries diagnosis has been stopped, as its effect can be harmful and damaging to teeth [91].

### 2.19.1. Development of ICDAS

During the first workshop for the development of ICDAS criteria, all participants examined 57 occlusal surfaces of extracted teeth. The clinical status of these surfaces was defined from a consensus of all participants, and then teeth were sectioned and examined under 10-x magnification for histological scoring. The histological validation showed that the percentage of tooth surfaces scored with ICDAS code 3 which had caries extending into dentin (88%) was higher than that for tooth surfaces with score 4 which was (77%) [15] **(Table 8)**. Therefore, the decision of the ICDAS II workshop to switch the original code 3 and 4 of ICDAS I was taken in Baltimore, USA in 2005. The change represents a more accurate sequence of caries progression [15]. Since that time, there has been no further change in codes of ICDAS; therefore, the suffix II has been dropped from the name [92].

### 2.19.2. ICDAS Criteria

According to Coordinating Committee 2005 [21], the system classifies stages of the caries process based on histological extent and activity to seven stages from sound to extensive distinct cavity with visible dentin, which are differentiated, based on the visual appearance of the tooth surface. The recording of dental caries using the ICDAS system is a two-stage process. The code consists of two digits, the first digit is the restorative status of the tooth and the second digit is for the caries severity [21]. Tables of ICDAS codes for restoration and caries severity will be illustrated in Material and Method in paragraph (4.4.2.1).

There are minor variations between the visual signs associated with each code depending on a number of factors. Therefore, a full description of each of the codes is given under the headings of Pits and fissures, smooth surface (mesial or distal), free smooth surfaces and caries associated with restorations and sealants (CARS) [21]. In this study, only the first code description on pits and fissures to detect and record caries was investigated. This table will be illustrated in Material and Method in paragraph (4.4.2.1). **(Table 11)**

**Table 8 :Percentage of tooth surfaces with caries extending into dentine in all codes of ICDAS criteria adapted from ICDAS II criteria manual (2005)** [15]

| Code | Number of teeth | Percentage into dentin (%) |
|---|---|---|
| **0** | 2 | 0 |
| **1** | 11 | 9 |
| **2** | 18 | 50 |
| **3** | 8 | 88 |
| **4** | 13 | 77 |
| **5+6** | 5 | 100 |
| **Total** | 57 | |

## 2.19.3. The validity of ICDAS of visual examination:

Jablonski *et al*., 2008 [93] conducted an in-vitro study to assess the reproducibility and accuracy of the ICADS II criteria for the detection of occlusal caries. Four examiners examined the occlusal surfaces of 100 permanent teeth. The examination was repeated three weeks later for intra-examiner reproducibility. The weighted Kappa values for inter- and intra-examiner reproducibility were 0.62 and 0.83 respectively. The results of this study confirm the reproducibility and accuracy of the ICDAS II system for diagnosis of dental caries at different stages. It can therefore be concluded that the ICDAS II system provides the current optimum methodology for visual caries diagnosis in both the primary and permanent dentitions.

Shoaib *et al*., 2009 [94] conducted an in-vitro study to assess the validity and reproducibility of the ICDAS II in the detection and assessment of the proximal and occlusal caries of 121 extracted primary molars, the intra-examiner reproducibility ranged from 0.74 to 0.84 for both occlusal and proximal surfaces. The inter-examiner reproducibility ranged from 0.66 for proximal, the researchers concluded from this study that the ICDAS II criteria for diagnosis are appropriate when applied to primary teeth for the diagnosis of both proximal and occlusal caries.

Diniz *et al*., 2009 [95] conducted a study to show the good inter- and intra-examiner reproducibility and the accuracy of ICDAS II in detecting occlusal caries, especially in the outer half of the enamel by using 163 molars that were assessed twice by two examiners using the ICDAS II scoring. Unweight kappa coefficient was used to assess inter- and intra-examiner reproducibility. The inter- and intra-examiner kappa values were 0.51 and 0.58 respectively and it was concluded that ICDAS II presented good reproducibility and accuracy in detecting occlusal caries.

Nelson *et al*., 2011 [96] presented a study to examine dental examiners' one-year consistency in utilizing the ICDAS criteria after baseline training and calibration. Three examiners received training, and one-year later re-calibration was conducted, subjects aged 8-16 years, and for the re-calibration subjects aged five to six years were employed for the study. The ICDAS criteria were used to classify visual caries lesion severity (0-6 scale), lesion activity (active/inactive), and presence of filling material (0-9 scale) of all available tooth surfaces of permanent and primary teeth. The examination used a clinical light, mirror and air syringe. Kappa statistics were used to determine inter-and intra-examiner reliability at baseline and re-calibration. Activity kappa was in the poor to good range. All examiners improved with time. In conclusion, the baseline training/calibration in ICDAS was critical to maintain the stability of the examiners reliability over a one-year period. The ICDAS can be an effective assessment tool for community-based clinical trials.

Pit and fissure caries present diagnostic challenges due to its anatomical complexity. ICDAS II is a coding system for caries detection using clinical visual inspection. Sathyanarayanan *et al* ., 2017 [97] conducted this study to compare the reliability and validity of ICDAS II in detection of occlusal caries, with and without magnification, this study included 334 unrestored extracted human premolars and molars. Two examiners independently scored pit and fissure caries status using ICDAS II criteria without magnification and later under 6 x magnification using surgical microscope. The kappa values for Inter examiner reproducibility of visual and enhanced visual examination under microscope were 0.638-0.694, and intra examiner reproducibility for visual and enhanced visual examination was 0.665 – 0.594. Therefore, it was concluded that ICDAS II is a reliable, reproducible and valid diagnostic aid even without magnification.

Braun *et al*., 2017 [98] carried out a study to compare the ICDAS scores and radiological evaluated caries depths to the histologically evaluated carious lesions in 48 extracted permanent teeth. Visual examination and scoring of the occlusal

aspect were performed according to the ICDAS II criteria followed by bucco-lingual digital X-ray images of the teeth. In assessing ICDAS II scores and histological findings, a rank correlation coefficient of r = 0.890 was found. ICDAS II/radiology and histology/radiology showed correlation coefficients of r = 0.658 and 0.661.The present study indicated an acceptable validity of the ICDAS II criteria when applied to permanent teeth. Dentin lesions can be reliably detected. Thus, ICDAS assessment provides the possibility of reducing X-ray exposure for caries detection.

Limly *et al.*, 2019 [(99)] displayed a study to assess the inter-examiner reproducibility in the detection of occlusal caries using ICDAS by Unaided Visual and Enhanced Visual Examination. This observational study was in vivo study in Indira Institute of Dental Sciences. The study was done on 80 occlusal surfaces of unrestored and non-cavitated caries on molars of patients with aged between 18-30 were categorized based on ICDAS code. Fractured tooth, developmental deformities, tooth with pits and fissure sealant, enamel hypoplasia were excluded from the study. Two primary examiners and other four examiners independently scored occlusal caries status using ICDAS criteria without magnification and under 3x magnification using operating microscope. Kappa statistics was performed. In the current study, the inter examiner agreement was good to fair and had acceptable reproducibility with or without magnification using ICDAS criteria. Therefore, it was concluded that ICDAS is a reliable, reproducible and valid diagnostic aid.

## 2.19.4. Comparison of dental caries by DMFT and ICDAS systems

In Brazil, Braga *et al.*, 2009 [(100)] evaluated the feasibility of using ICDAS-II in epidemiological surveys and compared it with WHO criteria. Two examiners using ICDAS-II or WHO criteria examined each two hundred and fifty-two children (36–59 months old). Dmf-t, dmf-s, caries prevalence and examination time were calculated using both systems. The study concluded that examination

by ICDAS-II took twice as long as by WHO criteria. On the other hand, they found that ICDAS-II, besides providing information on non-cavitated caries lesions, could generate data comparable to previous surveys that used WHO criteria.

Banava *et al*., 2012 [101] evaluated the caries status recorded with ICDAS and compared it with DMFT index, as a common method. The sample size was 110 dental students that were selected randomly and examined for caries. All teeth surfaces were cleaned with a brush, rubber cup and prophylaxis paste and then rinsed. Dental examination was performed using a clean dental mirror, a WHO probe and under adequate light conditions by two calibrated examiners according to the DMFT system and ICDAS. The authors found that ICDAS provided more accurate information than DMF for the investigators and epidemiologists. The DMFT number did not show any details about the dental status of the cases.

Souza *et al*., 2015 [102] described the caries situation in a group of children, in mixed dentition phase, using ICDAS classification. In addition, they compared between ICDAS and dmf/DMFT in 50 participants of a social program, from 7 to 11 years old. All dental surfaces were examined receiving a two-digit code. The first code refers to the presence of restoration/sealant while the second one denoted the severity of carious lesions. The coefficient intra-examiner agreement was 0, 83. Caries prevalence was considered high because 100% of the children had some surface with non-cavitated caries lesions. They reported that ICDAS could be easily transformed to dmf-s or DMF-S without compromising its integrity to allow comparisons between both indexes. For dmf-s/DMF-S decayed surfaces were considered ICDAS codes 3 to 6, resulting in a dmf-s = 6, 57 where 11 children (27, 5%) presented no decayed deciduous teeth surface. DMF-S = 2, 0 showed that 15 children (37, 5%) had none decayed permanent surface, determining an underestimation of the caries disease when using dmf-d/dmf-s and DMF-S indexes. The study reported that ICDAS identified a high prevalence of non-cavitated lesions in the sample. The index applied after adjusted to dmf or

DMFT showed that the dmf and DMFT indexes underestimated the tooth decay disease in the studied population. ICDAS appeared as a flexible and easy index, but of delicate use, requiring a short training period.

Melgar *et al*., 2016 [103] conducted a study to describe and compare findings regarding the prevalence and severity of dental caries when using ICDAS and DMFT/dmft in an epidemiological study. This cross-sectional study evaluated 150 preschoolers and their mothers. Data was collected with ICDAS and then transformed into DMFT/dmft. Prevalence of caries and its severity with ICDAS were 92%, 84% and 31.3% in children and 97.3%, 96.6% and 80% in adults. It was observed that the DMFT/dmft index would underestimate 60% of non-cavitated lesions in children and 16.6% in adults. The results from this study showed that one should evaluate the purpose of the study in the adult population and the cost-effectiveness of using a more time-consuming method, like ICDAS, whether it is important to estimate the lesions at an earlier stage. Moreover, the DMF-T index underestimates the presence of the disease in children evaluated as it ignored the most prevalent clinical presentation of caries found in the studied sample, especially non-cavitated lesions.

Castro *et al*., 2018[14] conducted a study in Brazil to compare between the DMF index and ICDAS to provide information to guide future method choices. They compared the mean application time of each method and the frequencies obtained by each method using the following indicators: the most severe caries lesion per individual; the mean number of missing, filled and decayed teeth. The mean time taken to apply the DMF was 3.8 min, for ICDAS it took 8.9 min. When calculating the indicator the most severe caries lesion per individual, the prevalence rates were as follows: 28.1% for DMF, 84.0% for ICDAS. The mean numbers of D, M and F teeth were 6.0 according to the DMF, 6.2 according to ICDAS. The study concluded that the DMF underestimated the occurrence of caries lesions in individuals but was the fastest method to apply. ICDAS obtained

detailed information regarding lesion severity, but it was a time-consuming method and difficult to analyses.

Taqi *et al* ., 2019 [104] conducted a study to determine Caries status of children aged 11-12 years at five government and two private schools in Pakistan. WHO standards and the modified ICDAS methods were used to determine the dental caries status of each subject. The intra-examiner reliability of 0.88 indicates a substantial agreement for the WHO method. The inter-examiner kappa value achieved by the trainee was 0.69 and 0.82, indicating substantial agreement for the modified ICDAS. Results of the two methods were compared. The study found that there was no statistically significant difference in values of the DMFS / DMFT index as well as the prevalence of dental caries between two methods ($p>0.05$ each). Intra-examiner reproducibility was higher with the WHO method compared to the other index used ($p<0.05$). The authors found that ICDAS could be used in future epidemiological investigations as it records carious lesions at an earlier stage and provides relevant information to plan appropriate prevention: However, prolonged examination time could limit its use in field surveys. They also found that the WHO method only recorded obvious caries lesions and did not provide additional information regarding the state and stages of caries.

Nedoklan *et al*., 2020 [105] conducted a study to compare dental caries frequency in the Croatian population through two periods and compare two methods: ICDAS and DMFT index. The study included 279 teeth from 69 human remains: Set I of 30 remains and 126 teeth dated from 9th to10th centuries A.D. In addition, Set II of 39 remains and 153 teeth from the 20th century. Methods used for caries prevalence were ICDAS and DMFT. ICDAS scoring system showed significantly higher caries frequency in Set I of 64.34% and in Set II 59.47%, compared to DMFT method with 16.52% for Set I and 28.75% for Set II. The results showed that the use of ICDAS system provides detection of very small carious lesions, while early stages of caries cannot be observed with the DMFT method. The ICDAS system has a more precise and advanced approach for caries lesions.

