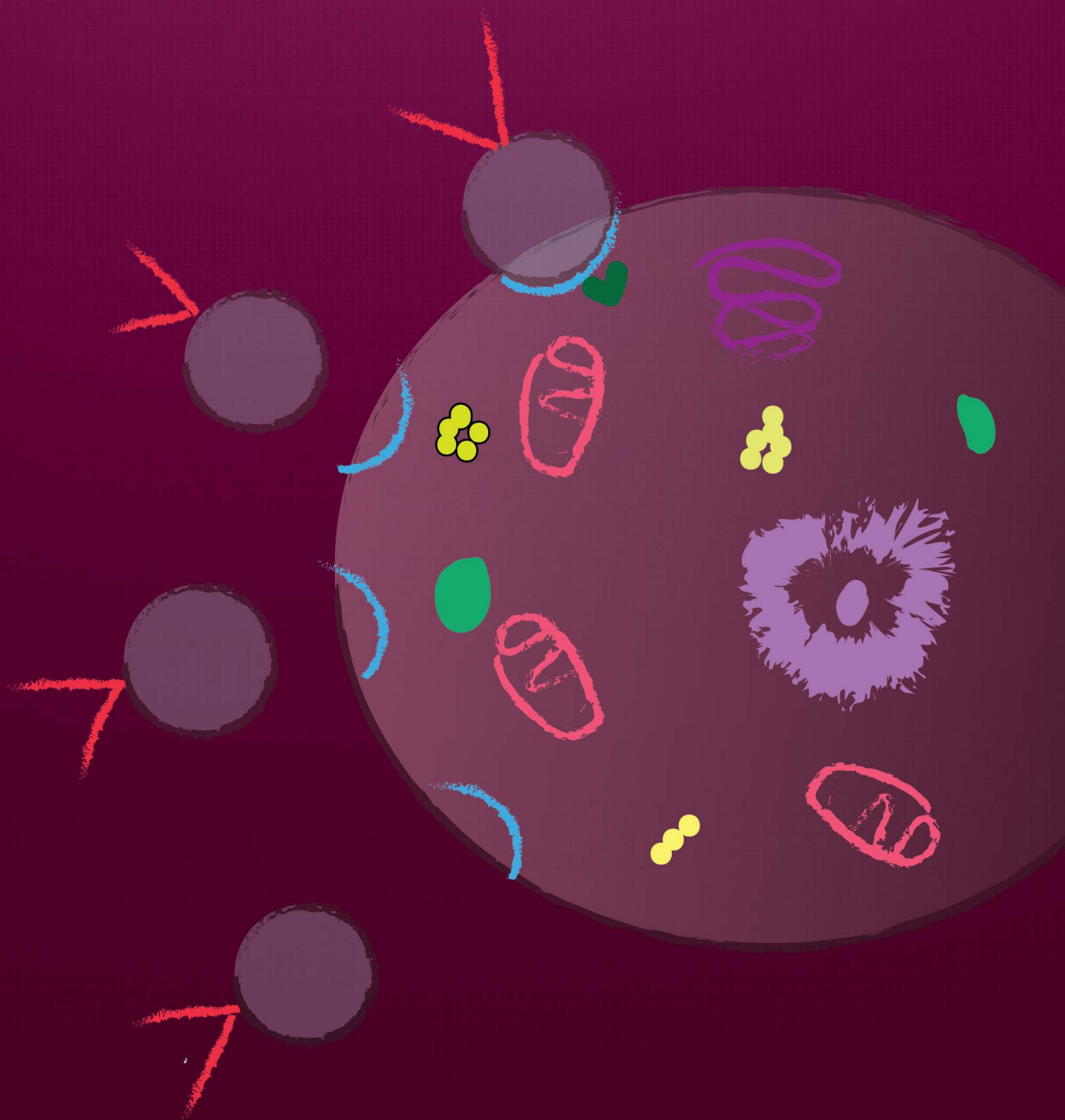


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# Contents

## ORIGINAL ARTICLE

- Antifungal Activities of *Ziziphus mauritiana* against *Candida albicans*: In Vitro Study 1

*Hasnah Begum Said Gulam Khan, Nurul 'Izzah Mohd Sarmin, Mohd Hafiz Arzmi, Hanis Farhana Amiruddin, Anis Arina Mohd Radzi*

- Performance of dental undergraduate students using International Caries Detection and Assessment system (ICDAS) 13

*Noorharliana Mohamed Zohdi, Mohd Faiz Nasruddin, Muhammad Aiman Sanusi, Muhammad Atep Nordin, Mohamad Rahmatullah Rusli*

- Treatment Satisfaction and Its Influencing Factors Among Fixed Orthodontic Patients in UiTM 21

*Shamsul Shamil Bin Shamsul Fadzil, Ahmad Izzuddin Bin Ahmad Khalil, Indah Yuri Noviaranny, Nagham Mohammed Abdullah Al-Jaf, Jamil Ahsan Kazi*

- Evaluation of image quality of bitewing radiographs taken by UiTM dental students. 32

*Liyana Hazirah A Rasid, Safiyyah Razak, Afzan Adilah Ayoub, Marlena Kamaruzaman, Nurul Whahidah Azmi*

## CASE REPORT

- Managing Unexpected Iatrogenic Opening of Anterior Bite During Active Orthodontic Treatment: A Case Report. 44

*Nor Dayana Mohd Ali, Sarah Haniza Abdul Ghani*

- Submission Guidelines** 52

Cover illustration (by Dr. Nik Mohd Mazuan Nik Mohd Rosdy): Cell in Function

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Original Article

## Antifungal Activities of *Ziziphus mauritiana* against *Candida albicans*: In Vitro Study

Hasnah Begum Said Gulam Khan<sup>1,\*</sup>, Nurul 'Izzah Mohd Sarmin<sup>1</sup>, Mohd Hafiz Arzmi<sup>2</sup>, Hanis Farhana Amiruddin<sup>1</sup>, Anis Arina Mohd Radzi<sup>1</sup>

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### Abstract

Medicinal plants have been discovered and used in traditional medicine and pharmaceutical industries since centuries. In the current study, *Ziziphus mauritiana* leaves was used as it is rich with many biological active compounds such as flavonoids, polyphenols, saponins and tanins. Previous studies reported the antibacterial and antifungal effects of *Z. mauritiana* towards various microorganisms. However, the antifungal activities of *Z. mauritiana* methanol extracts on *Candida albicans* (Clinical and American Type Culture Collection Strains) have not been discovered extensively.

**Objectives:** Therefore, the aim of the current study is to investigate the antifungal activity of *Z. mauritiana* leaves methanol extracts against *C. albicans* ATCC strain and clinical isolate (from oral cancer patient).

**Methods:** Antifungal susceptibility test (AST) was performed using disc diffusion, minimum inhibitory concentration (MIC) and minimum fungicidal concentration (MFC) to determine the antifungal activity of methanol leaves extract of *Ziziphus mauritiana* against *C. albicans* ATCC and clinical isolates.

**Results:** The results obtained showed that there is no zone of inhibition seen from disk diffusion test for both strains. However, the minimal inhibitory and minimal fungicidal concentration showed that *Ziziphus mauritiana* methanol extracts was able to inhibit *C. albicans* clinical isolate but not ATCC strain at 500mg/mL.

**Conclusion:** The finding of this study suggests that that *Ziziphus mauritiana* leaves methanol extract showed promising results against *Candida albicans*. Thus, it can be used as a source for functional ingredients for pharmaceutical drug industries in-order to reduce or inhibit oral fungal infection.

**Keywords:** Antifungal, *Ziziphus mauritiana*, *Candida albicans*, plant extract

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### Introduction

Fungal infections are common throughout much of the natural world. In humans,

fungal infections occur when fungus invades our body and the immune system unable to destroy the fungus. Fungal infections are often caused by fungi that are common in the environment. One of the most common fungus is known as *Candida albicans* which normally lives as normal flora in human body, cause no harm and has symbiotic relationship with the host. According to Singh et al. (1), about 30% to

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50% human population carries *C. albicans* as their normal flora. However, under certain conditions, it becomes an opportunistic pathogen and can quickly transform from a harmless inhabitant of mucocutaneous tissues to a highly pathogenic organism capable of killing its host under the appropriate conditions. It can be harmful in some cases, such as imbalance of immune defence system, due to trauma or post-surgery. It may cause mucosal infection in healthy individual or produce systemic infection. In the oral cavity it is commonly associated with denture-related stomatitis and oral candidiasis. According to A Akpan et al. (2), oral candidiasis is an opportunistic infection of oral cavity. It appears as whitish to yellowish patches in the oral mucosa and usually predispose to elderly who wears denture, immunocompromised individual, poorly controlled diabetes mellitus, patients on corticosteroids or psychotropic therapy and those with impaired salivary gland. The risks also increase if patient does not take good care of the oral and denture hygiene. As claimed by A Akpan et al. (2), the incidence of *C. albicans* isolated from the oral cavity has been reported to be 45% in neonates, 45%–65% of healthy children, 30%–45% of healthy adults, 50%–65% of people who wear removable dentures, 65%–88% in those residing in acute and long term care facilities. 90% of patients with acute leukaemia undergoing chemotherapy, and 95% of patients with HIV.

Oral candidiasis, if left untreated may cause pain and discomfort, burning sensation and altered taste sensation. In some extreme cases, if the infection invades until the bloodstream, it may lead to severe infection and can cause fatality. Oral candidiasis is usually treated by topical antifungal medication such as

Nystatin, Amphoterecin B and Miconazole together with chlorohexide 0.12% mouthwash Pina G et al. (5). Chlorohexidine has antimicrobial properties and has been extensively used in medical and dental field. In dental field, chlorohexidine is commonly prescribed to patient with periodontal disease as antiplaque agent. It also used as irrigation material in root canal treatment due to its broad spectrum antibacterial and antifungal properties. However, chlorohexidine has its disadvantages which are brownish staining of the teeth and alteration of the taste sensation. In a study done by Lee JA et al. (3), a short term of salty taste impairment was observed with the use of 0.2% aqueous chlorohexidine solution. So, the ideally usage of chlorohexidine is 0.12% (<https://www.drugbank.ca/drugs/DB00878>). Plants are considered as natural products that has being widely used to treat various systemic and local diseases since centuries. Medicinal plants have attained significant source of potentially new chemotherapeutics regimen. Jujube or Bidara is a common name for *Ziziphus mauritiana*. It belongs to the genus *Ziziphus* and *Rhamnaceae* family. It has many benefits due to the presence of biological active compound in the leaves.

The therapeutics potential of *Z. mauritiana* has being reported in numbers of previous published scientific papers. It is used to treat various form of systemic (i.e. gastrointestinal and genitourinary tract related disease, diabetes, bronchitis and anaemia) and local diseases (i.e. skin infections, diarrhoea and fever) stated by Mishra et al. (4). Nonetheless, the leaves extracts contain antimicrobial or antibacterial potential against *S. aureus*, *B. cereus*, *S. pneumoniae*, *C. albicans*, *B. subtilis*, *P. vulgaris* and *E. coli* [Abdallah et al. (6) ; Ghasham A A et al. (7)], antioxidant effect [Abdallah et al. (6) ; Ghasham A A

et al., (7)], and treatment for ulcer (Siddharth P et al., (8)). However, to the best of our knowledge and extensive literature review search, the antifungal efficacy of methanol extract of *Z. mauritiana* on *C. albicans* have not yet been investigated extensively. Therefore, in this current study, we investigated the antifungal efficacy of methanol extract of *Z. mauritiana* on *C. albicans* strains. This study aims to reduce the usage of synthetically derived antifungal by determining the antifungal activities of the methanol leave extract of *Z. mauritiana*.

## Material and Methods

### Plant extract

*Ziziphus mauritiana* leaves powder was purchased from local supplier.

### Preparation of plant extract

First, 100g of the *Ziziphus mauritiana* leaves powder were weighted using electronic weighing machine. Then it was soaked in 500mL of methanol in a screw cap bottle covered with aluminum foil at room temperature on a shaker for 3 days. The solutions were then centrifuged at 9000rpm for 10 min using high speed centrifuge machine in-order to separate the sediment and the supernatant. The supernatant was filtered using Whatman filters paper No. 1 to get a clear filtrate and placed it into 50mL Falcon tube. The solvent was removed from the extract by using rotary evaporator. After that, it was stored in -80°C freezer for overnight prior freeze drying process. Eventually, the filtrate was freeze-dried up to 3 days until it became crystalized and finally the freeze-dried sample was stored at 4°C for further analysis.

### Fungal strains

The fungal used in this study was *C. albicans* from American Type Culture collection (ATCC) strain. The clinical strain was isolated from oral cancer patient, donated by Dr Mohd Hafiz Arzmi, from Kulliyyah of Dentistry, IIUM Kuantan. Both strains were kept in glycerol (25%) at -80°C freezer.

### Preparation of media

#### a) Sabouraud dextrose agar (SDA)

65g of SDA powder (Oxoid) was suspended in 1 litre of mili-Q water. The suspension was mixed together using magnetic stirrer and boiled using hot plate until it dissolved completely. Then, it was autoclaved at 121°C for 15 minutes. The sterilized agar was then poured into sterilized petri dishes and let it solidified inside biological safety cabinet (BSC). The plates were allowed to sterilize under Ultraviolet (UV) for 30 minutes before placed it inside sterile plastic bag and stored at 4°C chiller for further use.

#### b) Sabouroud dextrose broth (SDB)

65g of SDB powder was suspended in 500mL of mili-Q water. The suspension was mixed together and boiled using hot plate and a magnetic stirrer until it dissolved completely. Then, it was sterilized by autoclaving at 121°C for 15 minutes. The broth then dispensed into sterilized universal bottles. Finally, the broth was stored at 4°C chiller for further use.

### Preparation of fungal suspension

*C. albicans* ATCC and clinical isolate obtained from glycerol stock (-80 °C) were subcultured on Sabouraud dextrose agar (SDA) and incubated at 37°C for 18-24 hours. On the next day, colony morphology of the fungal tested were observed. Single colony from both cultures were taken for

Gram staining in-order to observe the cell morphology and also to ensure that the working cultures are not contaminated with other microorganism. Single colonies were also taken from both strains and inoculated in Sabouraud dextrose broth (SDB) for the preparation of fungal suspension.

Both fungal suspensions were incubated at 37°C for 18-24 hours. On the next day, the optical density (OD) reading at 625nm wavelength were adjusted for both cultures prior antimicrobial assay. The OD reading for both cultures were standardized between 0.14-0.2 which are equivalent to  $1.5 \times 10^6$ - $1.5 \times 10^8$  colony forming units (CFU)/mL for disc diffusion assay and minimal inhibitory concentration (MIC) respectively.

#### **Antimicrobial assay**

The antimicrobial assay of the methanol extracts of *Ziziphus mauritiana* leaves towards *C. albicans* were evaluated by antimicrobial susceptibility test (AST), minimum inhibitory concentration (MIC), and minimum fungicidal concentration (MFC).

#### **Antifungal sensitivity test (AST)**

Antifungal assay of methanol extract of *Ziziphus mauritiana* leaves were tested using disc diffusion method for both *C. albicans* ATCC strain and clinical isolate. SDA media was used for AST test throughout the study. 1gm/mL and 500mg/mL of *Ziziphus mauritiana* leaves methanol extract were used for AST test. SDA plates were divided into 4 quadrants and labeled with positive control, negative control, 500mg/mL and 1g/mL for each quadrant respectively. Fungal suspension as prepared in the previous paragraph (ATCC strain and clinical isolate;  $1.5 \times 10^6$  CFU/mL) were spread on SDA media using sterilized metal loop. Once the fungal spread dried, four wells were prepared

using cork borer size 6 mm in diameter to deposit the test samples. Freeze-dried methanol extract was used for the preparation of the stock. 1gm/mL of the freeze-dried extract was prepared in 1mL of 10% DMSO. The respective concentration of 500mg/mL was prepared by diluting the stock solution in two fold. Filtered chlorhexidine digluconate (0.12%) and 10% DMSO were loaded into the plate as a positive and negative control respectively. DMSO percentage used for this study was determined after the minimal inhibitory concentration test was conducted using a serial dilution of DMSO (starting from 100%) against both fungal strains tested. The plates were incubated at 37 °C for 18-24 hours. The diameter inhibition zone was measured in mm unit to evaluate the antifungal activity and the test were conducted in triplicate for each isolate. Aseptic technique was applied throughout the procedures.