Houchaimi *et al*., 2020 [106] presented a study that compared ICDAS and DMFT/S in the evaluation of Carrie's status of the first permanent molar in 200 children aged 7 to 13 years. Participants were selected from two private schools in Lebanon. Two trained and calibrated examiners using a dental mirror and a WHO probe performed the examinations. The number of decayed (D), missing (M) and filled (F) teeth was recorded in DMFT/S form, and the numbers related to D, M and F were then added to record the DMFT/S value. In the ICDAS, the assessment of caries associated with restorations and sealant was recorded. The average age of the participants was 9.21 ± 1.927 (7 to13 years old). No significant difference was found between the mean time to score DMFT, and ICDAS indices (p value > 0.05). The prevalence of caries with DMFS was 54%. However, the prevalence of caries with ICDAS II was 77.5%. The study concluded that the DMF index is an international easy system that shows the carious history of teeth. However, the ICDAS assesses the different stages of caries and describes the restorative status of the tooth, promoting new preventive approaches and curative needs.

Vinícius *et al*., 2020 [107] demonstrated a study that compared the epidemiological indices approved by the WHO in oral health for dental caries. Caries disease was evaluated by the ICDAS and DMFT indices; the diagnostic results of these indices were then compared by means of percentages descriptive analysis. In this cross-sectional observational epidemiological study, preschoolers (5 to-6-year-olds), schoolchildren (7 to 12-year-olds) and adolescents (13 to 17-year-olds) in all age groups studied; there was a high prevalence of caries, where the number of white spot lesions was higher than that of dentin caries, according to the ICDAS code. The DMFT index presented worse results than the ICDAS, as the former did not consider white spot lesions or enamel cavitation. The DMFT only provides a number, which shows those teeth that have carious lesions, therefore The DMFT index underestimates lesions that do not require any invasive treatment, and it contributes to variations within a population and even in the

individual. Whereas, the ICDAS criteria allows for the detection of the disease in its initial stages were ranging from the identification of a white spot to the visible cavity in dentin The comparison of the results of the DMFT and ICDAS in this study indicated that the ICDAS is more accurate in describing the prevalence of caries in studies. Furthermore, the ICDAS allows for the planning of preventive treatment, interception or monitoring of carious lesions at individual and population levels.

# 3. Aims and objectives Chapter 3

## 3.1. Aim

The overall aim of this study is to compare between Decayed, Missed and Filled teeth (DMFT) index and International Caries Diagnosis and Assessment System (ICDAS) index.

## 3.2. Objectives

The specific objectives of this study are as follows:

**a)** To assess the prevalence of dental caries in some dental students in Benghazi city.

**b)** To assess the severity of dental caries in some dental students in Benghazi city.

**c)** To assess the caries index according to the age of some dental students in Benghazi city.

# 4. Materials and Methods Chapter 4

## 4.1. Study design

A descriptive cross-sectional study was carried out to compare between the Decayed, Missed and Filled teeth (DMFT) index and International Caries Diagnosis and Assessment System (ICDAS) index in recording dental caries among a group of dental students attending the Faculty of Dentistry, University of Benghazi, Libya during the period from the1st of November 2019 to the 10 of March 2020. A flow chart summarizing the main stages of the study design is illustrated in **(Fig .2)**.

## 4.2. Ethical aspects

The study was conducted within the school of clinical dentistry. Dental students were included and examined after being properly informed about the study verbally and in writing information sheet ***(Appendix1)***. Written a consent was obtained from all participants ***(Appendix 2).*** The study was approved by the Research Ethics Board of the Faculty of Dentistry of the University of Benghazi on Libya under Approval number 017 from date 28/5/2019 ***.(Appendix 3 )***

## 4.3. Recruitment

### 4.3.1. Target population

The chief investigator assessed dental students aged 19-27 years, who attended the Faculty of Dentistry. The project was explained to all participants. If they met the inclusion criteria, they were invited to participate in the study. Study information sheets, along with consent forms were provided. Teeth were examined and dental status were recorded using two caries measurement methods (DMFT) and (ICDAS) index.

The inclusion and exclusion criteria are:

#### *4.3.1.1. Inclusion criteria*

- Participants who are dental students.
- Participants aged 19-27 years of age at recruitment.
- Participants who signed the consent form and welling to join the study.

#### *4.3.1.2. Exclusion criteria*

- Participants who have difficulty opening their mouth for examination i.e. trismus, dental pain or dental infection or swelling.
- Participants who have retained primary teeth or and supernumerary teeth as it measured by ICDAS and not calculated on DMFT.

#### *4.3.1.3. The reasons for selecting dental students as a target population are:*

- Dental students are easier to reach as they receive their dental education and dental training in the faculty of dentistry.
- Dental students are educated and more likely to understand the nature of the study where they accept to be examined without requesting subsequent dental treatment.

## 4.4. Sample size

A minimum sample size of 441 participants was required to detect a minimum effect size of 0.2 at 95% confidence level and 80% power of paired test. The sample size was increased to 500 to accommodate any potential missing data. A convenient sample of 500 dental students were selected and evaluated in the descriptive cross-sectional study in which two caries measurement methods (DMFT) and (ICDAS) index were applied in the same group.

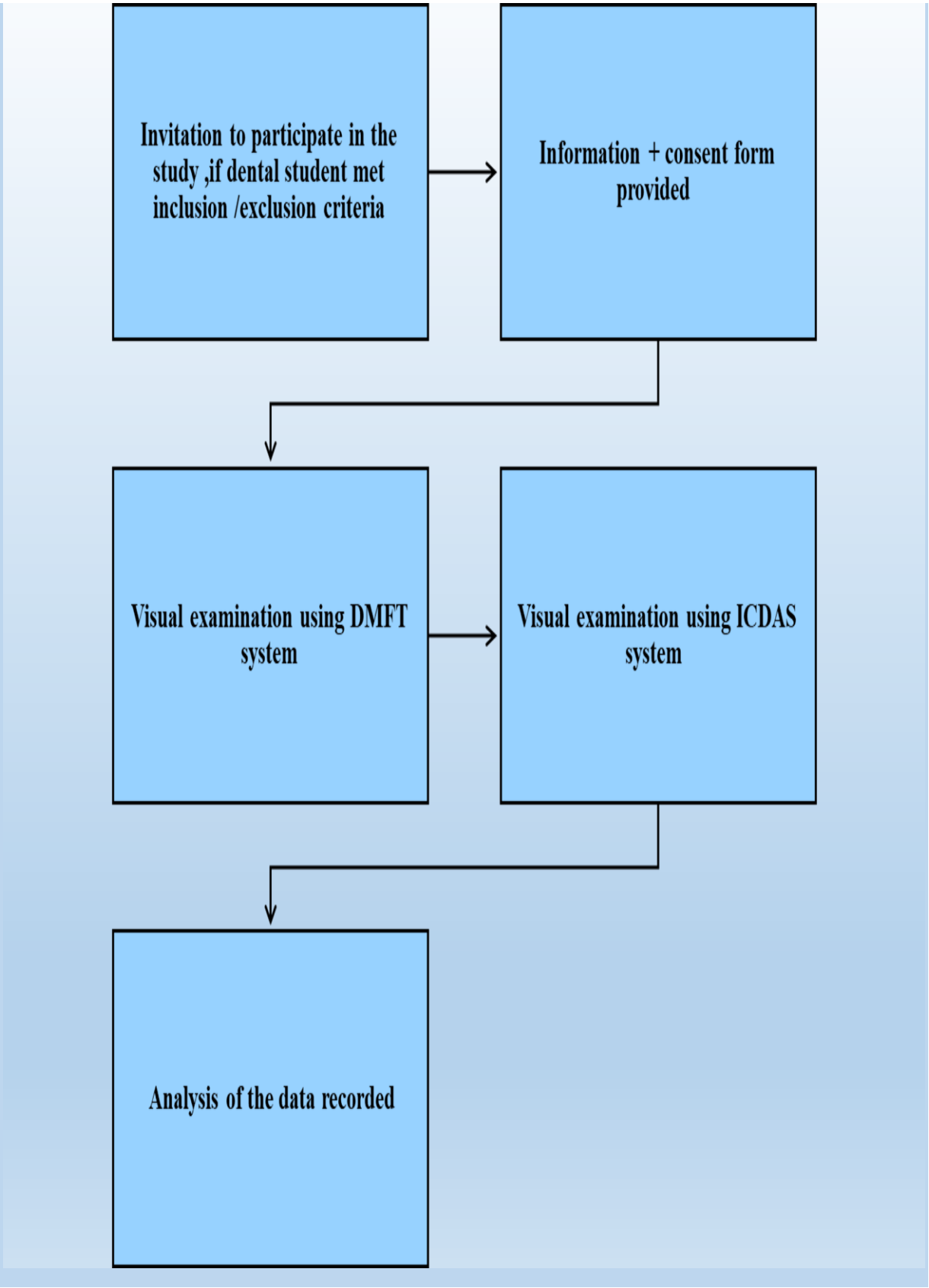



**Figure 2: Flow chart illustrates the summary of methodology**

### 4.4.1. Examination method

The aim of this study was to compare between Decayed, Missed and Filled Teeth (DMFT) index and International Caries Diagnosis and Assessment System (ICDAS) index in recording dental caries.

#### 4.4.1.1. DMFT [10]

DMFT index quantifies dental caries status in terms of the number of decayed teeth with untreated caries lesion (D) and the number of teeth, which have been lost due to caries (M) as well as the number of filled teeth due to caries (F). Teeth were recorded as decayed (D) only if a cavity with detectably softened floor, undermined enamel, or a softened wall was detected; all caries stages that precede cavitation were considered sound. In this index, teeth that were not included were: unerupted, congenitally missing, supernumerary, teeth removed for reasons other than dental caries, and primary teeth retained in the permanent dentition.

- When a carious lesion(s) or both carious lesion(s) and a restoration are present, the tooth is recorded as a D.
- When a tooth has been extracted due to caries, it is recorded as an M.
- When temporary filling is present, the tooth is recorded as a D, or when a filling is defective but not decayed, this is counted as an F.
- Teeth restored for reasons other than caries are not counted as an F.
- The basis for DMFT calculations is 32 teeth, i.e. all permanent teeth including wisdom teeth.

The Calculation of DMFT is as follows [10]:

1. Individual DMFT value = D + M + F

   D = Decayed teeth.

   M = Missing teeth.

   F = Filling teeth.

2. For population Mean DMF = $\frac{\text{Total DMF}}{\text{Total No. of the subjects examined.}}$

***According to WHO (2013) in order to calculate DMFT, the criteria for diagnosing a tooth status and the coding are as follows*** [10]:

(0): Sound crown. Which shows no evidence of treated or untreated clinical caries.

(1): Carious crown. Caries is recorded as present when a lesion in a pit or fissure, or on a smooth tooth surface, has an unmistakable cavity, undermined enamel, or a detectably softened floor or wall.

(2): Filled crown, with caries. A crown is considered filled, with decay, when it has one or more permanent restorations and one or more areas that are decayed.

(3): Filled crown, without caries.

(4): Missing tooth, due to caries.

(5): Missing due to any other reason. This code is used for permanent teeth deemed absent congenitally, or extracted for orthodontic reasons or because of periodontal disease, trauma, etc.

Calculation of DMFT can be derived directly from the previous codes. The D component includes all teeth with codes 1 or 2. The M component comprises teeth coded 4 in subjects under 30 years of age, the F component includes teeth only with code 3. Illustrate the codes and the related DMFT value in **(Table 9).**

## 4.4.1.2. ICDAS

The recording of dental caries using the ICDAS system is a two-stage process. The code consists of two digits, the first digit is the restorative status of the tooth **(Table 10)** and the second digit is for the caries severity **(Table 11).**

There are slight differences between the visual signs related with each code depending on a number of factors. Therefore, a full explanation of each of the codes is given under the headings of pits and fissures, smooth surface (mesial or distal), free smooth surfaces and caries associated with restorations and sealants (CARS) [22]. In this study, the first code description on pits and fissures to detect and record caries was used**. (Table12)**

The anatomical grooves, or pits and fissures on occlusal surfaces of permanent molars are more prone to caries development than smooth surface, which contributed to the morphological complexity of these surfaces that can trap food particles and promote the presence of bacterial biofilm, increasing the risk of developing caries lesions [59]. This is why this study focused on recording ICDAS on pits and fissure on occlusal and lingual surfaces. Furthermore, in order to record smooth surface caries and proximal caries, radiographic x-ray is required, therefore to a void x-ray exposure to participants and chief investigator. Therefore, recording smooth surface caries were excluded in this study.

**Table 9: Illustrate the codes and the related DMFT value [10].**

| **DMFT value** | **Crown** | **Condition/status** |
|---|---|---|
| | 0 | Sound |
| **D** | 1 | caries |
| **D** | 2 | Filled, with caries |
| **F** | 3 | Filled, no caries |
| **M** | 4 | Missing due to caries |

## Table 10: ICDAS codes for restoration status [21]

| Code | Description |
|---|---|
| **0** | Un-restored and unsealed |
| **1** | Partial sealant (a sealant which does not cover all pits and fissures of the tooth surface |
| **2** | Full sealant |
| **3** | Tooth colored restoration |
| **4** | Amalgam restoration |
| **5** | Stainless steel crown |
| **6** | Porcelain, gold or preformed metal crown or veneer |
| **7** | Lost or broken restoration |
| **8** | Temporary restoration |
| **Code 9** | Tooth is missing or has a certain condition |
| **96** | The tooth surface is not examinable because of poor accessibility or convenience |
| **97** | The tooth is lost due to caries |
| **98** | The tooth is lost due to reasons other than caries |
| **99** | Unerupted tooth |

**Table 11: ICDAS codes for caries severity [21].**

| Code | Description |
|---|---|
| **0** | Sound tooth surface |
| **1** | First visual change in enamel after air drying |
| **2** | Distinct visual change in enamel without air drying |
| **3** | Localized enamel breakdown with no visible dentine |
| **4** | Underlying dark shadow from dentin |
| **5** | Cavity with visible dentine |
| **6** | Extensive cavity with visible dentine |

## Table 12: Code Description on Pit and Fissure Caries [21].

| Code | Description |
|---|---|
| **0** | • No evidence of caries after 5 secs air-drying<br>• Surfaces with developmental defects and stains will be considered as sound. |
| **1-First visual change in enamel** | • No evidence of any change on surface wetting.<br>• Visible lesion after prolonged air-drying. |
| **2- Distinct visual change in enamel** | • On wetting, there is a carious opacity. |
| **3- Localized enamel breakdown** | • On wetting , there is a clear carious opacity<br>• Evidence of surface porosity after 5 sec drying time.<br>• Confirm the presence of a cavitation using who probe. |
| **4- Underlying dark shadow from dentin** | • Shadow of discolored dentin visible through an apparently intact enamel surface with or without localized breakdown |
| **5-Distinct cavity with visible dentin** | • Cavitation in opaque or discolored enamel exposing the dentin beneath. |
| **6- Extensive distinct cavity with visible dentin** | • Obvious loss of tooth structure, the dentin is clearly visible involves at least half of a tooth surface or possibly reaching the pulp. |

## 5.4. Data collection sheet:

A data collection sheet was developed which included three sections: The first section was concerning the personal information of the participants and included the following demographic data:

- *Name*
- *Age*
- *gender*
- *Year of study*
- *Medical history*

The second section was for recording DMFT values and the third section was for recording ICDAS values ***(Appendix 4).***

For recording both indices, a dental chart was used in each section. The Federation Dentaire International or FDI World Dental Federation notation system was used in this study. FDI is a two-digit numbering system that is widely used in many countries. The first digit represents a tooth's quadrant and the second digit represents the number of the tooth from the midline of the face. For permanent teeth, the patient's upper right teeth begin with the number, "1". The upper left teeth begin with the number, "2". The lower left teeth begin with the number, "3". The lower right teeth begin with the number, "4". For primary teeth, the sequence of numbers goes 5, 6, 7, and 8 for the teeth in the upper right, upper left, lower left, and lower right respectively [(108)].

This system helps to prevent errors when differentiating between right and left sides of the mouth or between upper and lower dental arches. It also has advantages when typing and is capable of being incorporated in computer languages.

**FDI two-digit tooth numbering system**
Teeth numbering chart for adult teeth [108].

| upper right | upper left |
|---|---|

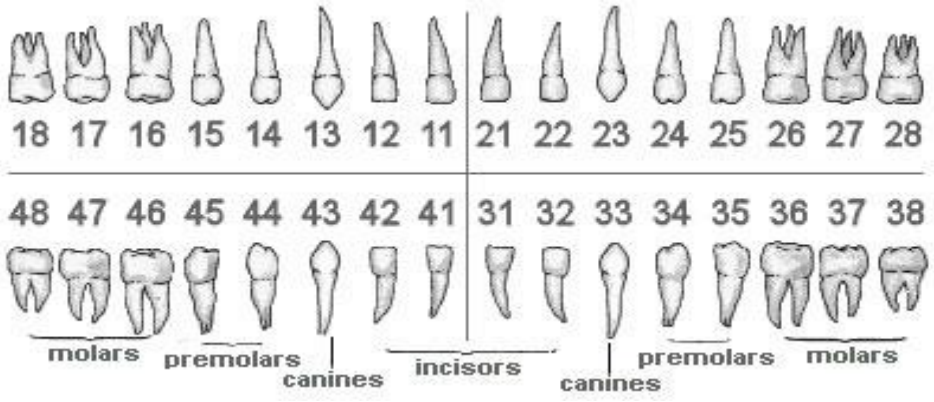
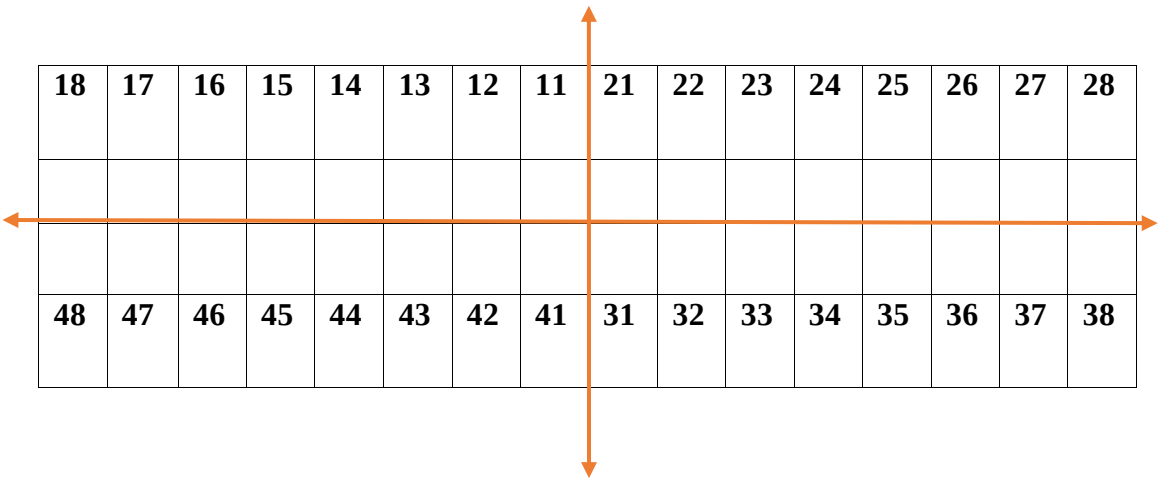



**Figure 3: Teeth numbering chart for adult teeth**



## 6.4. Training and calibration

First, the chief investigator reviewed information available on the icdas website (www.icdas.org). The training was conducted in the form of a lecture that discussed and reviewed the codes and their criteria. This was followed by a practice ICDAS training, which included images used during the online training lecture. The scoring was based on recording the correct ICDAS score of 60 images in the form of multiple choice, true and false questions and matching the proper answer with the image. The website allows multiple trials of the training until the user is confident with the scoring.

The reproducibility of ICDAS codes was assessed by calculating a single examiner (the chief investigator) carried out the intra-examiner agreement as the examination of participants in the main study. Examining 20 participants (dental students) carried this out and the codes for ICDAS were recorded in a separate data collection sheet ***(Appendix 5).*** The chief investigator reassessed the same participants after 3 weeks and the codes were recorded. The intra-examiner agreements were calculated and it was 100%. These 20 Participants were not included in the main study.

## 7.4. Pilot study

A pilot study was carried out by the chief investigator and was conducted in the first ten participants to test the data collection sheet, to identify problems in the proposed methodology, to measure the time required for filling the data and to become familiar with the procedure. Initially, the data collection sheet was amended until all sections were clear and easy to fill. Two versions were developed and edited before piloting. After piloting, no suggested changes were made; therefore, these ten participants were included in the main analysis.

## 8.4. Conduct of the main study

After obtaining ethical approval, the chief investigator informed all the clinicians and nurses in the Conservative Department about the study. The chief investigator was responsible for recruiting participants from the Conservative Department. Dental students were approached at their clinical sessions in the department.

## 1.8.4. Cases selection

All dental students, who were satisfied the inclusion criteria, were invited to participate in the study. The project was explained to participants and consent forms were provided along with study information sheets. The project was explained verbally and in writing. Participants, who agreed to join the study and signed the consent form, were examined on the same day. A few of them asked for a thinking time and were provided with appointments on their preferred time and date. Others agreed and signed the consent and preferred to be examined on another day where suitable appointments were booked for them.

## 2.8.4. Preparation for examination

On examination day, participant personal information was recorded in the first section of the data collection sheet. The examination was conducted in the dental clinic with normal operating light illumination, 3-in-1 syringe and a disposable examination kit composed of mirror, twizzer **(Fig .4)**. A ball-ended explorer (WHO periodontal probe) **(Fig .5)** which was used to remove any remaining plaque and debris and to check surface contours, presence minor cavitations or sealants and the condition of the teeth aided the examination.

### 3.8.4. Examination Procedure

The examination method was started from the right maxillary third molar moving anteriorly, passing through left maxillary, and then left mandibular and finally right mandibular teeth.

For DMFT index: The teeth were examined under wet condition and the score were recorded. The calculation of DMFT value were recorded in the same data collection sheet ***(Section 2)***.

For ICDAS index: The teeth were examined twice.

- First when the teeth were wet.
- Second re-examination was performed after 5 sec drying time with compressed air.

ICDAS scores were recorded in the data collection sheet **(*Section 3*).**

## 8.5. Statistical analysis

The Statistical Package for Social Sciences, version 24 (IBM Corp., Armonk, N.Y., USA) was used for data management and analysis. Descriptive statistics were used for sample characteristics and distribution of the numbers of carious teeth, missing teeth and filled teeth according to DMFT and ICDAS indices. Paired t test and Pearson correlation test were used to compare the mean numbers of decayed, filled, and missing teeth according to DMFT and ICDAS indices. To create comparable numbers of filled teeth according to ICDAS, the codes 3.4 and 5 were summed likewise; one-way ANOVA tests were used to compare mean numbers of DMFT and ICDAS components and total score by participants 'age group. Statistical significance was set at $\leq 0.05$

**Figure 4: disposable examination kit.**

**Figure 5: WHO periodontal probe.**

# 5. Results Chapter 6

## 5.1. Data handling

Descriptive cross-sectional study was carried out to compare between the Decayed, Missed and Filled teeth (DMFT) index and International Caries Diagnosis and Assessment System (ICDAS) index in recording dental caries among a group of 500 dental students attending the Faculty of Dentistry, University of Benghazi, Libya. Descriptive statistics were used for sample characteristics and distribution of the numbers of carious teeth, missing teeth, filled teeth according to DMFT and ICDAS indices the findings from the two indices were compared, and the following section will explain the results of this study in detail**.**

## 5.2. Sample characteristics

Figures 6, 7 and 8 describes the characteristics of study participants (500). A total of 500 dental students at the faculty of dentistry, university of Benghazi were examined for their caries experience using both DMFT and ICDAS indices most participants were females (73%), 4$^{th}$ year students (40%) and belonging to 22-24 years age group (53%). On the other hand, the least prevalent subgroups were 2$^{nd}$year students (10%) and 19-21years age group (21%).