#### **Minimal inhibitory concentration (MIC)**

Minimal inhibitory concentration (MIC) assay is used to identify the lowest concentration of the test sample to inhibit the visible growth of microorganism after 18-24 hours of incubation. In the current study, MIC assay was conducted using sterile 96 well microplates. The wells were labelled from well number 1 until well number 12. Firstly, 100µL of 1gm/mL methanol extract prepared in 10% DMSO was pipetted into the first well of each row as a starting concentration for MIC. 100µL of Sabouroud dextrose broth was pipetted into well number 2 up to well number 12 (from row A,B,C,E,F,G,H). After that, a two-fold serial dilution was performed by pipetting 100µL of the methanol plant extract from well number 1 into well number 2. The dilution was mixed well by up and down technique and this process repeated until well number 10. The

remaining 100µL of the extract dilution was discarded. Wells at row D left as a blank. Well number 11 pipetted with DMSO 10% (negative control) and well number 12 with 0.12% chlorhexidine (positive control). Then, 5µL of the standardized fungal suspension (as described in previous paragraph) was pipetted into well number 2 until well number 12. The same procedures were repeated for the blank but with the absence of fungal suspension. 100µL of Sabouroud dextrose broth was pipetted in well number 2 up to well number 10. 100µL of 1gm/mL methanol extract was pipetted into the first well for row A, B and C. Then, two-fold serial dilution was repeated same as previous microplates. These extract dilutions act as a control to be subtracted with the fungal-containing microplates to get the OD reading of the fungal itself by using microplates absorbance reader. All the test plates then incubated at 37°C for 18-24 hours. The growth of the tested fungal were observed on the next day. The well with the lowest dilution with no obvious growth of fungal by the naked eyes were considered as MIC value.

#### **Minimal fungicidal concentration (MFC)**

MFC is defined as the lowest concentration of antifungal that prevents the growth of fungal after subcultured on to antifungal-free media. Samples from MIC assay were used for MFC assay. Sample from each well that showed complete inhibition (optically clear well) same as positive control well were inoculated on sterilized SDA media. The SDA plates were divided into four quadrants and labelled. The aseptic technique was applied throughout the procedures. The SDA plates were incubated at 37°C for 18-24 hours. The quadrant with lowest concentration of the extract showed no fungal growth was considered as MFC.

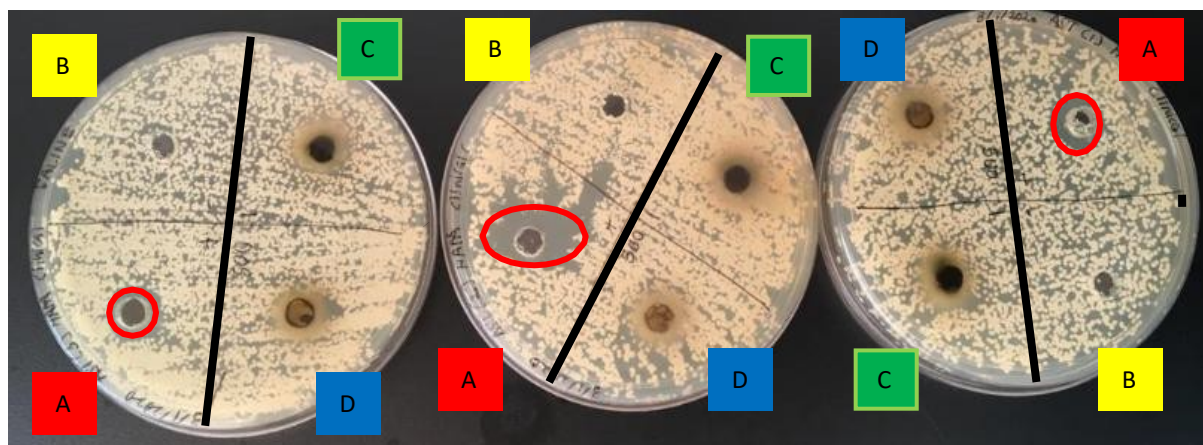
## **Results**

### **Antifungal Susceptibility Test (AST) of Methanol Extract of *Z. mauritiana* Leaves Against *C. albicans*.**

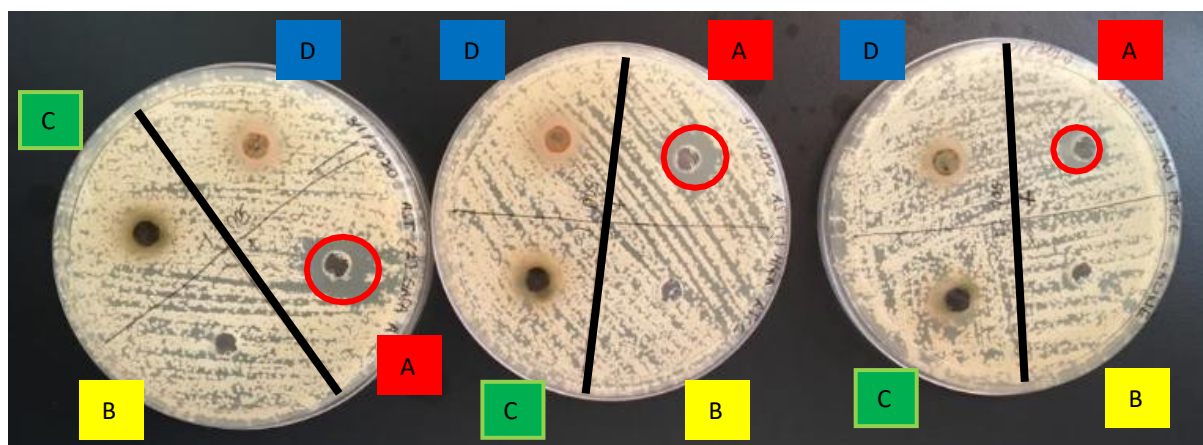
Antifungal assay was performed using disc diffusion method for *C. albicans* ATCC and clinical isolate strains respectively. Chlorhexidine (0.12%) and DMSO (10%) were used as positive control and negative control respectively. No clear zone of inhibition were observed in the presence of 500 mg/mL and 1 g/mL of methanol extract of *Z. mauritiana* leaves for both strains (Figure 1 and Figure 2). Table 1 and Table 2 shows the measurement of the zone for all tested samples. No clear zone were observed for negative control, 500mg/mL and 1gm/mL for both strain tested except for chlorhexidine (0.12%), which is the positive control with 26.667mm  $\pm$  0.653 diameter of inhibition zone.

### **Minimum Inhibitory Concentration (MIC) of Methanol Extract of *Ziziphus mauritiana* Leaves Against *C. albicans*.**

MIC test was performed in-order to obtain the bacteriostatic concentration of the methanol extract of *Z. mauritiana* leaves against both *C. albicans* strains using 96 well microplates. The results are shown in Figure 3 and summarized in Table 3. Based on the observation for ATCC strain (row A, B and C), all well starting from well number 2 until well number 10 shows turbidity which indicate the presence of fungal. This observation comparable to well number 11 (control negative). While, for clinical strain, well number 2 for row E, F and G did not show fungal sedimentation at the bottom of the plate or turbid broth which is similar to control positive well (well number 12). However, turbidity were observed for well number 3 until well number 10 which similar to well number 11 (control negative).



**Figure 1:** Antifungal susceptibility test of the methanol extract of *Z. mauritiana* leaves against *C. albicans* clinical strains. The Image shows the experiment done in triplicate for different concentration with the presence of positive and negative control.



**Figure 2:** Antifungal susceptibility test of the methanol extract of *Z. mauritiana* leaves against *C. albicans* ATCC strains. The image shows the experiment done in triplicate for different concentration with the presence of positive and negative control

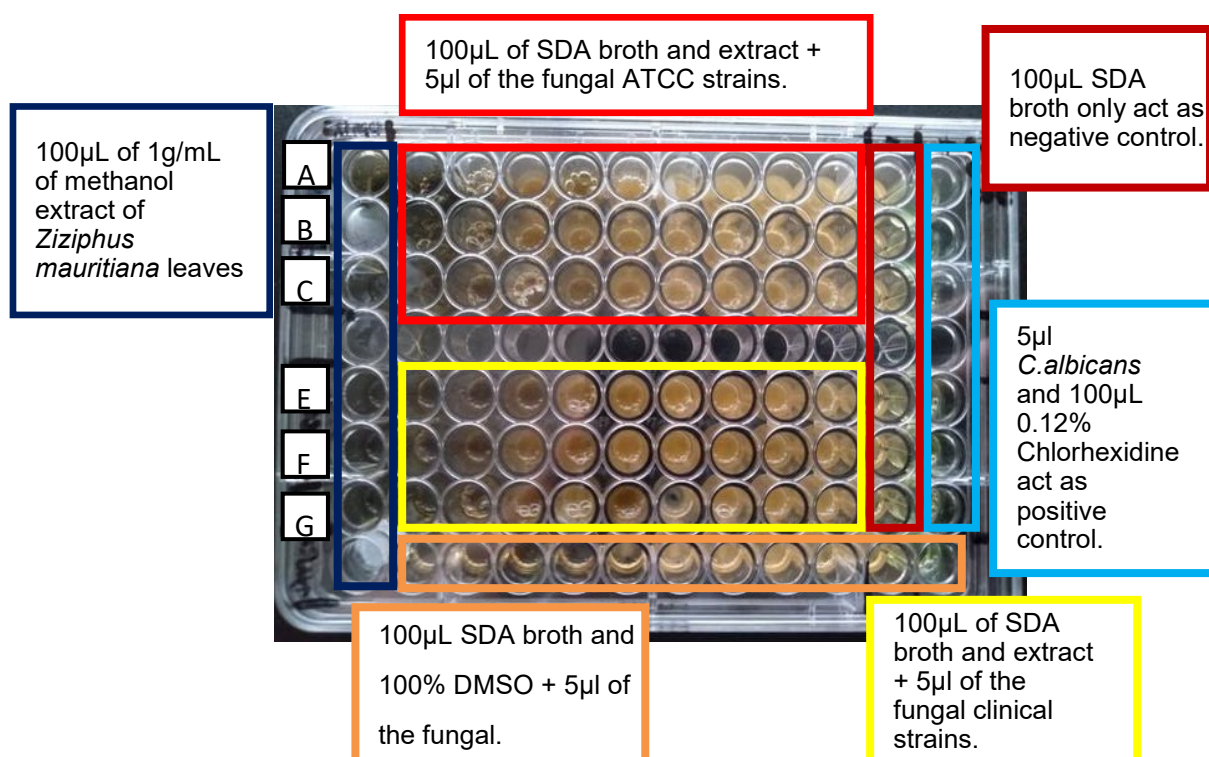
Indicator:	A	= 0.12% Chlorhexidine as positive control
	B	= 10% DMSO as negative control
	C	= 1g/mL methanol extract of <i>Z. mauritiana</i> leaves
	D	= 500mg/mL methanol extract of <i>Z. mauritiana</i> leaves

Organisms	Well		Zone of Inhibition (mm)			
			Plate 1	Plate 2	Plate 3	Mean (SD)
Clinical <i>C. albicans</i>	Positive Control	CHX	26	27	27	26.7
	Negative Control	10% DMSO	0	0	0	0
	<i>Z. mauritiana</i>	500 mg/ml	0	0	0	0
		1000 mg/ml	0	0	0	0

**Table 1:** Antifungal susceptibility test analysis showing zones of inhibition (mm) around the extracts at varying concentrations towards clinical strains of *C. albicans*.

Organisms	Well		Zone of Inhibition (mm)			
			Plate 1	Plate 2	Plate 3	Mean (SD)
ATCC <i>C. albicans</i>	Positive Control	CHX	26	27	27	26.7
	Negative Control	10% DMSO	0	0	0	0
	<i>Z. mauritiana</i>	500 mg/ml	0	0	0	0
		1000 mg/ml	0	0	0	0

**Table 2:** Antifungal susceptibility test analysis showing zones of inhibition (mm) around the extracts at varying concentrations towards ATCC strains of *C. albicans*.



**Figure 3:** MIC results of *C. albicans* observed through naked eyes from 96 well microplate



Plant extracts	Organism	Concentration of methanol extract <i>Z. mauritiana</i> (mg/ml)								
		500	250	125	62.5	31.25	15.53	7.81	3.91	1.96
<i>Z. mauritiana</i>	Clinical <i>C. albicans</i>	C	T	T	T	T	T	T	T	T
		C	T	T	T	T	T	T	T	T
		C	T	T	T	T	T	T	T	T
	ATCC <i>C. albicans</i>	T	T	T	T	T	T	T	T	T
		T	T	T	T	T	T	T	T	T
		T	T	T	T	T	T	T	T	T

Key: C = Clear

T = Turbid

**Table 3:** Minimum inhibitory concentration (MIC) result of methanol extract of *Ziziphus mauritiana* leaves against *C. albicans*.

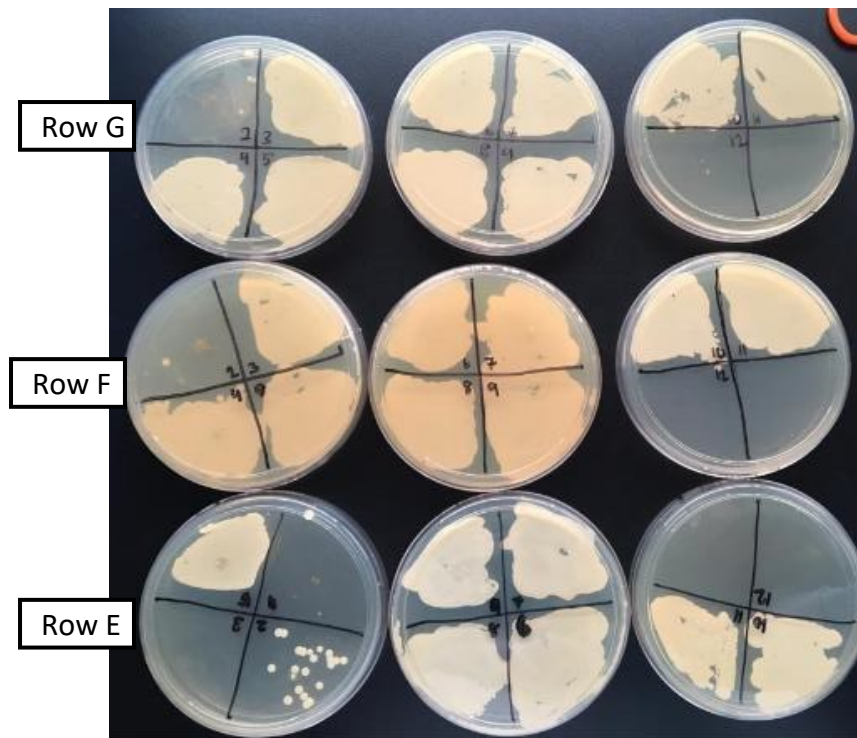
### Minimum Fungicidal Concentration (MFC) of Methanol Extract of *Z. mauritiana* Leaves Against *C. albicans*

Minimum fungicidal concentration was performed in-order to obtain bactericidal concentration of the methanol extract of *Z. mauritiana* against both *C. albicans* strains. MFC test was performed right after MIC test was completed. Samples from well 2 until well 12 were inoculated on a fresh media to detect any growth of the fungal. After incubated 18-24 hours, the results were observed on the media. In the current study, MFC test was performed not only for the well that is clear until the first well that showed turbidity but for all wells (well number 2 until well number 12) in-order to reconfirm the inhibition of fungal growth. The extract against *C. albicans* clinical strains showed inhibition of fungal growth only from the sample inoculated from well 2 for row F and G except for well 3 from row E (Figure 4). No inhibition were observed for *C. albicans* ATCC strains from row A, B and C (Figure 5). Based on both tests, MBC and MIC values are comparable at the concentration of 500 mg/mL against clinical strain of *C. albicans* and no inhibitory effect of *Z. mauritiana* was observed against *C. albicans* ATCC strains as interpreted in the Table 4.