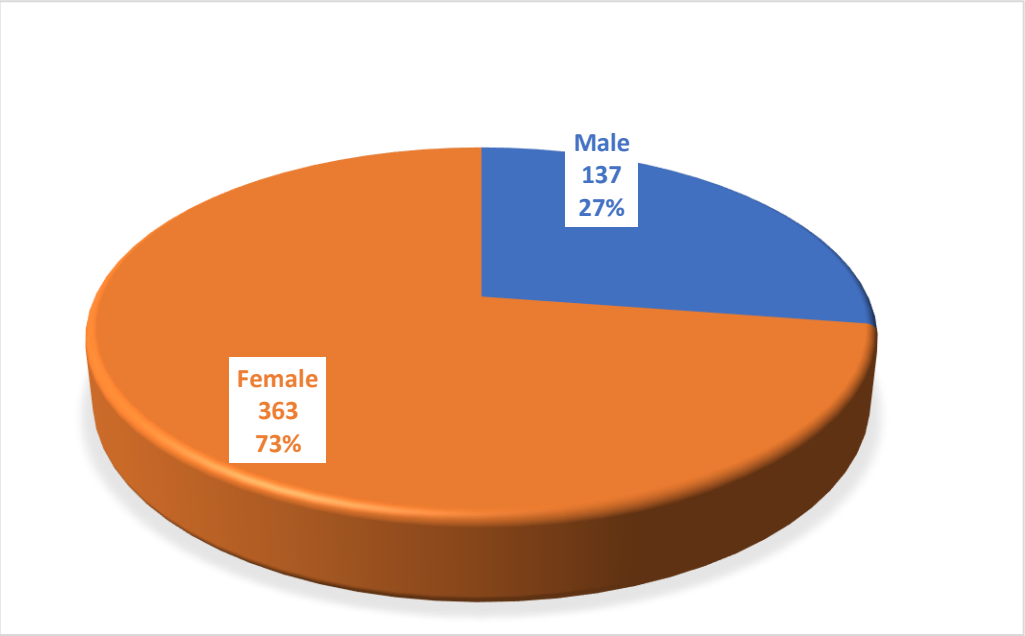



**Figure 6: Distribution of participants by gender.**

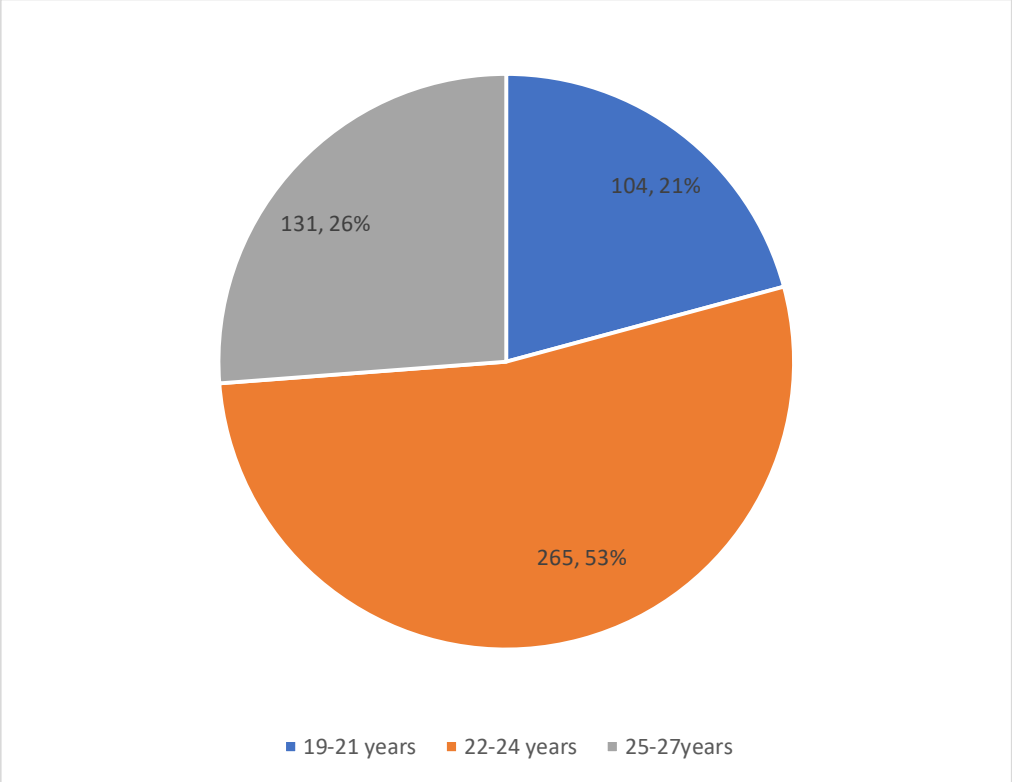



**Figure 7: Distribution of participants by age groups.**

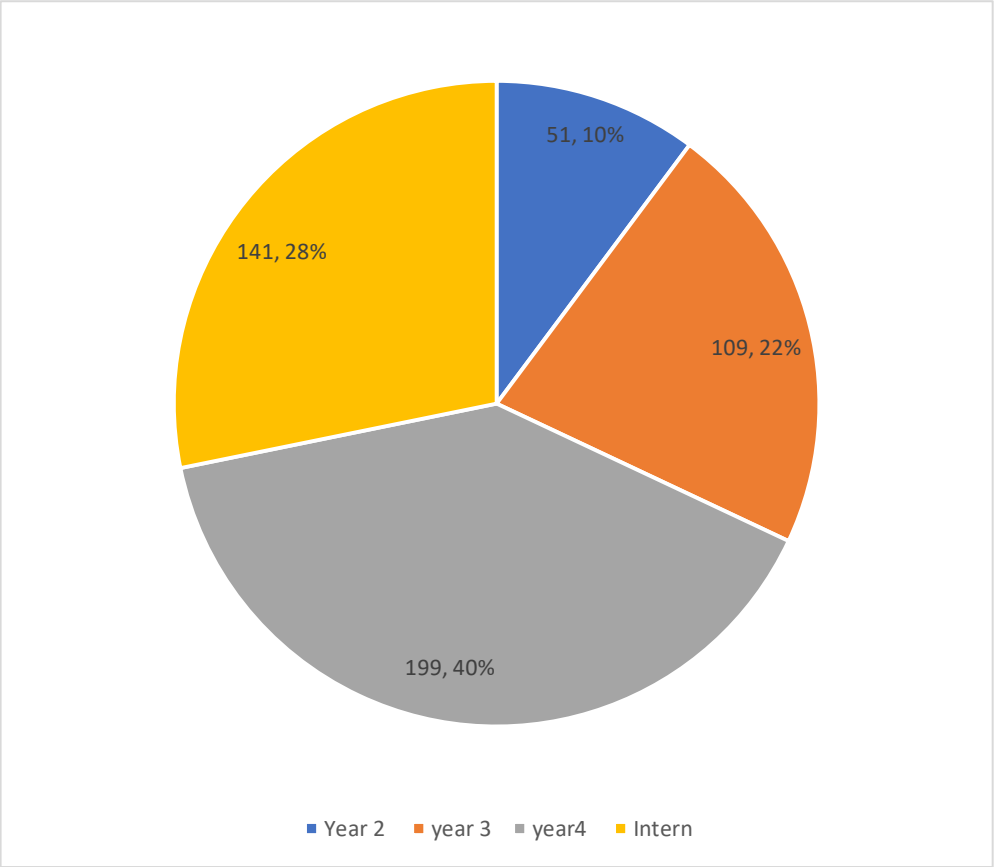



**Figure 8: Distribution of participants by study year.**

## 5.3. Dental caries experience and severity according to DMFT index

All participants had caries experience (DMFT>0). Figure 9 depicts the distribution of DMFT components. Most of them has decayed teeth (89.6%) and filled teeth (76.6%) whereas teeth lost due caries were observed in above the quarter of participant (27.6%).

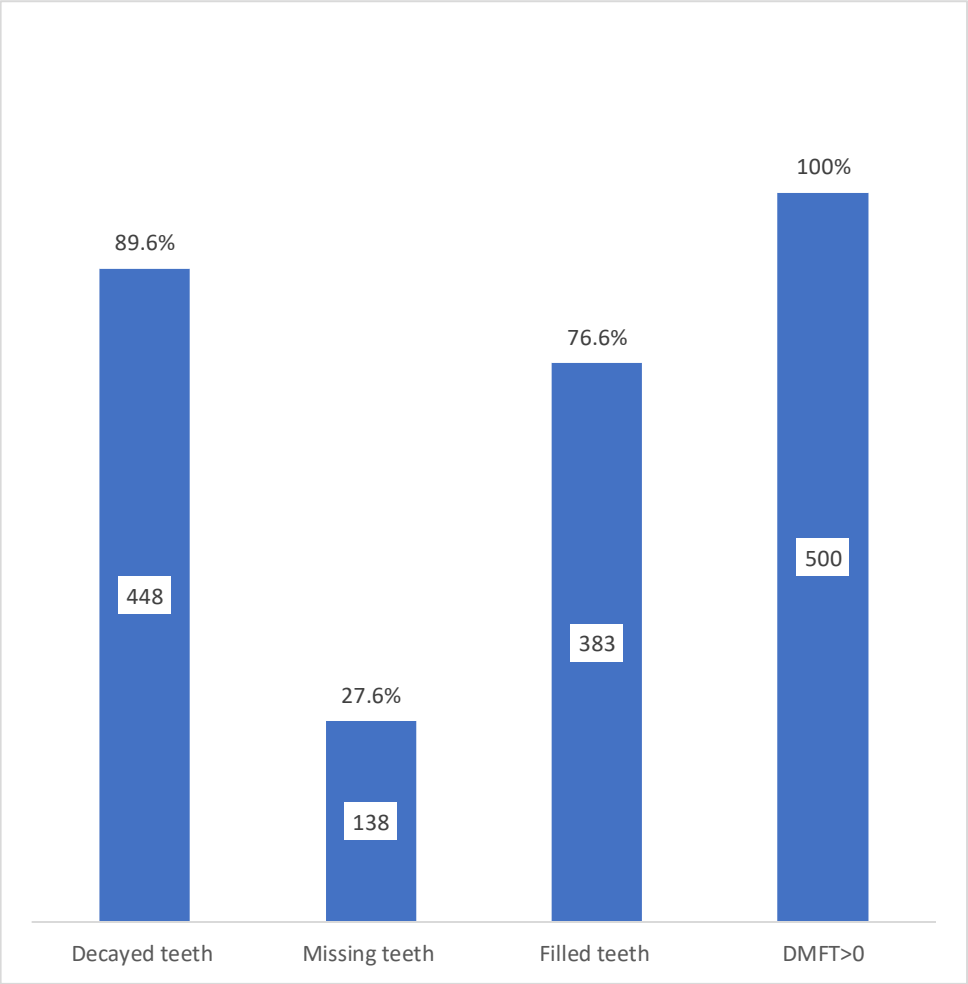



**Figure 9: caries experience according to DMFT**

## 5.4. Dental caries experience and severity according to ICDAS index:

Figure 10 shows the proportions of participants by caries severity. All participants had some form of caries in different phase of caries progression and extension. However, the most common presentations were distinct visual changes (92.2%) and localized enamel breakdown (82.2%). This was followed by first visual changes in enamel (66.2%) and dark shadow in dentin (50.8%). The least common forms were extensive cavity (4%) and distinct cavity into dentin (9.2%).

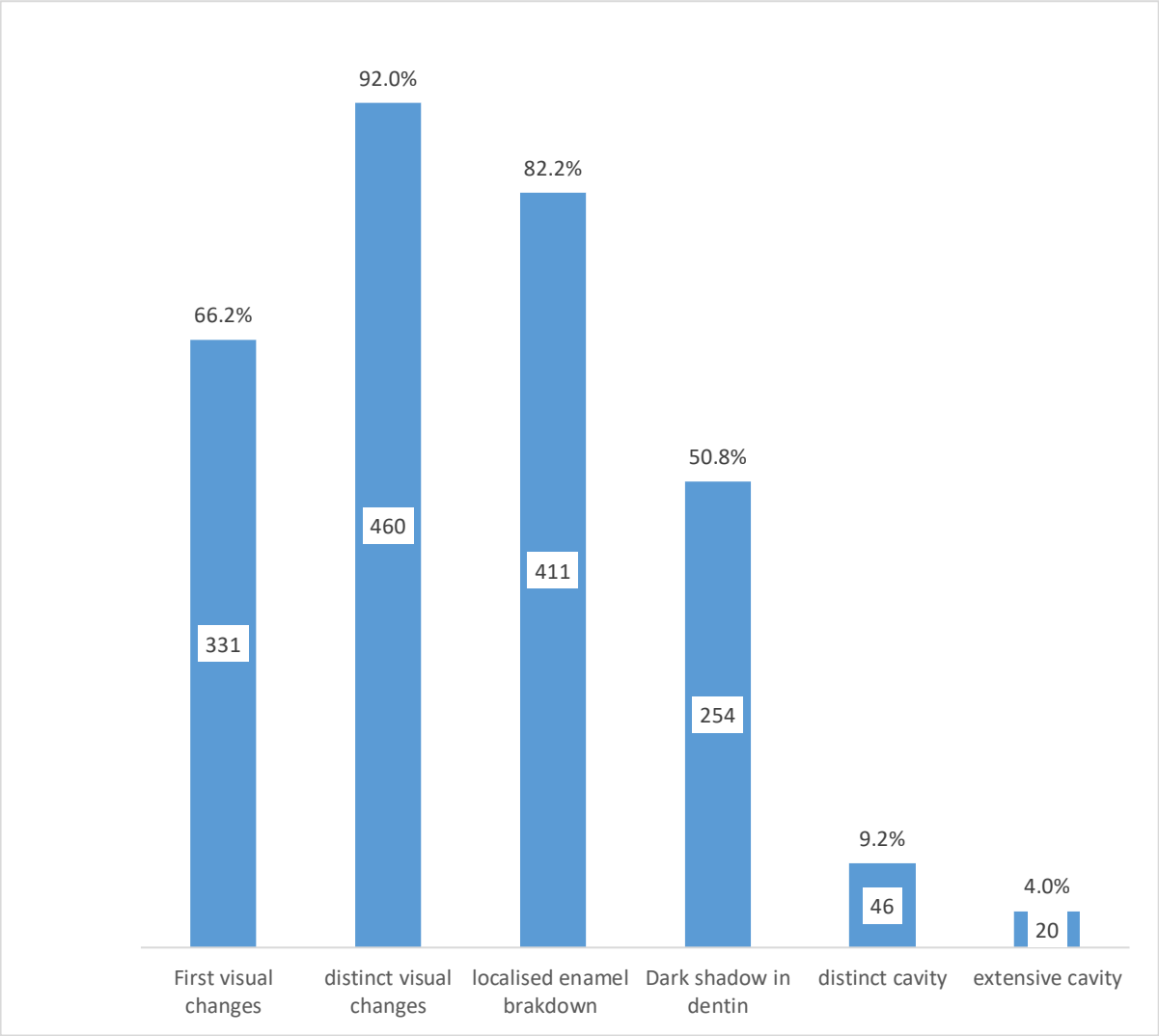



**Figure 10: Distribution of participants by caries severity according to ICDAS.**

## 5.4.1. Restoration status according to ICDAS index

Figure 11 shows the distribution of participants by their restoration status. Most of participants had tooth colored restorations (57.8 %) and amalgam restorations (41.4%). This was followed by fissure sealants (28.6%) and porcelain crowns (22.8%). The least common restorations observed were stainless steel crowns (1.2%) and incomplete sealant or lost/fractured restorations (0.6%).

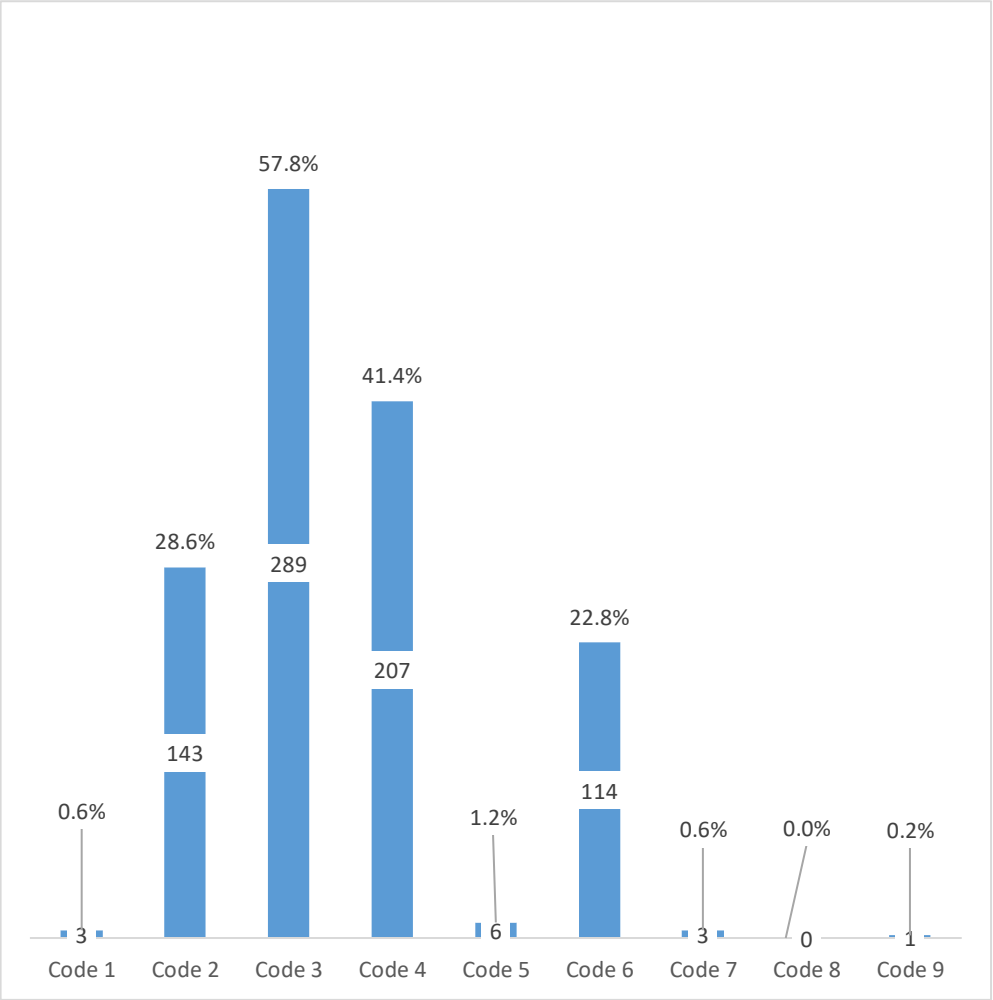



**Figure 11: Restoration status according to ICDAS.**

## 5.4.2. Tooth loss status according to ICDAS index

Figure 12 shows the distribution of participants according to tooth loss status. Most of participants had unerupted teeth (68 %). Nearly the quarter of participants lost their teeth due to caries (24%), and 8% of them lost their teeth due to other reasons.

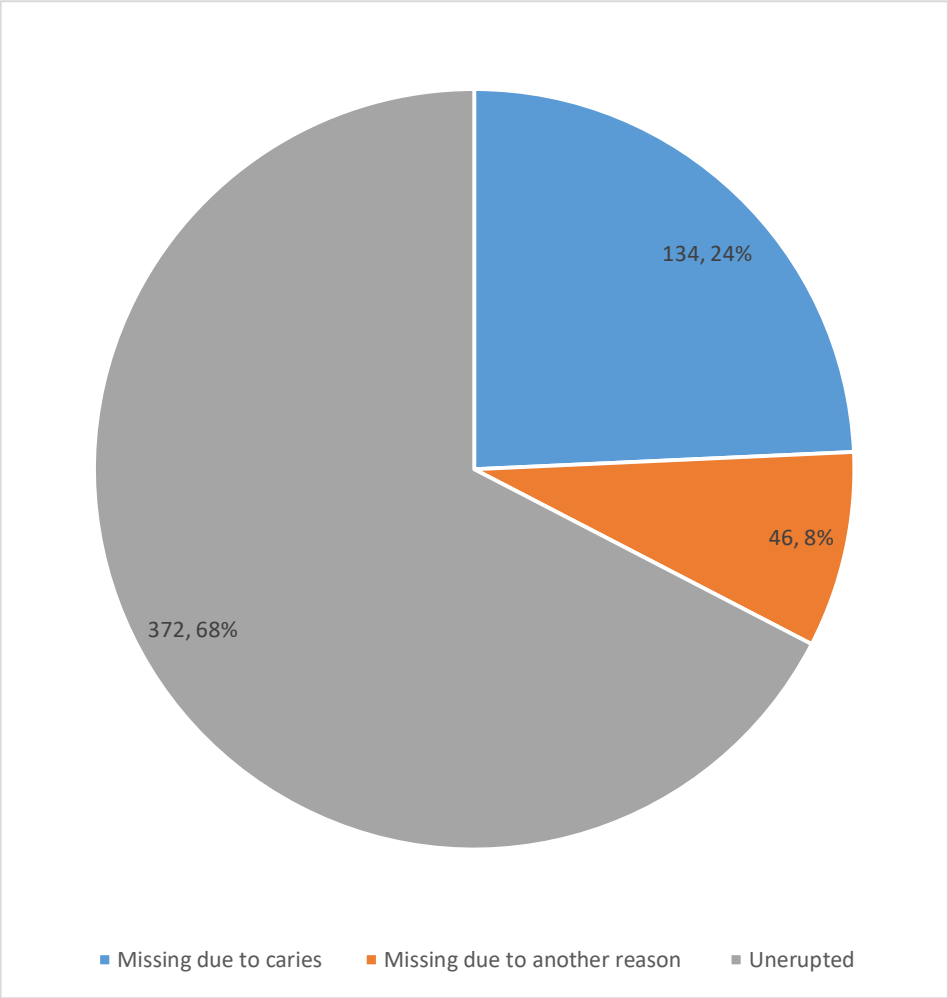



**Figure 12: Distribution of tooth loss according to ICDAS.**

## 5.5. Comparison of DMFT and ICDAS

Table 13 presents comparisons and correlation tests of carious, filed teeth and missing teeth according to DMFT and ICDAS. No statistically significant differences in numbers of missing teeth due to caries (p=0.854) or filled teeth (p=0.166). On the other hand, ICDAS index revealed significantly higher numbers of decayed teeth and the overall score than DMFT Index (p≤0.001). The correlation test revealed statistically significant correlation between numbers of carious, filed teeth and missing teeth according to DMFT and ICDAS index (p≤0.001).

**Table 13: Comparison of caries, filled teeth and missing teeth according to DMFT and ICDAS**

| | **DMFT** | **ICDAS** | **Paired t test** | **Correlation coefficient** | **P vale** |
|---|---|---|---|---|---|
| | **Mean ± SD** | **Mean ± SD** | **P value** | | |
| **Carious teeth** | 2.40 ± 1.15 | 8.0 ± 3.63 | ≤0.001 | 0.568 | ≤0.001 |
| **Missing teeth due to caries** | 0.35 ± 0.63 | 0.35 ± 0.65 | 0.854 | 0.929 | ≤0.001 |
| **Filled teeth due to caries** | 2.28 ± 1.80 | 2.25 ± 1.79 | 0.166 | 0.980 | ≤0.001 |
| **Total score** | 5.02 ± 2.47 | 10.60 ± 4.05 | ≤0.001 | 0.649 | ≤0.001 |

## 5.6 Comparison of caries by age group

Table 14 and 15 present comparisons of carious, filed teeth and missing teeth according to DMFT and ICDAS by age groups of participants. No statistically significant differences in numbers of missing teeth due to caries (p=0.140, 0.083), filled teeth (p=0.360, 0.260) or carious teeth (p=0.257, 0.539). However, 22-24 years age groups had generally lower numbers in all components of DMFT.

**Table 14: Comparison of caries, filled teeth and missing teeth according to DMFT**

| | 19-21 YEARS | 22-24 YEARS | 25-27 YEARS | P VALUE |
|---|---|---|---|---|
| | **Mean ± SD** | **Mean ± SD** | **Mean ± SD** | |
| **Carious teeth** | 2.56 ± 1.19 | 2.29 ± 1.46 | 2.47 ±1.79 | 0.257 |
| **Missing teeth due to caries** | 0.43 ± 0.07 | 0.30 ± 0.04 | 0.38 ± 0.06 | 0.140 |
| **Filled teeth due to caries** | 2.22 ± 0.17 | 2.21 ± 0.12 | 2.47 ± 0.15 | 0.360 |
| **DMFT>0** | 5.21 ± 2.19 | 4.80 ± 2.49 | 5.33 ± 2.60 | 0.091 |

**Table 15: Comparison of caries, filled teeth and missing teeth according to ICDAS**

| | 19-21 YEARS | 22-24 YEARS | 25-27 YEARS | P VALUE |
|---|---|---|---|---|
| | **Mean ± SD** | **Mean ± SD** | **Mean ± SD** | |
| **Carious teeth** | 8.69 ± 3.04 | 7.79 ± 3.83 | 7.94 ±3.63 | 0.539 |
| **Missing teeth due to caries** | 0.39 ± 0.65 | 0.32 ± 0.66 | 0.37 ± 0.64 | 0.083 |
| **Filled teeth due to caries** | 2.21 ± 0.18 | 2.17 ± 0.18 | 2.47 ± 0.18 | 0.260 |
| **ICDAS score** | 11.28 ± 3.70 | 10.24 ± 4.19 | 10.77 ± 3.60 | 0.072 |

# 6. Discussion

## 6.1. Overview

Early detection of dental caries is one of the important steps in modern dentistry to form awareness among the community that renders the evaluation of the prevalence and severity of caries activity, essential to create preventive and therapeutic programs [20]. In order to prevent or control caries, a reliable caries assessment index is needed [80]. In the epidemiological studies, DMFT is the most commonly used index for the caries assessment. It measures the prevalence of dental caries based on decayed, missing and filled teeth due to caries [9]. Benefits of this system include simplicity, ease to use in clinical practice and the opportunity for comparing results collected from many populations over long periods [11]. This index has limitations such as inability to record the initial white spot lesions and lack of codes to record enamel lesions, furthermore it does not provide any information about the caries status and the depth of the lesion`s penetration, restoration types, and their conditions [109]. Recently, a new index was introduced for the evaluation of caries status, the ICDAS systems. The advantages of ICDAS system include accuracy, reproducibility, easy to understand the severity and activity state of the lesion and the condition of the tooth [19]. The stages of caries progression are also easily detectable by the investigators and clinicians [15]. Nevertheless, the shortcomings of this system include the requirement of drying and checking the tooth surfaces, which is a relatively considered time-consuming procedure in epidemiological studies [102].