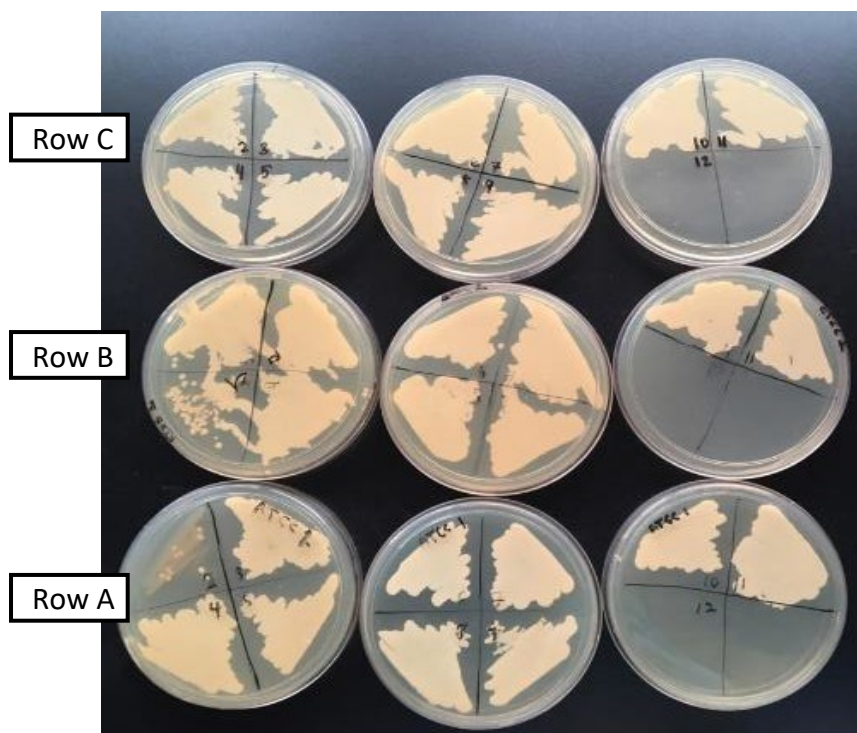
### Discussions

Medicinal plants have been used widely around the world since ancient time for the treatment of various diseases. World Health Organization reported that about 80% of the total population in the developing country depend on medicinal plant for primary health care needs (Oyebode O et al, (9)). Its popularity increases due to their availability, low cost and less side effect compared to the synthetically derived drugs. Medicinal plants also known to have varieties of active ingredients such as phenol, flavonoids, tannins and many more that shown to confer protection against various ailments. Thus, it plays a vital role in drug development. Therefore, the search for exploitation of natural products especially of plant origin, has greatly increased in recent years. In the current study *Z. mauritiana* or commonly known as 'Bidara' in Malaysia, was chosen due to its potential and phytochemical ingredient that benefit in treating numerous diseases. Besides that, *Z. mauritiana* are grown locally and we can easily purchase from local company in Malaysia. Previous scientific reports showed *Z. mauritiana* has antioxidant effect, antibacterial effect (Abdallah et al. (6); Ghasham A A et al. (7))





**Figure 4:** MFC of the methanol extract of *Z. mauritiana* leaves against *C. albicans* clinical strains.



**Figure 5:** MFC of the methanol extract of *Z. mauritiana* leaves against *C. albicans* ATCC strains

Plant extracts	Organism	Concentration of methanol extract <i>Z. mauritiana</i> (mg/mL)								
		500	250	125	62.5	31.25	15.53	7.81	3.91	1.96
<i>Z. mauritiana</i>	Clinical <i>C. albicans</i>	+	+	+	+	+	+	+	+	+
		-	+	+	+	+	+	+	+	+
		-	+	+	+	+	+	+	+	+
	ATCC <i>C. albicans</i>	+	+	+	+	+	+	+	+	+
		+	+	+	+	+	+	+	+	+
		+	+	+	+	+	+	+	+	+

Key: - = No growth

+ = Growth

**Table 4:** Minimum bactericidal concentration (MBC) of methanol extract of *Ziziphus mauritiana* leaves against *C. albicans*.

and antiulcer effect (Siddharth P et al., (8)). However the antifungal activities of the leaves extracts have not been extensively investigated in Malaysia.

Therefore, the current study was conducted using the methanol extract of *Z. mauritiana* leaves which is mainly grown in Malaysia and investigation on the antifungal activities of the methanol leaves extracted towards the *C. albicans* ATCC and clinical strains was performed. The antifungal study was performed using disc diffusion test for both *C. albicans* strains (ATCC and clinical strains). Based on the result from the figure 9 and figure 10, the inhibition zone cannot be seen surrounding the well loaded with 500mg/mL and 1g/mL of methanolic extract of *Z. mauritiana* for both *C. albicans* strains used in the study. The inhibition zone only can be seen around the positive control which is chlorohexidine 0.12% solution. The current study is comparable with a study done previously by Abalaka et al. (10). They found that antimicrobial test

conducted analysis showed no inhibition zone seen when tested with *Z. mauritiana* leaves extract. However, the different between their study and the current study is we used methanol as solvent whereas they used ethanol in the preparation of the extracts at various concentrations. Minimum inhibitory concentration (MIC) and minimum fungicidal concentration (MFC) was conducted to determine the lowest concentration that inhibits and kills the fungal respectively. In the current study, MIC and MFC was done on both selected strains (*C. albicans* ATCC and clinical strains) using 96 well microplates. Based on the result summarized in table 3, the MIC and MFC of the methanol extracts against the *C. albicans* clinical strain was at concentration of 500mg/mL but showed no inhibition against *C. albicans* ATCC strains. It shows that methanol extracts of the *Z. mauritiana* has the ability to inhibit *C. albicans* clinical strain only, but not *C. albicans* ATCC strains. Probably higher

concentration is required in-order to inhibit *C. albicans* ATCC strain. 500mg/mL may not enough to disrupt the cell wall or the growth of the ATCC strain. Abalaka et al. (10), reported that there is no bacteriostatic and bactericidal effects shown for MIC and MFC against *C. albicans* strain used for their study. However another study conducted in India reported moderate activities of the ethanolic and methanolic extracts of *Ziziphus mauritiana* leaves on *C. albicans* tested by Sivasankri et al. (11). Whereas, study conducted in Saudi on methanolic extracts of *Ziziphus mauritiana* on *C. albicans* strains by Gasham A A et al, (7) showed significant level of antifungal effect with the tested concentrations. Variation in the previous and current study may be due to the origin the *Z. mauritiana* trees. *Z. mauritiana* grown in different geographical location may exhibit different antimicrobial effects due to the presence of different active compounds. Study conducted by Abalaka et al. (10) in Nigeria on phytochemical screening of *Z. mauritiana* leaves extract shows the presence of various bioactive compounds such as cardiac glycosides, polyphenols, resins, saponins and tannin. Another study done in Malaysia by Hasnah et al, (12) on the phytochemical screening found that *Z. mauritiana* contain alkaloids, phenols, tannins, flavonoids, and saponin when extracted using methanol as solvent. Another study on the composition of *Z. mauritiana* also done in Malaysia reported the presence of various nutrients such as crude protein, fat, carbohydrates and crude fibers (Jailani FNAM et al., (13)). The presence of various active compounds in the *Z. mauritiana* leave extracts have great potential in the treatment of various human diseases. However, further studies are required in-order to gain more information on the bioactive components and the effect of *Ziziphus mauritiana* leaves extracts on

oral fungal infection as there are not many studies reported for this organism either in Malaysia or other countries. In addition, more studies regarding the mechanism and mode of action of this plant extracts are also required.

## Conclusion

In conclusion, the finding from the current study suggest that methanol extract of *Z. mauritiana* leaves has antifungal activity against the etiology agent of oral fungal infection mainly *C. albicans*. Thus, the information gained from this study, may be served as a source for development of new oral health care product especially in treating oral fungal infection. In addition, the result obtained from the current study can be used as reference by other researchers.

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Original Article

## Performance of dental undergraduate students using International Caries Detection and Assessment system (ICDAS)

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### Abstract

**Objectives:** This study aimed to assess intra- and inter-examiner reliability of International Caries Detection and Assessment System (ICDAS) and modified epidemiology ICDAS (MOD) code by undergraduate dental students with different clinical experiences.

**Methods:** A total of 150 dental undergraduate students with varying clinical experiences (0, 1 and 2 years of clinical experience) were recruited. Participants received training through a theoretical lecture on ICDAS criteria by an experienced National Benchmark Group (NBG) examiner and underwent e-learning program prior to ICDAS calibration. Visual examination on extracted permanent teeth (N= 45) with different location and stages of caries progression ranging from ICDAS scores 0 to 6, was performed using the ICDAS criteria. The assessments were repeated after one hour. The data were analysed to evaluate inter-examiner and intra-examiner reliability in the form of kappa scores using SPSS 23 Software.

**Results:** Mean kappa values for intra- and inter-examiner reliability for ICDAS code, were between 0.41 to 0.60, and 0.61 to 0.80 respectively. For MOD code, mean kappa values for intra- and inter-examiner reliability were between 0.61 to 0.80. Good intra-examiner agreement (>0.61) was observed in both ICDAS and MOD code for all groups.

**Conclusion:** All students performed similar agreement, therefore, clinical experience within 2 years does not influence the performance of visual inspection in detecting caries using ICDAS. The results of the study shows that ICDAS and modified epidemiology ICDAS codes has good reproducibility and is feasible to be used as a tool in clinical practice as well as patient education.

**Keywords:** ICDAS, caries detection, visual inspection, dental education

**Abbreviations:** ICDAS (International Caries Detection and Assessment System); MOD (Modified epidemiology ICDAS); NBG (National Benchmark Group)

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### Introduction

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Conventional caries detection method using Black's caries classification system has been widely used in general practice and teaching institutions since more than 100 years ago. The system uses a visual-tactile inspection aided by a sharp dental probe, relying on surface texture for

presence of caries and recorded cavitated lesion. This method of caries detection has been disproved as a diagnostic technique and shown to be unnecessarily damaging to tooth structure (Ekstrand et al., 1987; Lussi et al., 1993). Caries detection based on the World Health Organization (WHO) index has been used vastly in epidemiological settings but recorded caries at the level of cavitation (Nyvad et al., 2008). The WHO criteria decayed-missing-filled teeth/surfaces (DMFT/S) index neglects enamel non-cavitated caries, thus often lead to underestimation of caries experience and prevalence.

The International Caries Detection and Assessment System (ICDAS) has been introduced to improve the validity and reliability of visual caries detection methods (Ismail et al., 2007). This visual scoring system was developed to standardise caries detection procedures for clinical research, clinical practice, epidemiological surveys and education (Ismail et al., 2007). It relates the detection of lesion severity, assessment of lesion activity and monitoring of lesion behaviour over time (Pitts, 2009). This system combines components of various caries classification systems into one standard system by the use of a six-point scale that ranges from the earliest visible stage of enamel caries to extensive lesions with cavitation exposing dentine in order to describe caries severity stages (Topping et al., 2009).

In the past 30 years, there has been a gradual international shift towards minimal intervention dentistry (Tyas et al., 2000), which has been supported by the Fédération Dentaire Internationale. This approach is in line with the ICDAS since the system is based upon the modern evidence on cariology which enables the

concept of caries prevention and monitoring of a lesion. ICDAS has been shown to have acceptable values of sensitivity, specificity and reproducibility for detection of both early and more advanced carious lesions (Ismail et al., 2007; Cook et al., 2007; Jablonski-Momeni et al., 2008, Nogueira et al., 2017).

Diagnosing caries using ICDAS has now been accepted in many countries and is gaining acceptance. The European Core Curriculum in Cariology recommends ICDAS to be included in cariology curriculum in dental school (Pitts et al., 2011). Currently, dental educational institutes all around the world have shown interest in ICDAS within their dental curriculum; this includes dental schools in Europe, North and South America, as well as Asia. The ICDAS method has been shown to be easily adapted by dental students (Diniz et al., 2010; Jablonski-Momeni, 2012).

Malaysia has been slowly adapting ICDAS in dental schools and general clinical practice in the Ministry of Health. Implementation of ICDAS involves a theoretical learning module in the form of pocket lecture and e-learning package available on the International Caries Classification and Management System (ICCMS) website, to assist in the educating of students and clinician. This teaching resources includes the ICDAS protocols for caries detection and an element of testing to promote standardization of the use of the ICDAS codes. The training includes calibration of caries detection in which students or clinicians performed in-vitro examination on extraction teeth.

Our working hypothesis was that caries detection using ICDAS would be influenced by the examiner's clinical experience. The ICDAS caries detection method should

present a different reproducibility and reliability dependent on the examiner's expertise. To test this hypothesis, we aimed to assess intra- and inter-examiner reliability of International Caries Detection and Assessment System (ICDAS) and modified epidemiology ICDAS code by undergraduate dental students with different clinical experiences.

## Material and Methods

This study was approved by the committee for Ethics in Research, Faculty of Dentistry, Universiti Teknologi MARA, Malaysia.

### Sample selection and training

A total of 150 dental undergraduate students with different clinical experiences were grouped into 3 groups:

Group 1: no clinical experience (n:50)

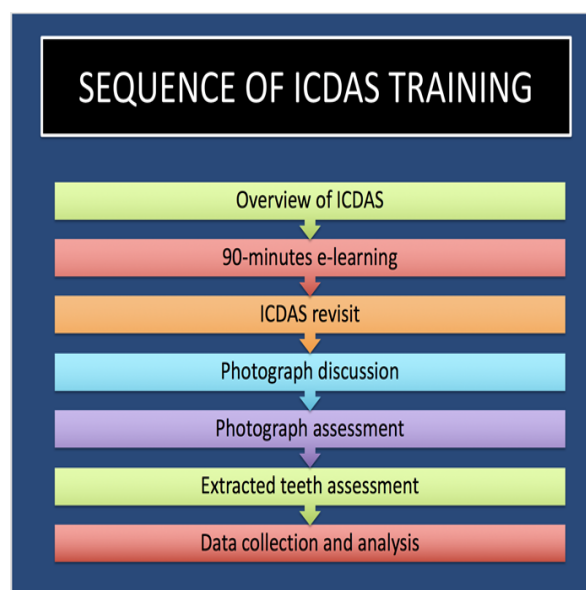
Group 2: 1-year clinical experience (n:50)

Group 3: 2 years clinical experience (n: 50)

Participants were introduced to ICDAS criteria in the form of lecture during pre-clinical year, underwent 90 minutes e-learning program and revision of ICDAS. Revision of ICDAS includes photograph assessment and discussion prior to the in-vitro extracted teeth assessment (Figure 1). This sequence of ICDAS training has been used to calibrate undergraduate students, dental clinicians and academics in most dental institutions in Malaysia.

### Visual examination and assessment

In vitro visual examination extracted permanent teeth (N= 45) with different location and stages of caries progression ranging from ICDAS scores 0 to 6, was performed using the ICDAS criteria. Prior to the calibration, these extracted teeth were



**Figure 1:** Sequence of ICDAS training. ICDAS training involves a theoretical learning module in the form of lectures and e-learning package, photographic assessment and discussion, in-vitro assessment and data analysis.

labelled and scored accordingly by the National Benchmark Group (NBG) trainers, a consensus between the calibrated NBG trainers was achieved in cases of disagreement. The same sets of extracted was used for each calibration. The examination was guided by black and white photographs of each lesion. A blunt WHO periodontal probe, dental mirror, triple air-syringe, operating light illumination, table of ICDAS codes and a score sheet were provided at each station. The surfaces of each extracted tooth were examined in wet and dry condition. Each examiner was required to score the lesion using ICDAS two-digit code (Table 1) and modified epidemiology ICDAS on the score sheet. Modified epidemiology ICDAS code is a modification of ICDAS caries code 1 and 2, in which it is scored as code A (Table 2). Assessments were repeated one hour after the first calibration to assess the intra-examiner agreement of each individual.



## Data management

All data were collected and saved in excel sheets and compared to the scores from NBG. The data were analysed to evaluate inter-examiner and intra-examiner reliability in the form of kappa scores using SPSS 23 Software. Inter-examiner kappa agreement is an agreement between individual and

NBG scores, whereas intra-examiner agreement is an agreement between the same individual in the first and second calibration. Both agreement for ICDAS and modified epidemiology ICDAS codes for inter and inter-examiner were calculated.

The inter and intra-examiner kappa agreement were classified into poor, fair,

ICDAS code	Criterion
0	Sound tooth surface: no evidence of caries after 5 s 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 dentine
5	Distinct cavity with visible dentine
6	Extensive (more than half the surface) distinct cavity with visible dentine

**Table 1:** ICDAS codes and criteria

MOD code	Criterion
0	Sound tooth surface: no evidence of caries after 5 s air drying
A	ICDAS code 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
	ICDAS code 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

**Table 2:** Modified Epidemiology ICDAS (MOD) codes and criteria



INTERPRETATION OF KAPPA SCORE	
Value	Details
<0.20	poor agreement
0.21-0.40	fair agreement
0.41-0.60	moderate agreement
0.61-0.80	good agreement
0.81-1.00	very good agreement

**Table 3:** Interpretation of kappa coefficient based on Fleiss and Cohen (1973)

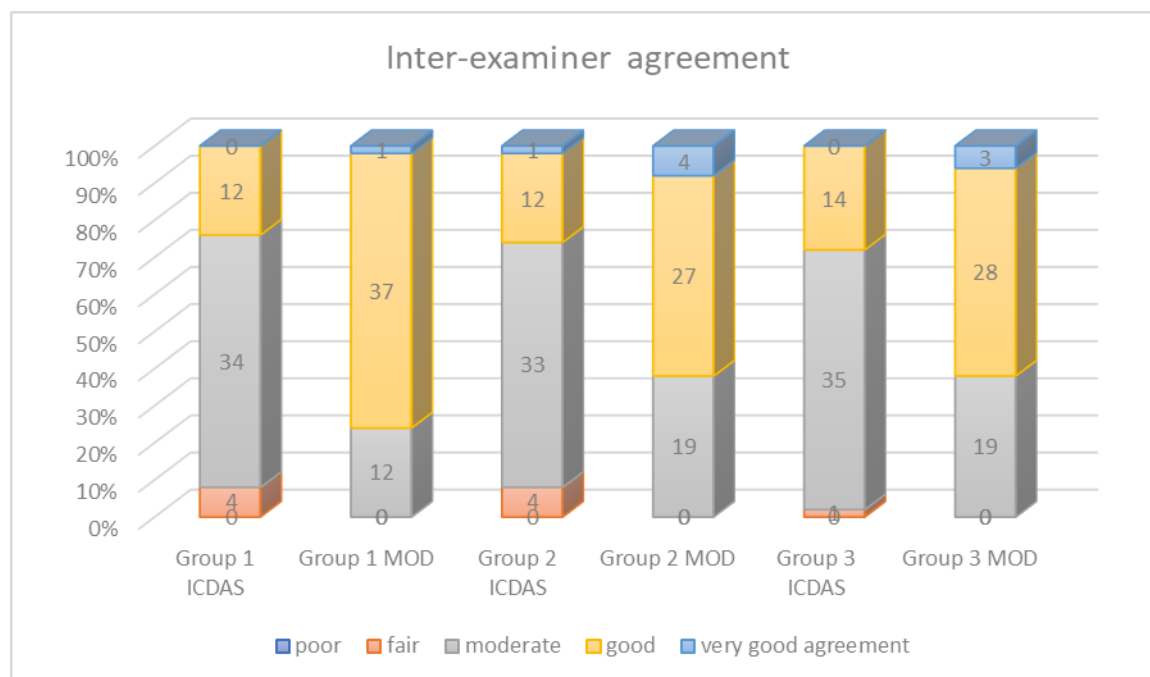
moderate agreement, good and very good agreement (Table 3) based on Fleiss and Cohen (1973) kappa interpretation. Good kappa agreement is achieved when the kappa value is more than 0.61 and moderate agreement is observed when the kappa value is between 0.41 to 0.60.

### Results and Statistical Analyses

A total of 150 dental undergraduate students with different clinical experiences (2 years, 1 year and no clinical experience)

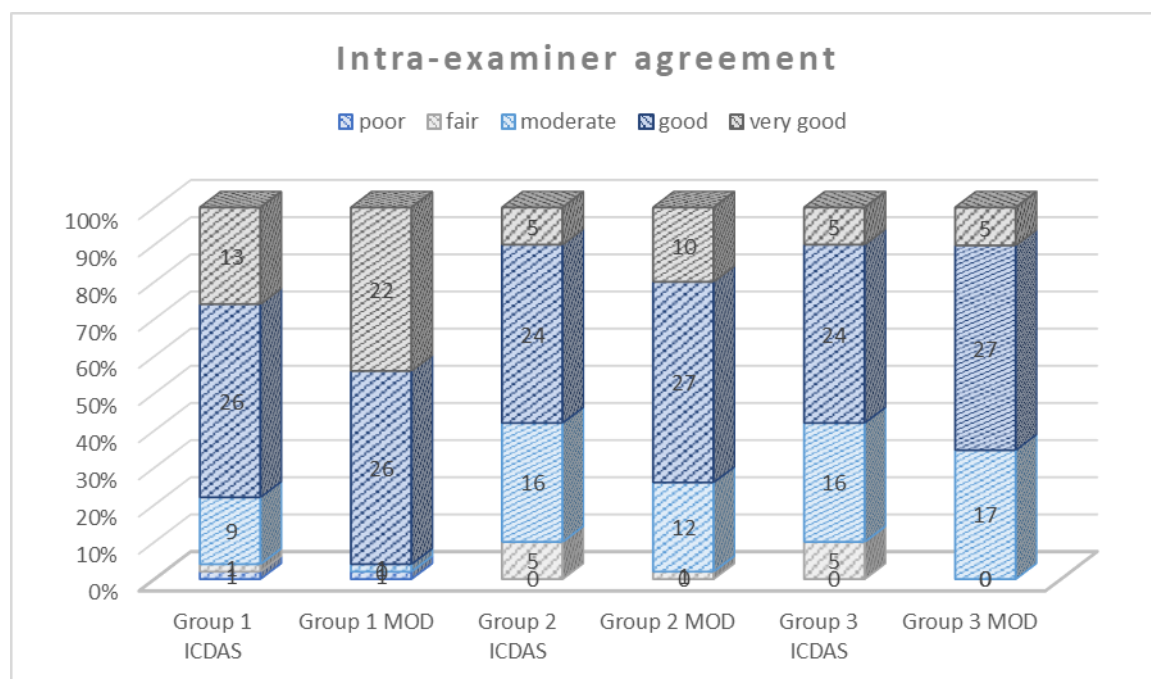
underwent ICDAS training and calibration. Students had no experience using ICDAS in vivo for all groups. Each student examined a total of 45 extracted teeth in vitro, 51 surfaces with varying severity of caries lesion ranging from sound to severe caries extension using the two-digit ICDAS and modified epidemiology ICDAS (MOD) code. On examination, 14% (n=7) was sound (ICDAS 0), 24% (n=12) had early enamel demineralisation (ICDAS 1 and 2, MOD code A), 27% (n=14) had moderate caries extension (ICDAS 3 and 4) and 35% (n=18) had severe caries extension (ICDAS 5 and 6).

Inter-examiner agreement was calculated by comparing the results of the benchmark (NBG) scores and the scores of examiners with different levels of experience, using kappa statistics. Inter-examiner agreement for ICDAS code showed moderate agreement with kappa value between 0.41-0.60, in 66% to 70% of students for all groups (Figure 2). Good inter-examiner



**Figure 2:** Inter-examiner agreement for ICDAS and Modified Epidemiology ICDAS (MOD)

Mean kappa value for inter-examiner agreement for ICDAS and MOD code were between 0.41 to 0.60 and 0.61 to 0.80 respectively.



**Figure 3:** Intra-examiner agreement for ICDAS and Modified Epidemiology ICDAS (MOD). Good intra-examiner agreement with kappa value more than 0.61, was observed in both ICDAS and MOD code for all groups.

agreement ( $>0.61$  kappa value) were reported for modified epidemiology ICDAS code in 76% of group 1 (no clinical experience), 62% of group 2 (1 year clinical experience), 62% of group 3 (2 years clinical experience) (Figure 2).

Good intra-examiner agreement was observed in both ICDAS ( $>58\%$ ) and MOD ( $>74\%$ ) codes for all groups. More than 74% students have good agreement in group 3 (2 years clinical experience) and 96% of students with no clinical experience when examining using modified epidemiology ICDAS code (Figure 3). Overall group 1 showed good inter-examiner agreement MOD (76%). Highest percentage of students in group 1 were observed with good intra-examiner agreement in both ICDAS and modified code, 78% and 96% respectively. However, all groups were observed to have moderate agreement (0.41-0.60 kappa value) in detecting caries using ICDAS.

## Discussions

Inter-examiner reliability of dental undergraduate students using ICDAS was found to be moderate, kappa value ranged between 0.41 and 0.6. This agreement is slightly lower compared to study reported by Ismail et al. (2007). The reliability of six examiners to classify tooth surfaces by their ICDAS caries status ranged between good to excellent, kappa coefficients ranged between 0.59 and 0.82 (Ismail et al., 2007). A systematic review by Ekstrand et al., (2018) reported reproducibility values were more than 0.60. However, assessment was performed by experienced clinicians in most of these studies.

All groups reported to have moderate agreement using ICDAS, however, good inter-examiner agreement ( $>0.61$  kappa value) was observed when modified ICDAS (MOD) code was used. In modified

epidemiology ICDAS (MOD) code, early enamel caries lesion (ICDAS code 1 and 2) is coded as MOD code A. Students were unable to differentiate ICDAS 1 and 2, when the caries lesion is at enamel level. However, this is acceptable as treatment options for ICDAS 1 and 2 involve preventive or non-operative treatment only. Intra-examiner agreement was higher compared to inter-examiner agreement. Good (0.61-0.80 kappa value) to very good (>0.80 kappa value) intra-examiner agreement was observed for all groups using ICDAS and MOD code. Students who had no prior clinical experience were very consistent in their assessment for both ICDAS and modified epidemiology caries detection.

Overall, mean kappa values for intra- and inter-examiner reliability for ICDAS code, were between 0.41 to 0.60, and 0.61 to 0.80 respectively. Jablonski-Momeni et al. (2012) reported mean kappa values for intra- and inter-examiner reproducibility were between 0.34 and 0.72 for predoctoral dental students. For MOD code, mean kappa values for intra- and inter-examiner reliability were between 0.61 to 0.80. Good intra-examiner agreement (>0.61) was observed in both ICDAS and MOD code for all groups.

## Conclusion

Caries detection using ICDAS performed by dental undergraduate students was observed to have moderate reliability for ICDAS codes and good reliability for modified epidemiology ICDAS codes. Good to excellent intra-examiner agreement indicated that this caries detection system has good reproducibility. ICDAS criteria seem to be instinctively understood by students without clinical experience, even though most of these students had never

before seen a carious tooth. All students performed similar agreement, therefore, clinical experience within 2 years does not influence the performance of visual inspection in detecting caries using ICDAS. A step by step training and calibration is imperative for students and clinician prior to the use of ICDAS for caries detection in-vivo, on patients. The results of the study shows that the International Caries Detection and Assessment System (ICDAS) and modified epidemiology ICDAS (MOD) code has good reproducibility and is feasible to be used as a tool in clinical practice as well as patient education. This tool can also be used by clinicians with minimal or no clinical experience.

## Conflict of Interest/Funding

None declared

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Original Article

## Treatment Satisfaction and Its Influencing Factors Among Fixed Orthodontic Patients in UiTM

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### Abstract

**Objectives:** The aims of this study were to evaluate patient's satisfaction regarding the orthodontic treatment provided by the Faculty of Dentistry Universiti Teknologi MARA (UiTM) and to determine the factors that affected their satisfaction level.

**Methods:** : A cross-sectional study was conducted among the patients treated with full fixed appliances in the faculty's orthodontic clinic using a validated questionnaire.

**Results:** : The final sample consisted of 105 subjects (response rate 76%) which comprises of 26 males and 79 females were chose with 97% of the respondents are Malay. Most subjects had orthodontic treatment duration of more than 1.5 years (100%) and were still wearing fixed appliances (89%). Items included in the questionnaire: reasons for seeking orthodontic treatment, questions relevant to satisfaction with orthodontic treatment, doctor-patient relationship and pain experience during orthodontic treatment. Concerning the doctor patient relationship, 91% of the respondents were contented with their orthodontist. Respondents answered 'Yes' to the treatment plan explained prior to the procedure (91.4%), questions answered promptly (94.3%), gentleness of the orthodontist (91.4%) and dental assistant (88.6%), orthodontist honesty about treatment duration (90.5%) and cost (97.1%), and recommendation to others (90.5%).

**Conclusion:** Generally, patients who had received orthodontic treatment from the orthodontic clinic in Faculty of Dentistry UiTM were satisfied with the overall treatment outcomes. However, there were still some aspects of the service that can be improved in the future in order to provide a better healthcare services specifically in orthodontic treatment.

**Keywords:** : Treatment Satisfaction, Orthodontic Treatment, Malaysia, Questionnaire

**Abbreviations:** UiTM (Universiti Teknologi MARA)

### Introduction

The Faculty of Dentistry, UiTM has started its dental services to the community in Shah Alam in 2008. In 2015, the faculty

has moved to Sg Buloh Campus which can be classified as an urban area with multiracial communities surrounding the vicinity. The new building and facilities offer a wide range of services, brand new laboratories and pre-clinical facilities with the latest technology equipment together with the state-of-the-art clinical facilities. The epoch of clinical governance and patient partnership in delivering high quality oral healthcare, it is necessary that

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patients' concerns and opinions are dealt with applicably. Patient satisfaction is an individual's appraisal, of the extent to which the care provided has reached that individual's expectations and preferences <sup>[1]</sup>. One of the most important goals of delivering dental care is assisting patients in their attempts to have an acceptable level of satisfaction with their overall oral cavity and dentition <sup>[2]</sup>.

Patient satisfaction is an important aspect in the assessment of the overall quality of life and providing quality dentistry <sup>[3]</sup>. Dento-facial problems which affect patients' function, performance, and aesthetics have known to shape patients' satisfaction with their dentition <sup>[4,5]</sup>. In the past, functional demands were the main attentiveness in dental treatment. Nowadays, the focus has shifted toward dental aesthetics. Among the treatment options offered for those who seek better aesthetics, orthodontic treatment together with crowns, bleaching and tooth-colored restorations are the most desired one <sup>[6]</sup>.