Each epidemiological index has a particular characteristic that also influence the choice of which index to use. The aim of this descriptive, cross-sectional present study is to compare between DMFT index and ICDAS index on the detection of dental caries on a group of dental student attending the Faculty of

Dentistry, University of Benghazi, Libya on which two caries measurement methods were tested in a sample of 500 dental students composed of 363 female and 137 males which represented 73% and 27% respectively. The participants were categorized by age into three groups: 104 from 19-21 years age group (21%), 265 from 22-24 years age group (53%) and 131 from 25-27 years age group (26%). The Distribution of participants by study year was divided into four groups, 51 from the 2nd year (10%), 109 from the 3rd year (22%), 199 from the 4th year (40%) and 141 from the Intern year (28%).

## 6.2. Dental caries experience and severity according to DMFT index

DMFT-index is used in order to statistically determine the number of carious, extracted and filled teeth per person and the average value of this index in the tested population. All 500 dental participants students had caries experience (DMFT>0). The available data indicated a wide distribution of caries among the dental students. D-component of the DMFT index involves: carious teeth, teeth with definitely filling on one area while the other with caries, teeth with definite fillings that have recurrent or secondary caries and teeth with temporary fillings. The number of students who had decayed teeth was 448, which represented about 89.6% of the total number of the study samples, and it was the dominant component of DMFT value. It showed greater representation of decayed teeth, which was the biggest contributor responsible for the high caries experience values of the DMFT index. On the other hand, the number resulting from this evaluation did not give any information about the caries state, stage, and depth of penetration. It only provided a number that showed the teeth or surfaces that decayed only where it is important to estimate the lesions at an earlier stage. The DMFT index, based on the WHO criteria for epidemiological surveys in the present study, identified more advanced stages of tooth decay. In addition, it is valued in this study sample: the M-component, which is the number of missing teeth that was extracted due to caries and teeth lost due to caries. Teeth lost due

to trauma or primary teeth lost to exfoliation or when extracted for orthodontic reasons or periodontal disease was not included in the final DMFT scores. The number of students who had missed teeth was 138 that represents about 27.6% of the total number of study samples, about a quarter of participants. The low value of M-component may be due to the respondents for their oral health, regular check-ups as the students regularly examine each other as part of their training so consequently recognizing caries and seek dental treatment instead of dental extraction. The F-component is the teeth with definite fillings that have a high value in the DMFT index. The number of students who had filed teeth was 383, which represents about 76.6% of the total number of study samples. The high representation of teeth with definite fillings may be attributed to the improvement care of dental students for their oral health, regular check-ups. This indicates a pattern change towards restorative rather than extraction therapy and should have significant values for dental health service research in the future. DMFT gives a number that estimates decayed, missing or restored teeth/surface; however, it does not provide information on the depth of caries, the types of restoration and their conditions [(110)]. The need for treatment of decayed teeth and regular evaluation of teeth remains unknown.

In our study, the prevalence of dental caries in dental students recorded by DMFT was high (89.9%). The main causes of dental caries is increased exposure to poor oral hygiene and low awareness about oral health [(111)]. However, dental students are expected to have specific knowledge about dental disease prevention and oral hygiene, and thereby are expected to have lower caries prevalence but this was not the case in our study, which showed high caries prevalence. To explain the reasons for this high prevalence, further studies investigating oral health awareness and attitude among dental students are needed. These findings correspond with the data presented by Wyne *et al*., 2008 [(113)] and Drachev *et al*., 2017 [(114)] and Mousawi *et al*., 2017 [(115)].

Wyne *et al*., 2008 [113] found in their study high caries prevalence and severity (95%) in 211 dental students aged between 18-25 years, in King Saud University, Riyadh, Saudi Arabia recorded by DMFT. Another study conducted by Drachev *et al* in 2017 [114] included 309 dental undergraduate students of Russian nationality aged 18–25 years from the Northern State Medical University, represented a high prevalence of dental caries (96.0%) which also consistent with a descriptive study by Mousawi *et al* ., 2017 [115] carried out on 288 dental students on age range (18-24) year in Dentistry Colleges in Holy Karbala in Iraq, which presented a finding of high prevalence of caries (69%) among dental students. The differences in the prevalence rates may be due to the different study settings and the size of study samples.

In contrast, our finding conflicts with the results from a study by Igbinosa and Ogbeide, 2020 [116] where they found low caries prevalence (24%) among 812 undergraduate dental students in School of Dentistry in Nigeria. The low caries experience observed in their study was attributed to the high socio-economic background of the majority of the students that may have reflected a positive influence of their dental education and dental caries status. Besides that, they have recorded a high number of treated teeth at the end of their undergraduate period that was correlated to their motivation and good perception of their dental health.

## 6.3. Dental caries experience and severity according to ICDAS index

The results following examining 500 participants and recording dental status by ICDAS, revealed different phases of caries progression and extension. The most common presentation of caries was the distinct visual changes that was recorded in 460 dental students (92.2%). These results approved that the use of the ICDAS system provides an early detection of carious lesions. The importance of the early detection of dental caries lesions was attributed to the fact that it allows considering dental care prevention by changing the trend in recording non-

cavitated lesions in daily practice. ICDAS has the potential to promote preventive therapies by applying remineralization of non-cavitated lesions and preservation of teeth.

The second common presentation of caries was the localized enamel breakdown, which was recorded in 441 dental students (82.2%), followed by the first visual changes in enamel recorded in 331 dental students (66.2%). Dark shadow in dentin were recorded in 254 (50.8%) and distinctive cavities into dentin were recorded in 46 (9.2%) respectively. The least common caries presentation was the extensive cavity that recorded in only 20 dental students (4%). This suggests that dental students have reasonable dental awareness including dental treatment of carious teeth before it reaches this stage of extensive cavitation.

In our study, the non-cavitated distinct visual changes lesions (code 2) are highly prevalent. Results concerning the high percentage of non-cavitated lesions found in these studies indicates that there was an elevated possibility of progression toward cavities unless timely attention and monitoring was provided. These results confirm that the disease pattern has changed and suggest the need to redirect dental health programs towards early detection of dental caries using new criteria for diagnosis and assessment, as well as non-operative and preventive care by using diagnostic criteria similar to ICDAS [(15)].

Our results came to an agreement with findings from Castro *et al* ., 2018 [(14)], Cadavid *et al*., 2010 [(117)] and Ponnudurai *et al* ., 2016 [(118)] .Castro *et al*., 2018 [(14)] conduct a study in 260 students and staff who were attending the Medical, Dental and Social at State University of Bahia, Salvador, Brazil among 18-31years of age. The prevalence of dental caries was high (84.6%) according to the examinations performed using ICDAS. The distribution of caries codes was also assessed; they found that code 2, which represents non-cavitated/early lesions in the enamel, was the highest amongst the individuals (8.95%). Another study conducted by Cadavid *et al*., 2010 [(117)] among 447 children in Colombia, among

2.5 and 4.0 years of age and the results revealed severe early childhood caries at the (code 2) was detected in 332 (74.3%), and code 5, 6 was detected in 88 (19.7%) children. The greatest prevalence was recorded due to non-cavitated lesions (Code 2).

The results from our study were consistent with the findings of Ponnudurai *et al*., 2016 [118] in study consisted of 2796 schoolchildren aged between 6-14 years in India population. The prevalence of dental caries was 68.8% among the total sample studied which is highly significant. The distribution of caries codes in the study population was assessed and analyzed according to ICDAS criteria in which code 2 was the highest amongst the participants (4.32%).

### 1.6.3. Restoration status according to ICDAS index

According to ICDAS, the distribution of participants by their restoration status shows that most of them (289 dental students {57.8%}) had tooth colored restorations, which were represented by code 3. This modern filling is more natural looking and easily replicates the hard enamel on natural teeth, it is attractive and stronger compared to the traditional fillings [119]. During tooth preparation, less tooth structure needs to be removed so it is more conservative. This may explain why colored restoration was recorded in the majority of restorations in this study.

Code 4 that represents amalgam restorations was recorded in 207 (41.4%) participants, which was lower than tooth colored restoration. This type of filling is not natural looking, especially when the filling is near the front of the mouth, where it may show when a person laughs or speaks. In addition to prepare the tooth, the dentist may need to remove more tooth structure to place an amalgam filling than for other types of fillings, besides their alertness by the allergic to the mercury present in amalgam restorations [120].

Fissure sealants, represented by code 2, were recorded in 143 (28.6%). Based on recent studies, pits and fissures on occlusal surfaces of permanent teeth are

particularly prone to the development of dental caries. For that reason, the application of fissure sealants is recommended to create a physical barrier to the plaque's accumulation and caries progress [101].

Porcelain crowns that represented by code 6 and stainless steel crowns that represented by code 5 were recorded in 22.8% and 1.2% of dental students respectively. Incomplete sealant or lost/fractured restorations, which represented by code 7, was recorded in 0.6% of the sample. All these findings suggest that ICDAS provide information on the types and the condition of the restoration [107].

### 2.6.3. Tooth loss status according to ICDAS index

In the present study, the distribution of participants according to tooth loss shows that the majority of participants (273 {68%}) had unerupted teeth. Nearly the quarter of participants (134 {24%}) lost their teeth due to caries. The relatively low number of missing teeth due to caries recorded in this study may be explained by the fact that dental students are more likely to think about the adverse effect of missing teeth on oral conditions in their life, so this renders them avoiding dental extraction of their carious teeth and requests dental restoration instead. Tooth loss due to other reasons like trauma or orthodontic treatment was recorded in 8% of them. These findings prove that ICDAS not only shows the number of missing teeth but also represents the cause of tooth missing due to either caries or any other reasons.

## 6.4. Comparison of dental caries by DMFT and ICDAS systems

In the present study, the comparisons between carious, filed teeth and missing teeth according to DMFT and ICDAS was calculated by Paired t test and Pearson correlation tests. There were no statistically significant differences in numbers of missing teeth due to caries ($p=0.854$) or filled teeth ($p=0.166$). On the other hand, ICDAS index revealed significantly higher numbers of decayed teeth and the overall score than DMFT Index ($p\leq0.001$). DMFT indexes underestimated the

tooth decay disease in the study. The correlation test revealed statistically significant correlation between numbers of carious, filed teeth and missing teeth according to DMFT and ICDAS index ($p \leq 0.001$).

These result from our study corroborates with findings from Souza *et al*., 2015 [103], Melgar *et al*., 2016 [104] and Vinícius *et al*., 2020 [108] which all reported that ICDAS identified a high prevalence of non-cavitated lesions in their samples by estimating the lesions at an earlier stage, while the DMFT index only provides a number, which show those teeth that have carious lesions. This further suggests that DMFT index underestimates tooth decay in the studied population and lesions that do not require invasive treatment.

Castro *et al* .,2018 [14] reported in their study of the DMFT that even though being the fastest method to apply and the most common method in oral health epidemiology for the evaluation of dental caries, where it provides an easy comparison of the study population worldwide, it had the disadvantage of underestimating the occurrence of lesions. The ICDAS, as an alternative, recorded detailed information on caries severity through a high time-consuming measurement.

It was interesting to note that there was a good level of agreement between finding from Taqi *et al*., 2019 [105] and Houchaimi *et al*., 2020 [107]. They reported that ICDAS could be used in future epidemiological investigations since it records carious lesions at an earlier stage and describes the restorative status of the tooth, promoting new preventive approaches and curative needs, however, prolonged examination time could limit its use in field surveys. They also found that the DMFT index only recorded obvious caries lesions and did not provide detailed information regarding the state and stages of caries.

The comparison of the results of the DMFT and ICDAS in all these previous studies suggest that the ICDAS is more accurate in describing the prevalence of

caries in studies. The inclusion of non-cavitated lesions during the caries evaluation represents a challenge in diagnosis, which allows control of this process before the evolution of these lesions to a cavitation. Furthermore, the ICDAS allows for the planning of preventive treatment, interception or monitoring of carious lesions at individual and population levels.

## 6.5. Comparison of caries by age group

In the present study, the comparisons between DMFT and ICDAS by age groups of participants was measured by ANOVA test. There are no statistically significant differences in numbers of missing teeth due to caries (p=0.140, 0.083), filled teeth (p=0.360, 0.260) or carious teeth (p=0.257, 0.539). However, 22-24 years age groups had generally lower numbers (4.80 ± 2.49) in all components of DMFT and this may be attributed to the fact that the student in the fourth year may have more understanding about their oral health and have more chance to get early diagnosis of their dental status before caries lesions progress to cavities during their practical studies, while (19-21) group was found to have generally higher numbers (11.28 ± 3.70) in all components of ICDAS.

# 7. Conclusion

According to the results of the present study, all participants (500 dental students) had a high caries prevalence. The concluded data that related to the comparisons between DMFT and ICDAS indicated no statistically significant difference in numbers of missing teeth due to caries or filled teeth. On the other hand, ICDAS index revealed significantly higher numbers of decayed teeth and the overall score than DMFT Index. Within the result of this study, it was concluded that:

1. The strength of the ICDAS is in its ability to detect non-cavitated caries lesions that represents a challenge in diagnosis, which allows for control of this process, promote advanced preventive therapies and curative needs before the evolution of these lesions to cavitation and to provide more information regarding caries classification and describing the prevalence of caries in studies.