Orthodontic, a specialty in dentistry that deals with the diagnosis, prevention, and correction of malpositioned teeth and jaws, can help in refining physical, psychological and social changes as well as improving the quality of life <sup>[7,8]</sup>. In a study, there has been reported high levels of patient satisfaction with dentition following orthodontic treatment <sup>[9]</sup>. Sinha et al. <sup>[10]</sup> stated that doctor-patient interaction is crucial in predicting patient satisfaction. Abrams and Ayers <sup>[11]</sup> also found that a good personal relationship between the operator, and the patient together with good quality of care towards the patient will avoid patient dissatisfaction. Burke and Croucher <sup>[12]</sup> stated that the most important factors in determining patient satisfaction are to explain well the procedure towards the patient, then

sterilization and sanitation, and the operator skills in third place.

Operator should explain using layman term that can be understood by the patients and their caregivers to keep motivate the patients and to avoid patient dissatisfaction. Hence, treatment goals can be achieved easier <sup>[13]</sup>. Patient satisfaction not only works as an indicator for the quality of dental services, it also is a part of the assessment of the total quality management policy of a dental center <sup>[14]</sup>.

Thus, this research is important to assess the treatment satisfaction and its influencing factors among fixed orthodontic patients in UiTM. The future findings can be utilized for appropriate measures to improve the quality and patient satisfaction involving fixed orthodontic treatment in UiTM.

## Methods and Materials

### Instrument

We have selected a questionnaire for our study. Part of the questionnaire used in this study were based on questionnaires from previous studies <sup>[7,9,15]</sup>. Each of the domain in the questionnaire was proven to assess each area of concern. It consists of demographic information, length of treatment, reasons for seeking orthodontic treatment, question pertaining to satisfaction with orthodontic treatment and services, doctor-patient relationship and patient experience during orthodontic treatment. This questionnaire is using a three-point Likert scale ranging from one (satisfied) to three (dissatisfied). This unipolar scale used includes the following choices: completely satisfied (one), moderately satisfied (two) and dissatisfied (three).

For validation of the translation, from English to Malay language, A pilot study was carried out on 10 randomly selected patients to test on the newly modified and adapted questionnaire whether the translated instructions and questions are clear and easily understood to avoid doubts in the respondents. Amendments, enhancements and improvements were made according to the feedback collected. The linguistic validation of a questionnaire is not a direct nor medical/scientific translation of the original questionnaire, but the production of a translation, which is conceptually equivalent to the original and culturally acceptable in this study.

Adequacy of samples based on sample size calculator by Raosoft® Inc. ([www.raosoft.com](http://www.raosoft.com)), minimum recommended sample size is 100 samples with 5% margin of error and 80% of confident level based on current 572 active orthodontic patients in Faculty of Dentistry of UiTM, Sg Buloh.

Study sample includes participants from 14 to 37 years age group and patients who had received oral health care provided by Faculty of Dentistry, UiTM. All the patients were treated with full fixed appliances with a minimum length of 18 months of treatment. Case treated solely with removable or functional appliances will be excluded. This is done to prevent any bias due to the generally shorter treatment duration with removable appliances and longer time with functional appliances.

### Statistical Analysis

Quantitative variables were presented as mean  $\pm$  standard deviation, and qualitative data were presented as number and frequency. Data analysis was performed using mean and standard deviation and Chi-square test (IBM SPSS Statistics for

Windows, Version 26.0. Armonk, NY: IBM Corp).

### Ethical Considerations

The Research Ethics Committee of the Universiti Teknologi MARA has approved this study (REC/248/19). The informed consent process was approved on the basis of the questionnaire is being anonymous and self-administered and containing no identifiers. A Patient Information Sheet was attached to the questionnaire to explain the purpose of the study and to ensure respondent confidentiality. Anyone who was also interested in learning about the result of this study was able to request a copy through the contact address provided in the questionnaire.

### Results

The data obtained were entered into Microsoft Excel spreadsheet (2016) and Statistical Package for the Social Sciences software (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp). The data were processed and calculated for qualitative and quantitative data.

### Demographic Characteristics of the Respondents

Demographic characteristics of the respondents surveyed are revealed in Table 1. A total of 105 respondents were divided into 24.8% males and 75.2% females. Most of the respondents are Malay (97.1%) with 98.1% of the respondents practice Islam. 90.5% of the respondents are single and the rest are married (9.5%).

Out of the 105 respondents, 21-25 years

Characteristics	n		Percentage (%)	
<b>Gender</b>				
Male	26		24.8	
Female	79		75.2	
<b>Ethnicity</b>				
Malay	102		97.1	
Chinese	-		-	
Indian	-		-	
Others	3		2.9	
<b>Religion</b>				
Islam	103		98.1	
Christian	2		1.9	
<b>Marital status</b>				
Single	95		90.5	
Married	10		9.5	
<b>Age (y)</b>				
14-15	1		1.0	
16-20	16		15.2	
21-25	75		71.4	
26-30	10		9.5	
31-35	2		1.9	
36-37	1		1.0	
Mean	22.8		-	
SD	3.188		-	
Range	14-37		-	
<b>Duration of treatment (y)</b>				
≥1.5-<2.0	46		43.8	
≥2.0-<2.5	28		26.7	
≥2.5-<3.0	11		10.5	
≥3.0-<3.5	11		10.5	
≥3.5-<4.0	1		1.0	
≥4.0-<4.5	2		1.9	
≥4.5-<5.0	1		1.0	
≥5.0	5		4.8	
<b>Status of fixed appliance</b>				
Still wearing	93		88.6	
Debonded for 0-1 year	7	12	6.7	11.4
Debonded for 1-2 years	5		4.8	

**Table 1:** Demographic characteristics of respondents.



age group was the most dominated group (71.4%) followed by 16-20 age group (15.2%). Mean age of the respondents was 22.8 years (SD  $\pm 3.188$ ). Most of the respondents (88.6%) are still wearing the fixed appliance. Most of the respondents were treated with more than 18 months and less than 24 months of duration (43.8%).

### **Reasons for Seeking Fixed Appliance in Orthodontic Treatment**

As illustrated in Figure 1, the most common reason for seeking orthodontic treatment answered by the respondents was crowded teeth (73.3%), followed by protruding teeth (15.2%). 3.8% of the respondents claimed of having spaces between teeth, protruding jaws and other small problems as the reason for having orthodontic treatment. None of the respondents had seek for the treatment because of speech and eating difficulties.

Majority of the respondents had themselves recommended for the treatment by their own (69.5%), followed by suggestion by their friends and relatives (22.9%) and their parents (7.6%). None of the respondents answered recommendation for treatment by their dentist. Referral pattern is shown in Figure 2.

### **Orthodontic Treatment and Services**

Table 2 exhibits responses by the respondents to questionnaire items pertaining to orthodontic treatment and services. From the total of 11 questions answered from this section, the highest satisfaction percentage was recorded on the staff service (95.2%). A high rate of patient satisfaction with cost of treatment (88.6%) was also recorded.

Regarding treatment outcomes, it was also found that 77.1% of the respondents were satisfied with the improvement in alignment of teeth, other than improvement in general face appearance (73.3%) and teeth cleaning (65.7%). The least treatment outcome satisfaction was recorded in the improvement of chewing (58.1%).

In pertaining to time, 65.7% of the respondents were satisfied with total duration of treatment, number of appointments per month and waiting duration of waiting time before each appointment. 77.1% of the respondents were satisfied with the duration of each appointment.

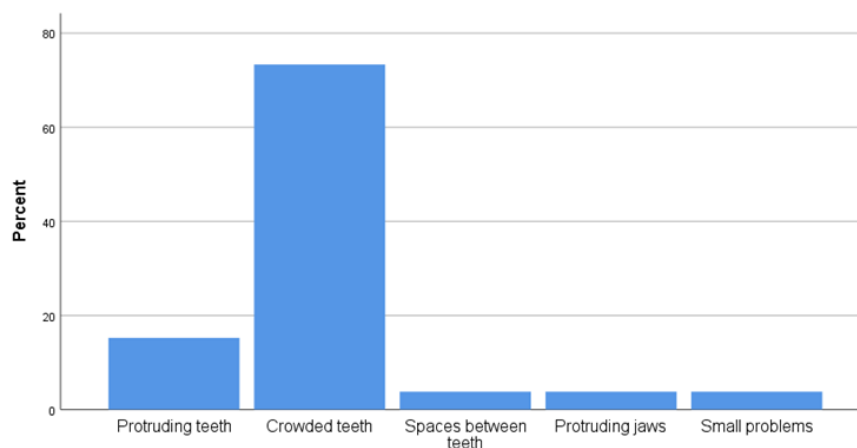
Concerning self-esteem, a total of 92 respondents (87.6%) were aware of the positive impact on their self-confidence from the orthodontic treatment.

Regarding experience of pain in the dental clinic, 18.1% of the respondents answered 'Yes' and 30.5% answered 'Sometimes'. While at home, 18.1% of the respondents experienced pain and 39.0% occasionally as shown in Figure 3.

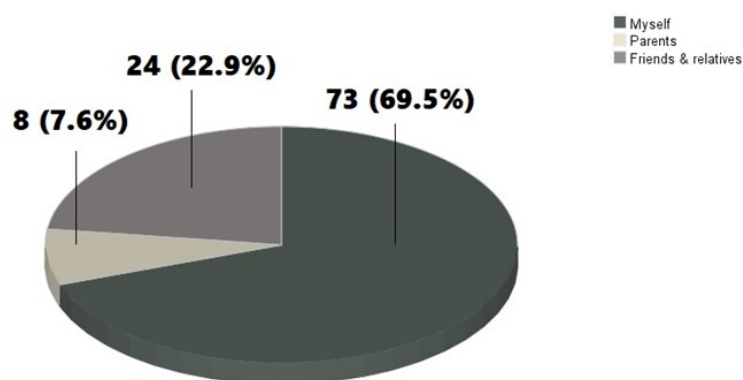
### **Doctor-Patient Relationship**

In a question asking about respondents' satisfaction towards their orthodontist, 91.4% of the respondents reported being satisfied with their orthodontist, while 8.6% answered "Sometimes".

In response to questions regarding doctor-patient relationship, 91.4% of the respondents stated that their orthodontist explained the treatment plan to them prior to the orthodontic treatment. Questions they had during the appointments were answered promptly (94.3%). Pertaining to gentleness during treatment, 91.4% of the respondents stated their orthodontist was gentle when treating them. Most of the



**Figure 1:** Reasons for seeking orthodontic treatment.



**Figure 2:** Who suggested orthodontic treatment for you?

Items	Response to questionnaire					
	Satisfied		Neutral		Dissatisfied	
	n	%	n	%	n	%
Improvement in alignment of teeth	81	77.1	24	22.9	-	-
Improvement in general face appearance	77	73.3	28	26.7	-	-
Improvement in chewing	61	58.1	40	38.1	4	3.8
Improvement in teeth cleaning	69	65.7	24	22.9	12	11.4
Total duration of treatment	69	65.7	24	22.9	12	11.4
Number of appointments per month	69	65.7	24	22.9	12	11.4
Duration of each appointment	81	77.1	24	22.9	-	-
Waiting duration before each appointment	69	65.7	24	22.9	12	11.4
Cost of treatment	93	88.6	12	11.4	-	-
Staff service	100	95.2	5	4.8	-	-
Increase on self confidence	92	87.6	13	12.4	-	-

**Table 2:** Responses to questionnaire items regarding orthodontic treatment and services.

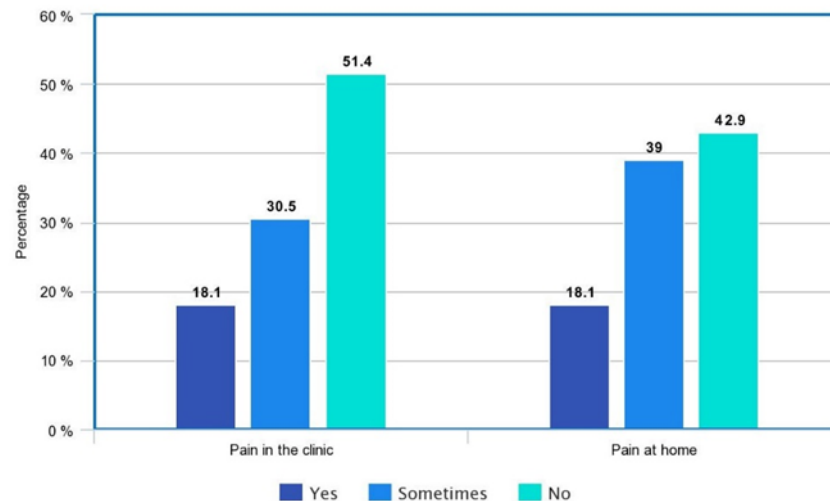


Figure 3: Percentages of responses regarding pain experience

respondents (88.6%) also reported that dental assistants were gentle while treating them.

Concerning orthodontist honesty in issues about treatment duration, 90.5% of the respondents answered “Yes”. 97.1% of the respondents also stated that their orthodontist were honest about treatment cost. 90.5% would recommend their orthodontist to others while 1.9% answered “No” and 7.6% answered “Sometimes” (Table 3).

### Chi-square test

Chi-square test was used to determine whether there is significance difference in

responses in relation to patient satisfaction after orthodontic treatment. Chi-square test indicated no statistically significant between gender and reasons for seeking orthodontic treatment in relation to the treatment satisfaction. However, there is a statistically significant between the age of the respondents and treatment satisfaction.

All the respondents were divided into two groups (Table 4) considering patient’s satisfaction with his/her orthodontist in relation to their responses pertaining to the doctor-patient relationship. Group 1 which consisted of 96 respondents who considered themselves satisfied with their orthodontist, while Group 2 consisted of 9 respondents who considered themselves

Items	Response to questionnaire					
	Yes		Some-times		No	
	n	%	n	%	n	%
Orthodontist explained the treatment plan to me prior to the orthodontic treatment	96	91.4	8	7.6	1	1.0
Questions I had were answered promptly	99	94.3	5	4.8	1	1.0
Orthodontist was gentle when treating me	96	91.4	9	8.6	-	-
Dental assistant was gentle when treating me	93	88.6	12	11.4	-	-
Orthodontist was honest in issues concerning treatment duration	95	90.5	9	8.6	1	1.0
Orthodontist was honest in issues concerning treatment cost	102	97.1	3	2.9	-	-

Table 3: Responses to questionnaire items regarding doctor-patient relationship.

	Group 1 (n=96) Satisfied with their orthodontist						Group 2 (n=9) Sometimes satisfied with their orthodontist						X <sup>2</sup> (P)
Items	Yes		Some-times		No		Yes		Some-times		No		
	n	%	n	%	n	%	n	%	n	%	n	%	
Orthodontist explained the treatment plan to me prior to	90	93.8	6	6.3	-	-	6	66.7	2	22.2	1	11.1	14.082 (.001)
Questions I had were answered promptly	95	99.0	1	1.0	-	-	4	44.4	4	44.4	1	11.1	45.812
Orthodontist was gentle when treating me	96	100.0	-	-	-	-	-	-	9	100.0	-	-	105.000
Dental assistant was gentle when treating me	89	92.7	7	7.3	-	-	4	44.4	5	55.6	-	-	18.936
Orthodontist was honest in issues concerning treatment	91	94.8	5	5.2	-	-	4	44.4	4	44.4	1	11.1	27.751 (.000)
Orthodontist was honest in issues concerning treatment	94	97.9	2	2.1			8	88.9	1	11.1	-	-	2.416 (.120)

**Table 4:** Comparison between two groups of respondents regarding doctor-patient relationship.

occasionally satisfied with their orthodontist.

By comparing the two groups using chi-square test revealed that a statistically significant difference was found between the two groups regarding the treatment plan explained to them prior to the orthodontic treatment ( $P=.001$ ), questions they had were promptly answered ( $P<.001$ ), gentleness of the orthodontist and dental assistant when treating them ( $P<.001$  and  $P<.001$  respectively) and orthodontist's honesty pertaining to treatment duration ( $P<.001$ ). Orthodontist's honesty about cost of treatment between the two groups revealed no statistically significant difference.

## Discussions

Respondents involved in this study were mainly Malay (97.1%) and female (75.2%).

Most of our respondents are single (90.5%) and within the age group of 21-25 years old (71.4%). This shows that females are likely to seek for orthodontic treatment more than males.

Pertaining to orthodontic treatment outcomes, this study revealed high proportion of respondents who were satisfied with their teeth alignment (77.1%), general face appearance (73.3%), improvement in chewing and teeth cleaning capabilities (58.1% and 65.7% respectively) after the treatment. Least satisfaction from the chewing improvement might be contributed by the dentition condition of the patient and duration of treatment received. Crowded teeth topped the list of the reasons our respondents seek for fixed appliance (73.3%) and majority of our patients have a treatment duration of less than two years (43.8%).

Large distribution of respondents also claimed that orthodontic treatment has level up their self-esteem level (87.6%). Compared to other impacts from the treatment, it was the highest recorded by the respondents. These results are consistent with the results in other studies<sup>[16,17]</sup> which demonstrated esthetic consideration as the main deliberation for respondents to seek for orthodontic treatment over other considerations. Known for a crucial feature (face) in the development of one's self-esteem and self-image, researchers noticed that the patients were more focused on the esthetics than anything else such as functioning<sup>[18,19]</sup>.

Regarding services offered by the orthodontic clinic, the highest satisfaction was recorded by the respondents on staff services (95.2%), followed by cost of treatment charged by the clinic (88.6%). Pertaining to time, 77.1% of the respondents were satisfied with the duration of each appointment. However, 11.4% of the respondents were dissatisfied with the total duration of treatment and waiting duration during each appointment. The same percentage were also dissatisfied with the number of appointments arranged during each month. These were probably due to the large number of patients seen per day.

This study also identified that 18.1% of the studied subjects experienced pain during the process of orthodontic treatment and the same proportion also experienced pain at home. Concerning gender, the present results revealed no difference in pain perception and experience in the clinic and at home between males and females.

Another important key in patient's satisfaction in addition to professional performance is the doctor-patient relationship<sup>[10]</sup>. Professional performance

or skills alone which will results in excellent treatment outcomes is not enough in determining patient satisfaction. As stated by Abrams and Ayers<sup>[11]</sup>, they observed that a good personal relationship between the operator and the patient together with good quality of care towards the patient will avoid patient dissatisfaction. This study demonstrated a high number of patient satisfaction with their orthodontist (91.4%). This satisfaction was contributed by the procedure well explained to the patient by the orthodontist (91.4%), questions they had during the appointment were answered promptly (94.3%), gentleness of orthodontist and dental assistant while treating them (91.4% and 88.6% respectively) and orthodontist were honest in issues pertaining to treatment duration and cost (90.5% and 97.1% respectively).

Finally, some of the limitations identified in this study were that the sample size for the study population was small, respondents have receiving treatment of less than 18 months and those who have their fixed appliance removed for more than 2 years.

## Conclusion

To conclude, generally the patients who received their fixed orthodontic treatment in Faculty of Dentistry Universiti Teknologi MARA (UiTM) were satisfied with their treatment. However, some aspects of the service need to be improved especially pertaining to doctor-patient relationship in determining patient satisfaction in the future.

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Original Article

## Evaluation of image quality of bitewing radiographs taken by UITM dental students.

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### Abstract

**Objectives:** To evaluate the quality of bitewing radiograph taken by Universiti Teknologi MARA (UiTM) dental students during daily clinical practices and to evaluate the difference in caries lesions found on bitewing radiographs and clinical examination.

**Materials and method:** 120 patients who attended the undergraduate dental clinic for dental examination were included in this study. The inclusion criteria were patients within the age range of 17-45 years old, possessing at least three sets of posterior teeth, with bitewing radiographs taken by undergraduate dental students. The number of caries lesions detected by clinical examination, bitewing radiographs, and a combination of both methods were recorded. The quality of 240 bitewing radiographs was classified into three categories; excellent, acceptable, and unacceptable. The frequency of radiographic errors; foreshortening/elongation, horizontal overlapping, inadequate film coverage, non-ideal centering and inadequate contrast and density were also evaluated.

**Results:** The quality of bitewing radiographs are mostly accepted to be used as a diagnostic tool and one of the factors which commonly affected the quality of the bitewing is the overlapping of adjacent teeth. The highest number of caries lesions were detected radiographically (74%) compared with 25% caries by clinical examination. The majority of radiographs (71%, n=171) were deemed to be of acceptable quality, 39(16%) were excellent, and 30(13%) were diagnostically unacceptable. "Horizontal overlap" was the most common error detected on the radiographs (n=139, 57.9%), followed by "non-ideal centering" (n=93, 38.8%), "inadequate contrast" (n=46, 19.2%) and "inadequate film coverage" (n=24, 10%). The highest number of caries lesions were detected radiographically (74%) compared with 25% caries by clinical examination.

**Conclusion:** The quality of the majority of bitewing radiographs taken by undergraduate dental students in this institution is acceptable. However, given that more than half of the radiographs possessed horizontal overlapping error, caries diagnosis may have been underestimated. Further training and periodic audits are required to reduce the percentage of errors in bitewing radiographs amongst undergraduate dental students.

**Keywords:** Bitewing radiograph, undergraduate dental students, caries, horizontal overlapping, radiographic diagnosis

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### Introduction

The dental literature is rife with numerous published guidelines and position statements outlining recommendations for promoting safety and effectiveness of



diagnostic oral radiography (Hewitt et al. 1989; Horner 1994; Espelid et al. 2003; American Dental Association 2006; Callaghan et al. 2007; Hart et al. 2009). There is good evidence that initial posterior bitewing radiographs are required for all new dentate patients over five years of age with posterior teeth (Horner et al. 2004; Goodwin et al. 2017). This procedure is required as an adjunct to clinical examination for the detection of caries on both the approximal and occlusal surfaces of the teeth (Pitts 1996). Bitewing radiography remains the recommended method of choice for caries diagnosis and treatment planning in most circumstances.

A good quality bitewing radiograph with minimal errors not only reduces the need for re-exposures, but also forms an essential part of caries diagnosis. The relationship between film/sensor, cone and tooth projects a consistent parallel orientation and reliable interpretation. Radiography involves, not only identifying the presence and nature of pathoses but also characterizing and differentiating normal structure. Various studies support the importance of using visual and clinical examination in combination with bitewing radiographs to increase detection of interproximal caries (Scarfe et al. 1994; Muhammed et al 1982). The use of film holders and beam-aiming devices have been shown to have several potential advantages in facilitating the procedure of taking a proper radiography by minimizing improper positioning or bending of the film and maintaining the relationship of film to the considered structures. Despite the evolution of dental radiology, the transition from conventional to digital radiography has not reflected an increase in image quality. Only a small percentage of dental radiography has achieved a satisfactory level of image quality (Svenson et al. 1994;

Emanuel et al. 2003). Ideally, 90% of radiographs should be of diagnostically acceptable standard or above, although minor errors that do not alter the diagnostic value are excusable (Emanuel 2003). This maintains the principles of ALARA (As Low as Reasonably Achievable) and therefore reduces the total amount of radiation attributable from dental sources. This study aimed to evaluate the quality of bitewing radiographs taken by Universiti Teknologi MARA (UiTM) undergraduate dental students and to evaluate the difference in caries lesions found on bitewing radiographs and clinical examination.

## Materials and Method

### Study design

This is a prospective cross-sectional study assessing bitewing records within the Faculty of Dentistry, Universiti Teknologi MARA (UiTM) over a 7-month period from June to December 2017. All UiTM undergraduate dental students are required to complete 49 hours of face-to-face comprehensive didactic module series on Oral and Maxillofacial Radiology. The topics involved range from radiation physics and protection, to techniques and interpretation of diagnostic images, and are taught over the course of both pre-clinical and clinical years. The students are also provided with ICDAS training, which encompasses a minimum of 50 hours of face-to-face comprehensive didactic module series. This module is comprised of various topics including ICDAS charting, treatment planning, and deep caries management. Ultimately, the students are required to pass an ICDAS calibration test prior to proceeding to their clinical years. Ethics approval was obtained from the UiTM Research Committee (600-IRMI (5/1/6)-REC/105/17).

During their clinical training, the undergraduate dental students are allowed to prescribe and take intraoral radiographs pending approval by their clinical supervisors, which normally comprises of either trained general dentists or specialists. The criteria for prescribing bitewing radiographs are based on recommendations by the American Dental Association (ADA 2012), which includes new, dentate and partially edentulous adult patients. Recall patients with and without increased caries risk were recommended to have their bitewings taken at 6-18- and 24-36-months intervals respectively.

### Sample size calculation

To assess the quality of bitewing radiographs, a minimum sample size for number of bitewing radiographs was calculated using PS software for two proportions. The significance level was set at  $\alpha = 0.05$  with a statistical power of 80% and  $p_0 = 0.1$   $p_1 = 0.7$ . A minimum sample size of 240 bitewing radiographs were derived from the sample size calculation.

### Inclusion criteria

New patients who attended UiTM Dental Centre between June and December 2017 to be seen by Year 3-5 undergraduate dental students were entered into the study. The inclusion criteria were:

- The patients' age ranges from 17 to 45 years old
- The patient must present with a minimum of three completely occluding pair of posterior teeth
- Bitewing radiographs were taken by undergraduate dental students of UiTM Dental Faculty between June 2017 to December 2017

### Exclusion criteria

- Bitewing radiographs assisted or taken by non-undergraduate dental students. This includes postgraduate students, dental officers, radiographers and specialists.
- Patients with mixed dentition

### Data collection

Subjects were chosen among the patients that were treated by UiTM dental undergraduates from year 3 until year 5. Clinical examination was conducted by these undergraduate dental students, and teeth were charted according to The International Caries Detection and Assessment System (ICDAS). The operators (the undergraduate dental students) were briefed by the examiners (R.L.H and R.S) prior to performing clinical examination on their patients. Subject's teeth were cleaned with a toothbrush or prophylaxis cup, and clinical examination was done on dried teeth surfaces using mouth mirror and ball-ended explorer. Caries charting was entered by the researchers into a pro forma, specifically to record the number of caries lesions present clinically. If all inclusion criteria were met, the examiners noted down the subject's record number for bitewing radiograph assessment at a later time. The bitewing radiographs were taken by corresponding operators using an EzSensor Classic CMOS sensor (Vatech, Korea), positioned with the aid of a paralleling device (XCP-DS® Digital Sensors Holder, Dentsply, USA). Radiation exposure was generated with an X-MIND DC™ (Acteon, France) x-ray machine, which is maintained by a resident radiographer and calibrated twice yearly. The bitewing radiographs were stored on the EasyDentV4@ viewer software version 4.1.4.5 (Vatech, Hwaseong, Korea). If the subject did not meet the inclusion criteria (e.g: no indication for bitewing radiographs or insufficient number of

teeth), the examiners continued to approach the next available subjects until 240 bitewing radiographs were obtained. In total, 180 subjects were clinically examined, 120 of which met the inclusion criteria, providing 240 bitewing radiographs.

There were 2 parts in the data collection process:

1. Assessment of quality of bitewing radiographs
2. Comparison of caries detection between clinical examination and bitewing radiographs

### Assessment of quality of bitewing radiographs

The quality of bitewing radiographs was evaluated according to a modified version of the "Quality Standards for Bitewing Radiography" table published in the European Guidelines on Radiation Protection in Dental Radiology 2004 (Horner et al. 2004). Each bitewing radiograph was assessed based on three main categories of operator-induced errors; image geometry, anatomical coverage, and density and contrast. Specifically, presence of the following radiographic errors was identified:

- **Foreshortening or elongation:** A vertical angulation error resulting in images appearing shorter or longer than the actual object.
- **Horizontal overlapping:** A horizontal angulation error resulting in overlapping of proximal surfaces
- **Inadequacy of film coverage:** Any radiograph that did not cover the mesial surface of the most posterior erupted tooth.
- **Non-ideal centering:** Maxillary and mandibular alveolar bone crests not visible, and the maxilla and mandible are imaged unequally

- **Inadequacy of contrast and density:** Inadequate contrast and density to allow distinguishment between enamel and dentine even after image manipulation of software

Any errors that were not defined in the assessment, were assigned as "Others". Then, each bitewing radiograph was further classified into three categories of 'excellent', 'acceptable' and 'unacceptable' based on their image quality (Table 1). The number of radiographic exposures was also recorded.

Excellent	Acceptable	Unacceptable
No fault	Some fault but not affecting image interpretation	Fault leading to radiograph being unsuitable for interpretation

**Table 1:** Criteria Standard For Bitewing Radiograph Based On European Guidelines On Radiation Protection In Dental Radiology 2004(Keith Horner et al. 2004).

### Comparison of proximal caries detection by clinical and radiographic methods

For this part of the study, the following data were obtained:

- **Total caries detected clinically:** Total number of occlusal and proximal caries lesions recorded during clinical examination by undergraduate dental students
- **Total caries detected radiographically:** Total number of occlusal and proximal caries lesions visible on bitewing radiographs as recorded by examiners
- **Total caries detected clinically and radiographically:** Total number of caries lesions that were confirmed via

both clinical and radiographic examination

### Clinical method:

The data for “total caries detected clinically” were obtained from the pro forma filled by the examiners.

### Radiographic method:

For this part of the study, the number of caries lesions detected on bitewing radiographs were recorded into a pro forma. Caries lesion detection on the bitewing was performed according to the ICDAS/ICCMS<sup>TM</sup> radiographic scoring system. Caries was defined as any lesion seen radiographically that fits the RA 1 to RC 6 score.

- RA 1: Radiolucency in the outer ½ enamel
- RA 2: Radiolucency in the inner ½ of the enamel +/- enamel-dentine junction (EDJ)
- RA 3: Radiolucency limited to the outer 1/3 of dentine
- RB 4: Radiolucency reaching the middle 1/3 of dentine
- RC 5: Radiolucency reaching inner 1/3 of dentine
- RC 6: Radiolucency into the pulp

### Radiographic calibration

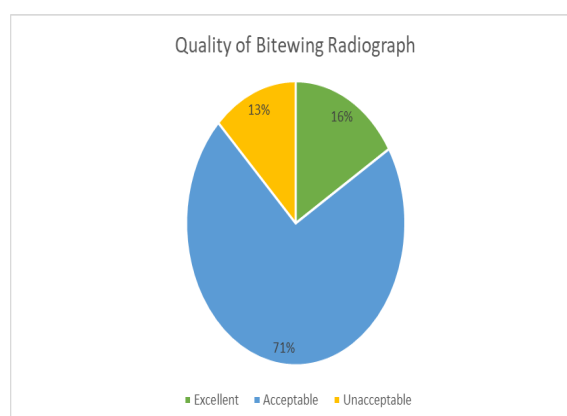
Two independent examiners (R.L.H and R.S) were calibrated by two observers, both of which were experienced endodontists. Forty-eight images were selected and viewed in a room with fixed ambient lighting. Calibration was performed in similar set-ups on two separate occasions, separated by a 14-day interval. The first examiner (R.L.H) assessed all bitewing radiographs whereas the second examiner (R.S) interpreted about 20% of the radiograph to determine interobserver agreement. Cohen’s kappa was used as a measure of reliability proving a good agreement ( $\kappa=0.709$ ) between observers.

### Statistical analyses

The quality of bitewing radiographs, and the data for caries detection between clinical examination and bitewing radiographs were expressed as frequencies and percentages. The intra-group difference for each radiographic error was assessed for statistical significance using chi-square test. Data analysis was done using SPSS (version 23.0 for Windows, SPSS Inc, Chicago, USA).