2. DMFT only provides a number that shows those teeth that have carious lesions; therefore, the DMFT index underestimates lesions that do not require any invasive treatments that lead to underestimate the tooth decay disease in the studied population.

## 7.1. Strengths and limitations

The main strength of this work was that the study is considered comparative between two indexes. Another strength point was the large sample size taken by the chief investigator during the study to measure the prevalence and severity of some dental students in Benghazi city.

_ An additional strength point was the cohort group of the sample in which all the participants were dental students in a nearby age group and the educational level. Furthermore, one single examiner on the study raised the intra-examiner agreement .

_ The limitation of this study was the choice of one table (pit and fissure surface) from four tables on ICDAS criteria to detect caries on the coronal surface. However, this decision was made to simplify the examination and decrease the time required to finish all four tables and to decrease x-ray exposure for the examiner and for each dental student when detecting caries on other tooth surfaces such as in case of proximal caries.

## 7.2. Recommendations

1. Further studies with large sample sizes are needed to measure the prevalence and severity of dental caries on dental students in faculty of dentistry in Benghazi city is recommended .

2. Further studies should be performed using different aspect of ICDAS criteria to detect caries state on other tooth surfaces is recommended.

3. Further studies to investigate the oral health awareness of dental students is required to clarify the reasons behind the high caries prevalence recorded.

4. Application of this ICDAS system in the routine clinical examination in our dental school, because it permits recognition of the severity and incidence of the caries at an early stage on individual and population level. In addition, it promote preventative therapies, which enhance the remineralization of noncavitated lesions resulting in inactive lesions and the preservation of tooth structure, function and esthetics.

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**Information Sheet**  **Appendix 1**

## Who am I ?

My name is Gatrelnada Elsharkasi and I am demonstrator and postgraduate student in conservative and endodontic department.

## What is the purpose of the study ?

Dental caries is a preventable and controllable disease. To apply measures, which can prevent or control caries, this can only be obtained if we have an accurate caries assessment system (index). The aim of this study is to evaluate the caries status through examination of all the teeth using a mirror and dental probe.

## What are the possible risks of taking part ?

There are no known risks for participating in the study. All information that you provides us for this study will be kept private. Your name will not appear on any documents. It will be allocated a code number, which will be used as identifier. Only the main researchers will know their name and code number.

## What are the possible benefits of taking part ?

You will have a very thorough assessment of the possible decay in your teeth. It is also hoped that the results of this study will improve our way of detecting tooth decay so that preventive treatment can be started sooner.

## What will happen to the results of the research study ?

Following completion of the study, we will analyze the findings. The results will be included in the researcher's MCD thesis and will be published in a scientific journal. We also plan to report our findings at national and international dental conferences so other dentists will benefit from knowledge gained from this study.

**Thank you for taking the time to read this information sheet concerning to my study.**

## CONSENT FORM Appendix 2

**Title of Project:** What is the best way to detect tooth decay ?

**Name of Researchers:** Mrs. Gatrelnada Elsharkasi, Professor. Najat Bubtina.

1. I confirm that I have read and understand the information sheet dated for the above study and have had the opportunity to ask questions.

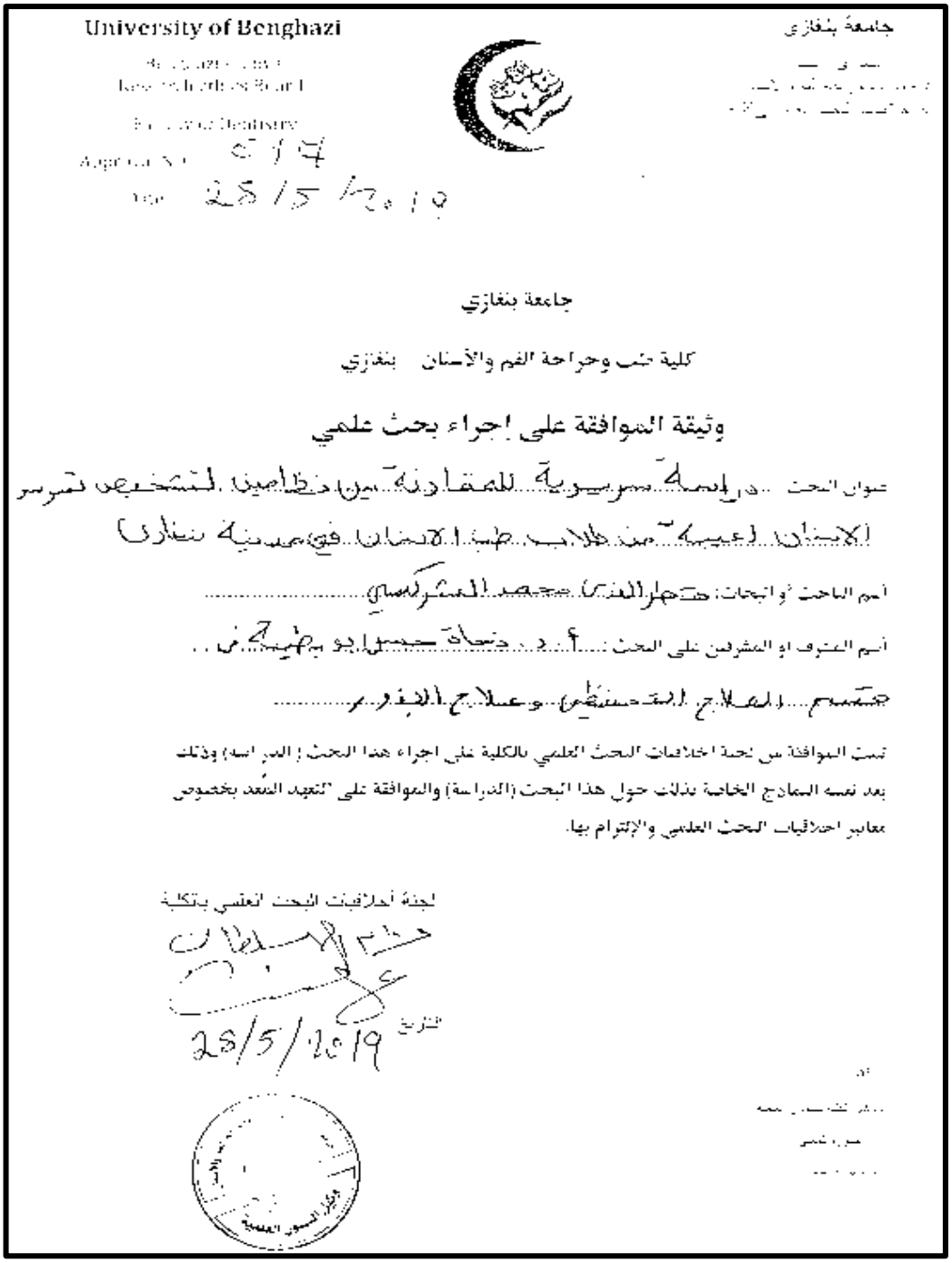
2. I understand that my participation is voluntary and that I am free to Withdraw at any time, without giving any reason.

3 . I understand that all data will be treated confidentially.

4. I agree for to take part in the study .

| **Number** | **Name of Participant** | **Signature** | **Date** |
|---|---|---|---|
| | | | |

# Appendix 3



University of Benghazi

جامعة بنغازي

جامعة بنغازي

كلية طب وجراحة الفم والأسنان بنغازي

## وثيقة الموافقة على إجراء بحث علمي

عنوان البحث: دراسة مرضية للمقارنة بين نظامين التشخيص تسوس الأسنان لعينة من طلاب طب الأسنان في مدينة بنغازي

اسم الباحث / الباحث: جلال الدين محمد المشركاسي

اسم المشرف او المشرفين على البحث: أ.د. جناة حسين ابو بطيخان

تخصص: العلاج التحفظي وعلاج الجذور

تمت الموافقة من لجنة اخلاقيات البحث العلمي بالكلية على اجراء هذا البحث (الدراسة) وذلك بعد تعبئة النماذج الخاصة بذلك حول هذا البحث (الدراسة) والموافقة على التعهد المُعد بخصوص معايير اخلاقيات البحث العلمي والإلتزام بها.

لجنة أخلاقيات البحث العلمي بكلية

التاريخ 25/5/2019

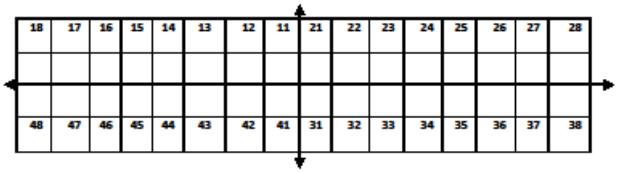
# Appendix 4

## DENTAL CHART

**1: PERSONAL INFORMATION:**

| | |
|---|---|
| NAME: | SEX: ☐ Male ☐ Female |
| AGE: ☐ 27 -25Y ☐ 24 -22 ☐ 19-21 Y | MEDICAL HISTORY: ☐ -VE ☐ +VE |
| YEAR: | |

**2. DMFT MEASURE**

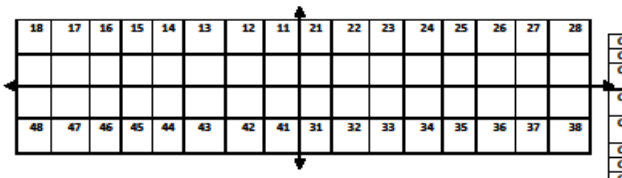



| | | |
|---|---|---|
| Sound | 0 | - |
| Caries<br>Filled with caries | 1<br>2 | D |
| Filled, no caries | 3 | F |
| Missing due to caries | 4 | M |

| | |
|---|---|
| D= | |
| M= | |
| F= | |
| D+M+F= | |

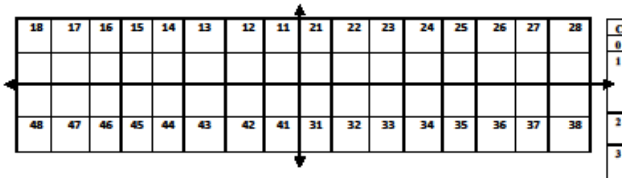
**3. ICDAS MEASURE: (ON PIT AND FISSURE SURFACE)**

**I. Restoration status:**




| CODE | Code Definition |
|---|---|
| Code 0 | Unfilled and unsealed teeth |
| Code 1 | Sealant applied but all pits and fissures are not covered |
| Code 2 | Sealant applied and all pits and fissures are covered |
| Code 3 | Tooth colored resin or glass ionomer restoration |
| Code 4 | Amalgam restoration |
| Code 5 | Stainless steel crown |
| Code 6 | Porcelain or veneer crown or PFM |
| Code 7 | Lost or fractured restoration |
| Code 8 | Temporary restoration |
| Code 9 | Tooth is missing or has a certain condition |
| 96 | The tooth surface is not examinable because of poor accessibility or convenience |
| 97 | The tooth is lost due to caries |
| 98 | The tooth is lost due to reasons other than caries |
| 99 | Unerupted tooth |

**II. Caries severity description:**




| Code | Description |
|---|---|
| 0 | Sound tooth surface |
| 1 | First visual change in enamel: Opacity or discoloration (white or brown) is visible at the entrance to the pit or fissure seen after prolonged air drying |
| 2 | Distinct visual change in enamel visible when wet, lesion must be visible when dry |
| 3 | Localized enamel breakdown (without clinical visual signs of dentinal involvement) seen when wet and after prolonged drying |
| 4 | Underlying dark shadow from dentine |
| 5 | Distinct cavity with visible dentine |
| 6 | Extensive (more than half the surface) distinct cavity with visible dentine |

## Examiner training sheet Appendix 5

| After 3 Week | Day 1 | No of Tooth | No of Student |
|---|---|---|---|
| 4 | 4 | 36 | 1 |
| 3 | 3 | 25 | 2 |
| 4 | 4 | 37 | 3 |
| 5 | 5 | 15 | 4 |
| 3 | 3 | 45 | 5 |
| 3 | 3 | 17 | 6 |
| 4 | 4 | 34 | 7 |
| 3 | 3 | 26 | 8 |
| 4 | 4 | 45 | 9 |
| 3 | 3 | 27 | 10 |
| 5 | 5 | 44 | 11 |
| 4 | 4 | 35 | 12 |

| | | | |
|---|---|---|---|
| 3 | 3 | 34 | 13 |
| 3 | 3 | 17 | 14 |
| 3 | 3 | 16 | 15 |
| 4 | 4 | 36 | 16 |
| 3 | 3 | 24 | 17 |
| 4 | 4 | 27 | 18 |
| 3 | 3 | 46 | 19 |
| 3 | 3 | 15 | 20 |

**Appendix 6**

# Clinical Comparison on Detection of Dental Caries by Decayed, Missed And Filled Teeth (DMFT) System and International Caries Diagnosis and Assessment System (ICDAS) on Some Dental Student in Benghazi City.