### Results

When 240 bitewing radiographs were analyzed based on their quality, 171(71%) of the bitewing radiographs were deemed to be of acceptable quality, 39(16%) were excellent, and 30(13%) were deemed diagnostically unacceptable (Figure 1). Of all the radiographs assessed, 90%(n=216) were taken without re-exposures. The remaining radiographs were taken with one (0.4%), two (8.4%), three (0.8%) and four (0.4%) re-exposures.



**Figure 1:** Quality of bitewing radiograph

Errors affecting the quality of the bitewing radiographs were shown in table 2. “Horizontal overlap” was the most common error detected on the radiographs (n=139,

57.9%), followed by “non-ideal centering” (n=93, 38.8%), “inadequate contrast” (n=46, 19.2%) and “inadequate film coverage” (n=24, 10%). There intra-group difference for each error was statistically significant ( $p=0.05$ ). No

foreshortening or elongation errors were reported in any radiographs.

The number of caries lesions detected radiographically (64.6%) was almost three-fold the amount diagnosed clinically (22.4%) (Table 3).

	Errors affecting quality of bitewing radiograph											
	Shortening or elongation		Horizontal overlap		Inadequate film coverage		Non-ideal centering		Inadequate contrast and density		Others	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
n	0	240	139	101	24	216	93	147	46	194	4	236
Percent%	0	100	57.9	42.1	10.0	90.0	38.8	61.2	19.2	80.8	1.7	98.3

**Table 2:** Factors affecting quality of bitewing radiograph

Total caries detected clinically		Total caries detected radiographically		Total caries detected clinically and radiographically	
n	Percentage	n	Percentage	n	Percentage
55	22.4	159	64.6	32	13.0

**Table 3:** Total caries detection by clinical examination and bitewing analysis

## Discussions

To aid correct patient diagnosis, an acceptable quality of radiograph is needed. The quality of a radiograph depends on a series of processes: positioning of the film or sensor within the patient's mouth; positioning of the x-ray tube; exposure factor setting; and the development of the exposed film. A fault or inadequacy in any of these processes will affect the image quality. In our study, radiographs were taken using a digital system, which allows post-exposure image manipulation, in addition to greater, if not equal dose reduction compared with conventional film radiography (Berkhout et al 2004). Furthermore, digital radiography also eliminates processing errors which has

been noted as the most significant contributor to repeat exposures in conventional film radiography (Button et al 1999; Yakoumakis et al 2001). This subsequently helps to reduce the number of unacceptable radiographs (Wenzel et al 2010), as evidenced in our results.

In the present study, the percentage of unacceptable radiographs (13%) corroborates with findings reported in a previous study conducted in the same institution (Yusof et al 2017). In the previous study, 15.1% of bitewing radiographs required re-exposure, the majority (56.7%) of which was due to operator errors. Upon comparison with other studies of similar objective, our percentage of unacceptable radiograph

(13%) is within the reported range of 5.5-36.8% (de Vries *et al* 1990; Kidd *et al* 1992; Machiulskiene *et al* 1999).

The number of unacceptable radiographs in our study not only averages the range reported in previous studies, but also compares with proposed achievable audit standards in general dentistry settings. The European Guidelines on Radiation Protection in Dental Radiology (Horner *et al.* 2004) acknowledges that no level of “unacceptable radiographs” should be tolerated and recommended that a fraction of no more than 10% of unacceptable radiographs should be targeted for. However, with an already low percentage of unacceptable radiographs in our study, undergraduate students should not be resting on their laurels. But instead, periodic audits should be conducted, focusing on the reasons and how to overcome errors, ultimately achieving a 50% reduction in unacceptable films at consecutive audit sessions (White *et al.* 1994). Re-training can also be proposed in an attempt to bring the percentage of rejected radiographs down to as low as possible.

Horizontal overlapping is a common error reported in bitewing radiographs (Marthaler *et al.* 1966; Haugejorden 1974; Sewerin 1981; Yusuf *et al.* 2017). It is an error that occurs due to failure of directing the positioning indicator device (PID) through the proximal surfaces of the teeth, giving rise to an image of horizontally overlapping contact points. A high number of overlapping error raises an issue in that, the number of actual caries lesions could have been underestimated. Shaw & Murray (1971) acknowledged this shortcoming, and categorised various overlaps based on their extent. In their study, the diagnostic threshold identified approximal caries only when it has reached the inner half of

enamel, ultimately underdiagnosing early enamel caries lesion. Conversely, setting a higher threshold for caries diagnosis to include enamel caries can also result in an overestimation of caries diagnosis. Rimmer *et al.* (1991) reported an increase of DMFT score from 1.7 to 4.7 when the diagnostic threshold for radiographic caries detection included all grades of caries lesion, as opposed to those involving dentine only.

In our study, the percentage of overlapping in radiographs is higher compared with that found in another study. Mourshed *et al.* (1971) analysed intraoral radiographs taken by undergraduate dental students and found that incorrect horizontal angulation manifesting as horizontal overlapping were present in 20.6% (652/3173) of radiographs. This percentage however, was calculated based on the total of periapical and bitewing radiographs. In another study, Haugejordan (1974) demonstrated that caries lesions extending beyond moderate overlaps could still be assessed despite the high number of overlapping present (30-40 %) in posterior teeth. This is perhaps a reassuring finding considering that although horizontal overlapping is not desirable, it is an error that cannot be consistently avoided even in the experienced hands of radiographers (Sewerin 1981).

“Inadequate contrast and density” was the third most common radiographic error (19.2%) in this study. For this parameter, a bitewing radiograph is noted as having “inadequate contrast” when post-exposure manipulation of the imaging software fails to allow discrimination between enamel and dentine. With the advent of digital radiography, this error should not occur unless if it is attributed to faulty exposure setting factors. Nonetheless, this observation highlights the need to reiterate the importance of confirming exposure

settings before radiograph taking amongst the undergraduate dental students.

In our study, the number of caries lesions detected via bitewing radiographs was three times that by clinical examination. This result corroborates with findings in another study which reported a three-fold increase of caries lesions detected with bitewing radiographs (de Vries 1990). However, an even larger difference has been documented. Poorterman et al. (1999) noted that, from a total of 1372 caries lesions, only 10.8% were detected clinically, of which, approximately eight times as many lesions were found radiographically (89.2%). In contrast, Machiulskiene et al. (1999) reported no significant difference between the mean number of cavitated caries lesion involving the dentine as detected by clinical ( $n=2.09$ ) or radiographic ( $n=2.94$ ) method. Although the difference in caries detection in our study may pose some questions on the precision of clinical caries detection amongst the undergraduate dental students, it must be borne in mind that there are limitations to radiographic examinations. This includes the fact that radiographs cannot discriminate between cavitated and non cavitated lesions (Nielsen et al 1996), let alone allow differentiation of active and arrested lesions. In fact, only 35-79% of radiolucencies in the one third or outer half of the dentine presents with cavitation clinically (Pitts & Rimmer 1992; Akpata et al. 1996; Hintze et al. 1998).

Since the introduction of the "lesion behavior" rather than the "lesion progression" concept, the way clinicians view the role of radiographs in caries management has been altered (Pitts & Rimmer 1992). Armed with the knowledge that carious process is a dynamic nature that exhibits interchanging phases of

demineralization and remineralization, various radiographic prescribing guidelines have since shifted their focus on monitoring caries lesion behavior, allowing clinicians to manage caries by preventive rather than interventive treatment (Pitts & Kidd 1992; Jenson et al 2007; American Dental Association 2012; Horner & Eaton 2013).

The European Guidelines on Radiation Protection in Dental Radiology (Horner et al 2004) indicates that, for a bitewing radiograph to have "adequate film coverage", the image must display distal surfaces of the canines to the mesial surfaces of the most posterior erupted teeth. However, issues of adequate film coverage with digital sensors has been raised previously. Bahrami et al. (2003) reported that fewer images produced with charge-coupled device (CCD) displayed canine and premolar surfaces than those by photostimulable phosphor plates (PSP), and this difference was statistically significant ( $p<0.05$ ). This limitation is attributed to the much bulkier and rigid nature of the CCD (compared with PSP and conventional film), thus requiring the sensor to be pushed further posteriorly to compensate for the patient's jaw anatomy and to reduce patient discomfort. In fact, conventional film and PSP plate were rated as the most comfortable receptors, demonstrating statistical significance of difference in visual analog scores (VAS) against CCD sensors ( $p<0.05$ ). For that reason, we modified the criteria for film coverage to include the mesial aspect of the most posterior erupted teeth to the most anterior points. In a majority of the bitewings assessed in this study, the general observation was that the anterior limit of the images often includes the mesial aspect of first premolars, and not as much the canine. However, this observation was not quantified, paving more room for improvement in future

studies alike.

In a systematic review that assessed the additional value of bitewing radiographs to clinical caries detection, data derived from seven studies included in the meta-analysis reported an increase of between 1.7 to 10% of extra approximal caries lesions detected with bitewings (Bloemendal et al 2004). This was observed when dentine was considered a diagnostic threshold i.e: enamel caries was not taken into account radiographically. When enamel caries (in addition to dentin) was included, the percentage increase of extra approximal caries detection rose to 13.6% (de Vries 1990). In our study, enamel was considered a diagnostic threshold i.e: enamel caries was included in the assessment, and 104(42.3%) additional caries lesions were detected with bitewing radiographs. The higher percentage in our study may be attributed to two reasons. Firstly, our study analyzed clinical and radiographic records performed by undergraduate dental students, whereby the experience in clinical caries detection varies based on their level of study and is inherently limited compared with that of general dental practitioners. In addition, our study included lesions as minor as incipient caries in the enamel during collection of radiographic data. These lesions are not as easily detected clinically, which explains the higher percentage of extra caries lesions detected radiographically compared to other studies (de Vries et al. 1990; Hintze et al. 1993; Machiulskiene et al. 1999; Poorterman et al. 1999,)

This study was conducted to assess the quality of bitewing radiographs taken by undergraduate dental students of UiTM, in addition to comparing the number of caries lesions detected by clinical and radiographic methods. The result shows overlapping as the most frequent error,

reflecting the lack of attention paid by the operator during tube head positioning, and perpetuating the importance of retraining. There are several limitations to this study. Firstly, the lack of dichotomization of data prevented us from assessing the difference between occlusal and proximal caries detected. Furthermore, intra-observer agreement was not calculated, thus putting into the question the examiner reliability. Should this study be repeated in the future, several changes should be made. This includes defining the diagnostic threshold when assessing radiographs with horizontal overlap to make the study more relevant and comparable to previous studies. In addition, recording visual analog scores (VAS) by patients during radiograph-taking could provide additional information with regards to acceptance of the specific sensor, thus a reflection on patient's comfort in digital radiography.

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Case Report

## Managing Unexpected Iatrogenic Opening of Anterior Bite During Active Orthodontic Treatment: A Case Report.

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### Abstract

**Introduction:** Orthodontic treatment even though managed and properly controlled, on some remote occasion may lead to presence of unwanted movement. Anterior open bite is one such example of an iatrogenic outcome. This article describes the management of an iatrogenic anterior open bite case that occurred in active orthodontic treatment in the early stage of leveling and aligning. A few modalities had been employed to manage the open bite through some artistic bends followed by the use of modified low transpalatal arch with extended looped arms with loops as well as orthodontic mini implants for distalisation and some intrusion mechanics. This case report is aimed to share authors' anecdotal experience on overcoming the open bite.

**Keywords:** Anterior open bite; anchorage; orthodontic mini implant

**Abbreviations:** AOB (Anterior open bite); DPT (Dental Panoramic Tomogram); MI (Miniscrew implant); Mm (Milimetre); Oz (Ounce); TPA (Transpalatal arch)

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### Introduction

Anterior open bite (AOB) is a condition when there is an open vertical dimension between the incisal edges of the maxillary and mandibular anterior teeth, while loss of vertical dental contact may exist between mainly the anterior with some premolar involvement (Subtelny, J.D., Sakuda, M., 1964). AOB can be classified as skeletal or dental open bite (Sassouni, V., 1969). Presence of AOB may lead to occasions such as deterioration of the occlusion,

mastication problems, speech difficulties and change in the appearance (Ngan, P., 1997; Kim, Y.H., et al, 2000).

Many modalities have been documented to manage open bite cases such as the tongue crib therapy, posterior bite blocks and magnets, posterior intrusion using skeletal anchorage functional appliances, headgears to inhibit the vertical maxillary growth, chin cups to hinder the mandibular growth, or anterior extrusion using intermaxillary elastics or orthognathic surgery (Cambiano, A.O., et al, 2018). However, the treatment of choice is subject to clinicians' preference case and patient suitability.

Anchorage is important in orthodontic treatment. It has been defined as

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resistance to unwanted tooth movement (Costello, B. J., et al, 2010; Profitt, W.R., et al, 2013). Orthodontic mini implants (MI) provides absolute anchorage and can be used to manage anterior open bite (Kuroda, S., et al, 2004). This case report describes methods and mechanics of overcoming an unwanted anterior open bite during an active orthodontic treatment for common sharing to benefit all.

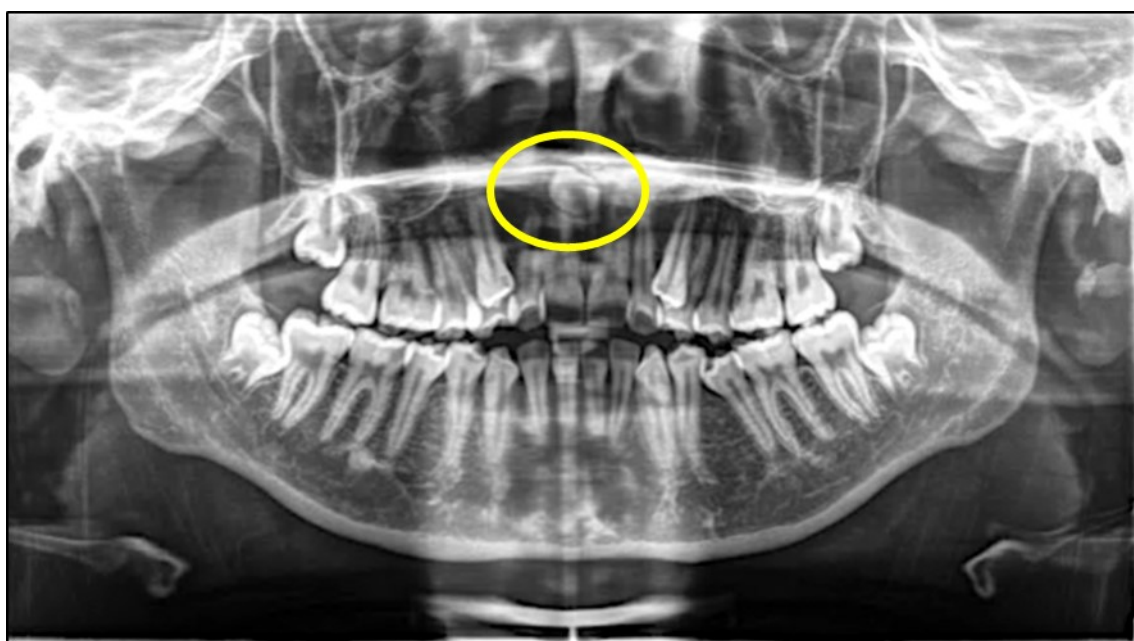
### Case Report

A.I., a 16 year old, Malay, young lady came to our clinic with a chief complain of overlapping teeth. She is asthmatic but currently under medication. She was presented with a Class II Division 1 incisor relationship on a Class 1 skeletal base with an average vertical proportion. Her malocclusion was complicated by the presence of supernumerary between the upper right and left central incisors, moderate crowding of the lower arch, severe crowding of the upper arch,

buccally erupted upper canines, increased overjet, minimal open bite of 1mm from the upper right second premolar to the contra-lateral second premolar, crossbites on the posterior without displacement, upper and lower centerlines shifted to the right by 1mm.

A.I. was treated with orthodontic camouflage in a single phase fixed appliances with surgical removal of the supernumerary as well as extractions of the upper first premolars and lower first molars (Figure 1). The Low Transpalatal arch (TPA) was prescribed as the anchorage reinforcement appliance.

The leveling and aligning phase took 6 months which resulted in an unexpected opening of the bite (from 1mm to 4mm) extending from the second premolar, anteriorly and to the contralateral second premolar even without continuously engaging the buccally erupted canines (Figure 2A). The AOB worsened due to the activation of the TPA while correcting the buccal crossbites and full engagement of



**Figure 1:** The dental panoramic tomogram (DPT) during pre-orthodontic treatment taken in January 2017. Note the presence of supernumerary (circled in yellow).

the upper canines. The AOB showed a symmetrical bowing effect from right to left. Both the upper and lower anterior teeth had proclined significantly with an overjet of 6mm which raised an alarming concern for both the operator and patient (Figure 2B).

At this stage (Figure 2B), mid treatment re-diagnosis of the mechanics was prompted and re-supervised to determine the cause of the AOB. An

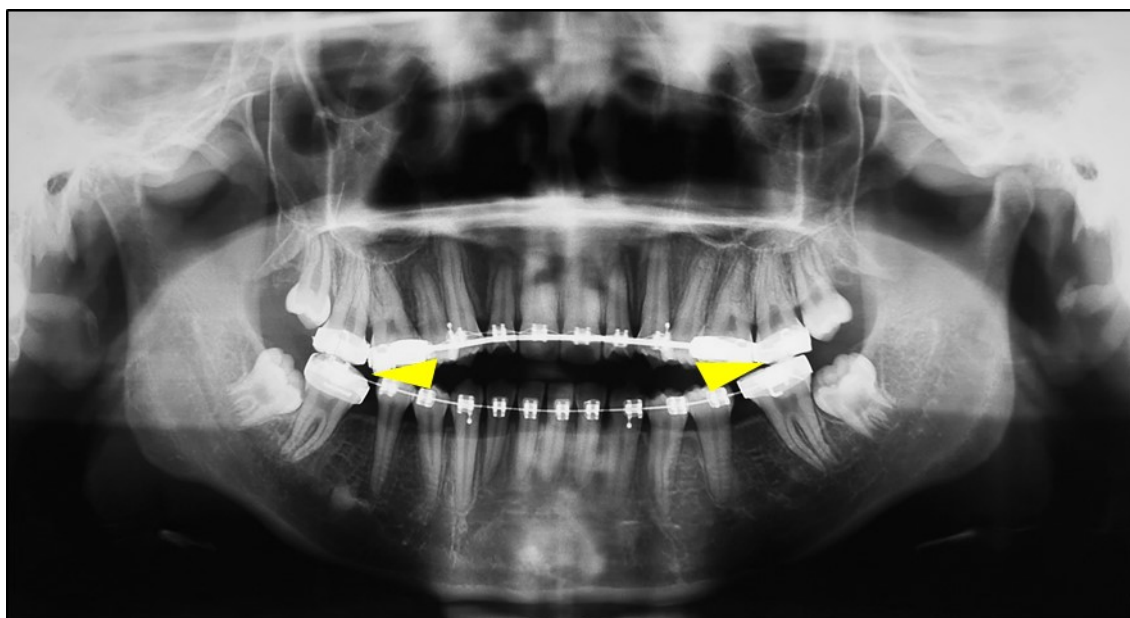
orthopantomogram was taken in June 2018 at mid-treatment to reassess the occlusal plane, parallelism of the teeth and possible points of teeth wedging (Figure 3). From the dental panoramic tomogram (DPT), the upper first molars was noted to be mesially angulated with the distal cusp plunging down out of the occlusal table, creating a wedge effect. Steps for immediate resolution was taken and outlined further in Phase 1, 2 and 3.



**Figure 2A:** Pre-treatment frontal view.



**Figure 2B:** Further opening of the bite (4mm) during leveling and aligning stage.



**Figure 3.** The dental panoramic tomogram (DPT) at mid-treatment. Note the presence of the magnitude of the wedge effect (yellow triangle).



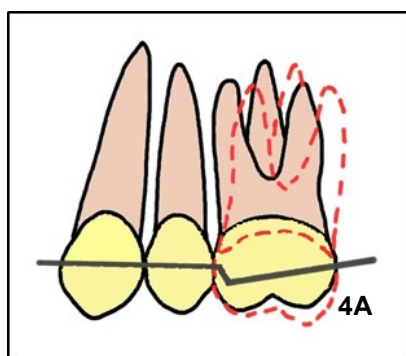
### Phase 1: Up-righting of the Upper First Molars and Reduction of the Anterior Open Bite

1. The AOB at this point was 4mm. Tip back bend of the upper first molars was introduced (Figure 4A). Upper and lower arch wires of 0.018 stainless steel were used.
2. Simultaneously, patient was instructed to use anterior box elastics (3.5oz) for full-time in the configuration of



(Figure 4B).

3. The upper second molars were excluded from the arch-wire at this point to allow maximum up-righting of the upper first molars. Patient was followed up after 3 months, the overjet and overbite was noted to be reducing steadily. The up-righting mechanics took 6 months (Figure 5).



**Figures 4A and 4B:** The Tip back bend to upright the first molars and the anterior box elastics.

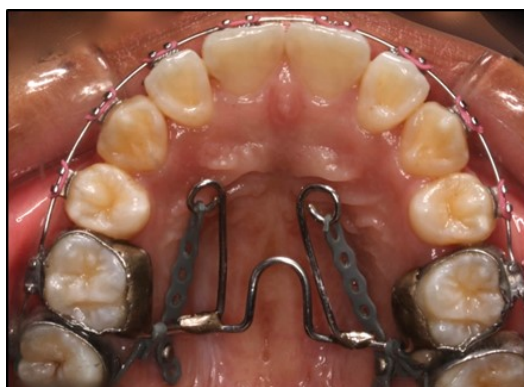
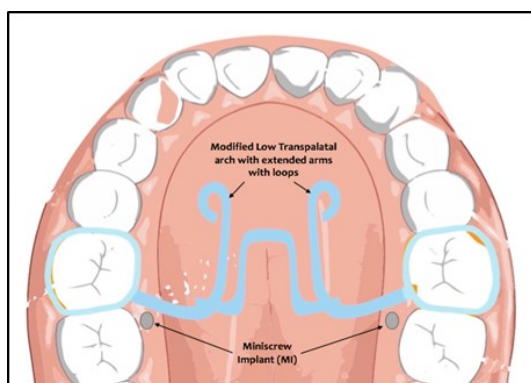


**Figure 5:** The dental panoramic tomogram (DPT) taken after the molar up-righting.

Note the reduction in the size of the wedge effect (orange triangle).

Phase 2: Modified Low Transpalatal arch and Molar Distalisation using the Orthodontic Mini Implants.

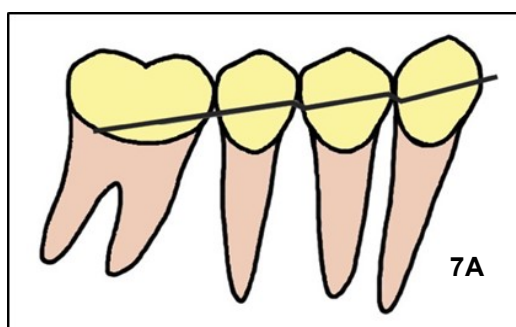
1. Removal of the upper third molars was planned to allow for distalisation of the upper arch.
2. Mini implant (ORLUS, Korea) was placed between the upper first and second molars at the palatal side.
3. Fabrication and cementation of the Modified Low TPA with extended looped arms anteriorly for distalisation and some intrusion effect (Figure 6A and 6B). The TPA was constructed using 1.0mm stainless steel, a rigid wire which prevented tipping of the teeth.
4. The upper and lower arch wires used were 0.018 stainless steel. Elastomeric chain was placed from the loops to the MIs to aid in the distalisation and was changed every month.
5. The upper second molars were up-righted through arch-wire after the removal of the third molars. Thus, this created some space to allow the first molars to be distalised via this modified TPA.



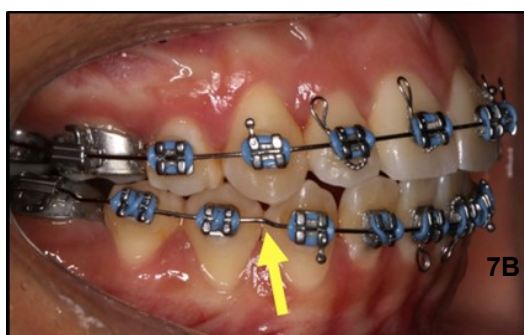
**Figures 6A and 6B:** The design of the Modified Low Transpalatal arch with loops used for distalisation with elastomeric chain in placed.

Phase 3: Distally Descending Multiple Tip Bends in the Lower Buccal Segment

1. A multiple artistic tip back bend ( 2<sup>nd</sup> order bend) with descending steps from the lower canines to the second molars on a 0.018 stainless steel wire was placed (Figure 7A and 7B).
2. The patient was instructed to continue using the anterior box elastics full time.
3. Note that the overjet has been reduced and there was an incisal overlap (Figure 8A and 8B). The treatment time took 1 year.

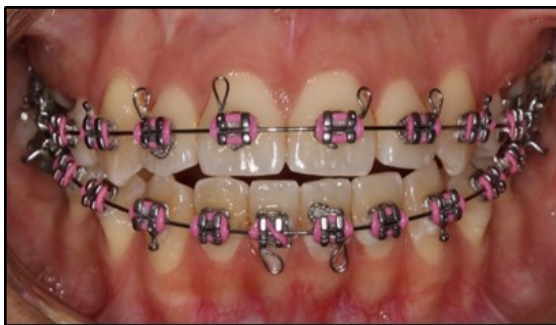


**Figure 7A.** The multiple descending second order bends on a 0.018" stainless steel wire.

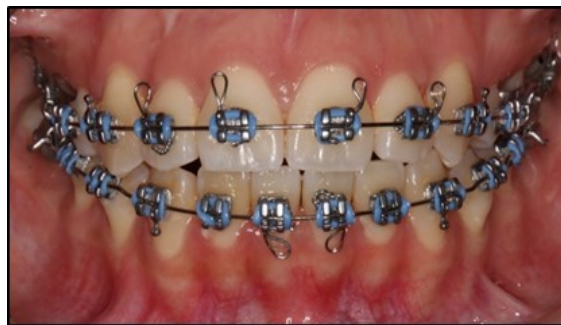


**Figure 7B.** The activated arch-wire placed in the lower arch.





**Figure 8A:** Reduced overbite following the tip back bend and distalisation.

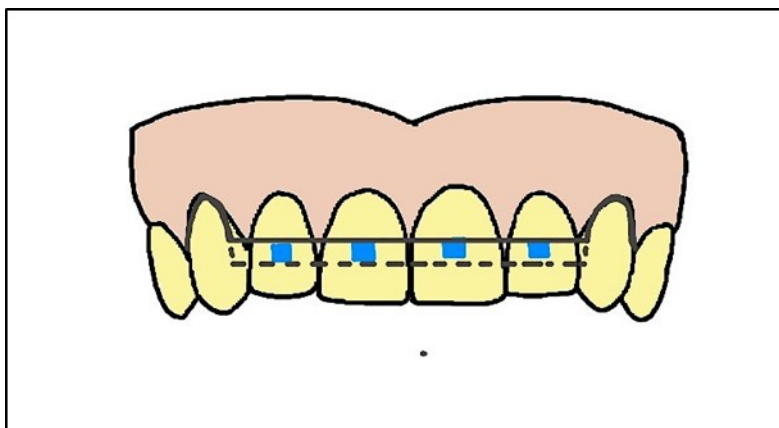


**Figure 8B:** Vertical overlap of the incisors achieved.

#### Planned Retention Phase:

The patient has been reviewed for vertical stability with anterior elastics and to further correct the centerline prior to debond. Retainers planned are the upper and lower Hawley retainers with mini composite tags

on the labial surface of the incisors. The labial bow will sit above the composite tags for the upper arch and below the tags for the lower arch (Figure 9). Bonded retainers are to be placed on the buccal side of the lower premolars and upper second premolars and first molars.



**Figure 9:** The design of the Hawley retainer with composite tags on the labial surface of the incisors.

#### Discussions

Time and time again the correction of AOB has been one of the toughest malocclusion to treat and the best method with strong evidence to treat it has yet to exist. It is imperative to identify the underlying cause of the presenting malocclusion prior to any orthodontic treatment. The aetiology could be due to skeletal, dental, soft tissue and habits. By acknowledging and understanding the underlying cause of a malocclusion, it would aid in treatment

planning and to ensure that the treatment will go as planned.

The possible aetiology of the AOB in this particular case are inherited incomplete overbite, high and buccally positioned upper right and left canines with potentially upwards inclination of the occlusal Curve of spee and moderate tendency to high vertical proportion (MMPA=30°).

Multi stage approach was required to treat the AOB as no specific mechanic was able to overcome the presenting malocclusion

and simply extruding the incisors only is prone to relapse. Uprighting the molars, employing the MIs for distalisation, anterior box elastics as well as the multiple artistic bends led to the counterclockwise rotation and improvement in the overjet and overbite.

As shown previously, the AOB of this patient worsened and aggravated during the active orthodontic treatment. Some of the causes of the further opening could be due to insufficient anchorage of the first molars and lack of vertical control; the upper second molars were not banded or bonded at the start; upper incisors proclination as a resultant of the upwards inclination of the occlusal plane and the inadequate space for the canine alignment; the choice of extraction (the upper first premolars and lower first molars) as well as the activation of the TPA, led to the worsening of the AOB.

A few recommendations could be made to avoid unwanted bite opening. One recommendation is to use adequate anchorage reinforcement such as the MIs and TPA to prevent anchorage loss as well as for vertical control. Continuous Nitinol arch-wire should also be avoided when the canines are buccally displaced. Segmental arch-wire mechanics of splitting the anterior and posterior segment during leveling is recommended with the distal tipping of the buccal segment incorporated early with stainless steel wire. Also, the upper second molars were not included at the beginning of the treatment as it was feared to worsen the vertical dimension. Banding or bonding can still be instituted by positioning the band or tube more occlusally on the second molars to avoid opening the bite further.

Presence of a habit such as lisping or tongue thrusting needs to be recognised and curbed at the start, during and even after

the treatment to prevent re-emergence of open bite. Habit breaking appliance such as the tongue crib can be proposed and incorporated in the modified TPA at the anterior region. Removal of the third molars at the start of the treatment also could allow uprighting (provided first and second molars are present).

Post treatment stability is questionable as there is a high tendency of relapse. Proper tongue posture and function is an important factor for stability. A close monitoring and follow up post debond is required.

## Conclusion

A thorough as well as accurate diagnosis and treatment planning is an important step in any orthodontic treatment. In spite of that, a slip-up may create another unwanted malocclusion and worsen it. In this case, a sudden emergence of unwanted open bite was managed promptly by re-diagnosing the mechanism and re-supervised by employing alternative mechanics. This case report showed one of the ways to manage an unwanted occurrence of an AOB.

## Acknowledgements

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92:669-671; Lang, TA, Secic, M (2006) How to report statistics in medicine: annotated guidelines for authors, editors and reviewers, 2nd edition, Philadelphia, PA, ACP Press; Sarter M, Fritschy JM (2008) Eur J Neurosci 28:2363-2364. compact presentation.

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