# دراسة سريرية للمقارنة بين نظامين لتشخيص تسوس الأسنان لعينة من طلاب طب الأسنان في مدينة بنغازي


By

**Gatrelnada Mohamed Elsharkasi**

(BDS, 2007)


## Protocol

Submitted In partial Fulfillment of the Requirements

For the Degree of Master Science

In


Conservative and Endodontic Department

Supervisor: Professor. Nagat Hassan Bubteina

Faculty of Dentistry

University of Benghazi

Benghazi _Libya


2019

## 1. Introduction

Dental caries is a dynamic disease affecting the teeth due to imbalance between demineralization and remineralization of dental hard tissues; it is the main cause of tooth loss and pain around the world [(1)]. It is one of the most prevalent chronic diseases of people worldwide; so individuals are susceptible to this disease throughout their lifetime [(2)].

Dental caries is a preventable and controllable disease. To apply measures, which can prevent or control caries, a reliable representation of it in a population is a requirement; this can only be obtained if we have an accurate caries assessment system (index) [(3)]. The most common epidemiologic scale for caries detection is DMF, which was first introduced in the 1930s [(4)]. In this scale decayed (D), missed (M) and filled (F) teeth are evaluated and reported according to the number of teeth (DMFT) or surfaces (DMFS) involved [(4)].

Although the DMFT index has advantages, they are balanced by its weaknesses because it does not account for the consequences of untreated cavitated dentine lesions and does not record carious lesions in enamel. Subsequently, the index provides an under estimation of the prevalence and severity of caries [(5)].

The DMF index can be problematic in that, DMF only provides a number that shows the teeth or surfaces, which are decayed, missed or restored. It is not clear that the final number explains which of the aforementioned conditions. Furthermore, the need for health care and or treatment of the carious teeth and regular evaluation of the teeth remains unknown [(6)].

In this investigation, Banava *et al* .,2012 in Iran indicated that DMFT indices were higher than those recommended by WHO in 2010 were there result was attributed to the fact that the DMFT number did not show any details about the

dental status of their cases [7]. Therefore, as to overcome difficulties experienced with the DMFT index and to combine other caries evaluation indices, a new visual and tactile dental caries detection system was developed for international use, designated the International Caries Detection and Assessment System (ICDAS) [8].

ICDAS is a clinical scoring system, which allows detection and assessment of caries activity. It was developed for use in clinical research, clinical applications and for epidemiological purposes. Investigators of cariology founded it [9].

Diagnosis of caries and dental conditions with this system leads to improved quality of diagnosis, prognosis, and clinical treatment. This system is accurate and reproducible and is very helpful in diagnosis of early carious lesions as well as long-term evaluations [10]. Bakhshandeh *et al*., 2011[11] reported that there is a strong relationship between ICDAS scores and the real depth of the lesion that is identified histologically. Neuhaus *et al., 2011* [12] performed another study that found there was a strong relationship between ICDAS criteria and histologic depth.

It was reported that the big successes of this system are as follows: the condition of the tooth and the stages of the caries process are easily measurable by the investigators and clinicians. On the other hand, it provides an easy way to understand the severity and activity state of the lesion [13].

ICDAS also support the preventative therapies, which encourage the remineralization of noncavitated lesions resulting in inactive lesions and the preservation of tooth structure, function and esthetics and a much-decreased DMF all-over [14]. However, the Coordinating Committee described the ICDAS criteria by dividing it into two categories: coronal primary and root caries, the ICDAS system has two digits coding for detection criteria of primary coronal caries. The first one is related to the restoration of teeth and has a coding that

ranges from 0 to 9 and the second digit coding ranges from 0 to 6, those are used to evaluate the various states of the teeth [15].

There are minor variations between the visual signs associated with each code depending on a number of factors. Therefore, a detailed explanation of each of the codes is given under the following headings: Pits and fissures, smooth surface (mesial or distal), free smooth surfaces and caries associated with restorations and sealants (CARS) [16]. In this study, the first code description on pits and fissures to detect and record caries will be used.

Therefore, this study will be conducted to evaluate the caries status using this new system while comparing it with the DMF index as a common method.

## 2. Aim of the study

The overall aim of this study is to compare between Decayed, Missed and Filled teeth (DMFT) index and International Caries Diagnosis and Assessment System (ICDAS) index.

## 1.2. Objective

The specific objectives of this study are as follows:

**a)** To assess the prevalence of dental caries in some dental students in Benghazi city.

**b)** To assess the severity of dental caries in some dental students in Benghazi city.

**c)** To assess the caries index according to the age of some dental students in Benghazi city.

# 3. Materials and Methods

## 3.1. Study design and sample type

A minimum sample size of 441 participants is required to detect a minimum effect size of 0.2 at 95% confidence level and 80% power of paired test. A convenient sample of 500 dental students will be selected and evaluated in a descriptive cross-sectional study in which two caries measurement methods (DMFT) and (ICDAS) index will be applied in the same group. All the individuals will be examined after being properly informed about the procedures of the study. Written consent will be obtained from all participants.

## 3.2. Examiner training

A single examiner will be trained and calibrated in the ICDAS Index system. Where the examiner evaluated and scored numbers of 20 students for this index. The same set of students will be re-examined after 3 week to test out intra-examiner agreement.

## 3.3. Examination method

The aim of this study is to compare between Decayed, Missed and Filled teeth (DMFT) index and International Caries Diagnosis and Assessment System (ICDAS) index in recording dental caries. Examinations will be performed on a dental unit under adequate light conditions by using a clean dental mirror, WHO probe per the DMFT, ICDAS index systems. Each examination will be initiated from the right maxillary third molar moving interiorly, passing through left maxillary, and then left mandibular and finally right mandibular teeth. Each tooth will be dried prior to examination.

## 3.3.1. DMFT

DMFT index quantifies dental caries status in terms of the number of decayed teeth with untreated caries lesion (D) and the number of teeth, which have been lost due to caries (M) as well as the number of filled teeth due to caries (F). Tooth/teeth will be recorded as decayed (D) only if a cavity with detectably softened floor, undermined enamel, or a softened wall will be detected; all caries stages that precede cavitation will be considered sound.

## 3.3.2. Calculating DMFT

Teeth not counted are unerupted teeth, congenitally missing teeth or supernumerary teeth, teeth removed for reasons other than dental caries, and primary teeth retained in the permanent dentition.

- When a carious lesion(s) or both carious lesion(s) and a restoration are present, the tooth is recorded as a D.
- When a tooth has been extracted due to caries, it is recorded as an M.
- When a permanent restoration is present, or when a filling is defective but not decayed this is counted as an F.
- Teeth restored for reasons other than caries are not counted as an F. and scores per individual can range from 0 to 28 or 32.

## 3.3.3. Calculation of Index [17]

According to WHO (2013) in order to calculate DMFT is as follows:

1. Individual DMFT value = D + M + F

| | |
|---|---|
| **D=** | |
| **M=** | |
| **F=** | |
| **D+M+F=** | |

2. For population Mean DMF = $\frac{\text{Total DMF}}{\text{Total No. of the subjects examined.}}$

## 3.4.1. ICDAS measures

The recording of dental caries using the ICDAS system is a two-stage process. The code consists of two digits, the first digit is the restorative status of the tooth (Table 1) and the second digit is for the caries severity (Table 2). ICDAS codes for restoration and caries severity are shown in Tables:

### 3.4.2. Table 1: ICDAS codes for restoration status [15].

| Code | Description |
|---|---|
| Code 0 | Unfilled and unsealed teeth |
| Code 1 | Sealant applied but all pits and fissures are not covered |
| Code 2 | Sealant applied and all pits and fissures are covered |
| Code 3 | Tooth colored resin or glass ionomer restoration |
| Code 4 | Amalgam restoration |
| Code 5 | Stainless steel crown |
| Code 6 | Porcelain or veneer crown or PFM |
| Code 7 | Lost or fractured restoration |
| Code 8 | Temporary restoration |
| Code 9 | Tooth is missing or has a certain condition |
| 96 | The tooth surface is not examinable because of poor accessibility or convenience |
| 97 | The tooth is lost due to caries |
| 98 | The tooth is lost due to reasons other than caries |
| 99 | Unerupted tooth |

### 3.4.3. Table 2: ICDAS codes for caries severity [15].

| Code | Description |
|---|---|
| 0 | Sound tooth surface: No evidence of caries after 5 sec air-drying. |
| 1 | First visual change in enamel: Opacity or discoloration (white or brown) is visible at the entrance to the pit or fissure seen after prolonged air-drying. |
| 2 | Distinct visual change in enamel visible when wet, lesion must be visible when dry. |
| 3 | Localized enamel breakdown (without clinical visual signs of dentinal involvement) seen when wet and after prolonged drying. |
| 4 | Underlying dark shadow from dentin. |
| 5 | Distinct cavity with visible dentin. |
| 6 | Extensive (more than half the surface) distinct cavity with visible dentin. |

## 3.5. Data collection sheet

The aim of this study is to compare between two indices in recording dental caries, therefore, a data collection sheet was developed which included three sections: The first section will be concerning the personal information of the participants and included the following variables:

- *Name*
- *Age*
- *Gender*
- *Year of study*
- *Medical history*

The second section will be for recording DMFT values and the third section will be for recording ICDAS values.

## 4. Statistical analysis:

All collected data will be tabulated and statistically analyzed by SPSS using univalent and bivalent data analysis to assess a difference in prevalence of caries and mean between DMFT and ICDAS in across study groups.

## 5. References:

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# دراسة سريرية للمقارنة بين نظامين لتشخيص تسوس الأسنان لعينة من طلاب طب الأسنان في مدينة بنغازي

**(دراسة سريرية)**

**قدمت من قبل :**

**قطرالندى محمد محمود**

**تحت إشراف :**

**أ. د. نجاة حسن بوبطينة**

## الملخص

**الخلفية والهدف.** الطريقة الشائعة لتقييم حالة التسوس هي عدد مؤشر الأسنان المتسوسة والمفقودة والمعالجة (DMFT). تم مؤخرًا تقديم النظام الدولي لتشخيص وتقييم تسوس الأسنان (ICDAS) لإجراء تقييم مفصل لتسوس. الهدف من هذه الدراسة هو تقييم حالة التسوس مع هذا النظام الجديد مع مقارنتها بنظام DMFT كطريقة شائعة.

**الخطوات:** كانت هذه دراسة وصفية مقطعية. تم اختيار المشاركين بشكل ملائم من بين 500 طالب طب أسنان يدرسون في كلية طب الأسنان، جامعة بنغازي، ليبيا. قام معاين واحد مدرب باستخدام مرآة الأسنان ومسبار منظمة الصحة العالمية بإجراء الكشف باستخدام نظامي DMFTو ICDAS. تم تسجيل عدد الأسنان المتسوسة (D) والمفقودة (M) والمعالجة (F) في نظام DMFT. في نظام ICDAS، تم إجراء تقييم حالة الأسنان في أسطح التجويفات والشقوق السنية في الحالات الفموية الجافة والرطبة وفقًا لرموز هذا النظام. تم استخدام Paired t testو Pearson correlation testللمقارنة بين مؤشرات DMFT و ICDAS.

**النتائج:** كان لدى جميع المشاركين تجربة تسوس مسجلة بنظام DMFT(DMFT> 0). وأيضا عند استخدام ICDAS تم تسجيل تسوس الأسنان في مراحل مختلفة من درجات التسوس. لا توجد فروق ذات دلالة إحصائية في أعداد الأسنان المفقودة بسبب التسوس (ع = 0.854) أو الأسنان المحشوة (ع = 0.166). من ناحية أخرى، أظهر مؤشر ICDAS أعدادًا أعلى بكثير من الأسنان المتسوسة مقارنة بمؤشر DMFT ($p\leq0.001$). أظهرت النتائج وجود دلالة إحصائية تبين قدرة نظام ICDAS على تسجيل أعداد أعلى للأسنان المتسوسة والأسنان المعالجة والأسنان المفقودة مقارنة بنظام DMFT ($p\leq0.001$).

**الخلاصة:** يمثل رصد التسوس الأولي الغير المجوف أثناء تقييم الأسنان بواسطة ICDAS تحديا في التشخيص، مما يسمح بالتحكم في عملية التسوس قبل تطورها إلى تجويف وبالتالي يعززمن العلاجات الوقائية المتقدمة. بينما لا يرصد مؤشر DMFT التسوس في حالاته الأولية التي لا تتطلب أي علاج تحفظي ترميمي.

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**قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في العلاج التحفظي وعلاج جذور الأسنان**


**كلية طب وجراحة الفم والأسنان**

**جامعة بنغازي**


**ابريل 2021**