Republic of Iraq
Ministry of Higher Education
and Scientific Research
University of Baghdad
College of Dentistry

Cleaning of the Removable Orthodontic Appliances. A dental Students and Orthodontic Specialists' Perception

A project submitted to

the College of Dentistry, University of Baghdad, Department of Orthodontic in Partial Fulfillment for the Degree of Bachelor in Dental Surgery

Rawan Osamah Zaki

Supervised by:

Prof. Dr. Dheaa H. AL-Groosh

BDS, MSc, PhD, AFHEA

May, 2023

﴿يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ﴾

(سورة المجادلة : 11)

Certification of the Supervisor

I certify that this project entitled "C**leaning removable orthodontic appliances. A dental students and orthodontic specialists perception**" was prepared by fifth-years student **Rawan Osamah Zaki** under my supervision at the College of Dentistry/ University of Baghdad in partial fulfillment of the graduation requirements for the degree of Bachelor of Dental Surgery.

Professor Dr. Dheaa H. Al-Groosh

BDS, MSc, PhD (UK), AFHEA (UK)

May, 2023.

Dedication

To

My parents…

The candle that burned up to light my way

To my brother and sister …

who support every step in my life

To my friends

for their endless love and support especially…

Sara & Mariam

Acknowledgements

All praises to Allah Almighty for the strengths and blessing in my life and in completing this project. Special appreciation goes to my supervisor, Prof. Dr. Dheaa Al-Groosh for his supervision and constant support. His invaluable help of constructive comments and suggestions throughout the experimental and project work have contributed to the success of this research. Sincere thanks to all my friends for their kindness and moral support during my study especially my perfect friends Sara and Mariam. Thanks for the friendship and memories. Last but not least, my deepest gratitude goes to my beloved parents and also to my brother and sister for their endless love, prayers and encouragements and support to get such success. To those who indirectly contributed in this research, your kindness means a lot to me. Thank you very much.

Table of contents	

List of table	
Table 3-1: comparison between the materials used for fabrication of removable orthodontic appliance between orthodontic specialists and students using Pearson Chi square test.	**21**
Table 3-2 compare between orthodontic specialists and students belief about Wearing time of removable orthodontic appliances using person chi square test.	**22**
Table 3-3compare between orthodontic specialists and students belief about Age of patient use removable orthodontic appliances	**23**
Table 3-4 compare between orthodontic specialists and students belief about Use brush as primary method for cleaning	**24**
Table 3-5 compare between orthodontic specialists and students belief about Use of extra brush method for cleaning	**25**

List of abbreviation	
PMMA	**Poly methyl meth acrylate**
EPS	**extracellular polymeric substance**
C. albicans	**Candida albicans**
ROA	**Removable orthodontic appliances**
OAs	**Orthodontic appliances**
SPP	**species plural (more than one species)**
TMJ	**temporomandibular joint**

Introduction

0rthodontics is the branch of dentistry concerned with facial growth, development of the dentition and occlusion, and the diagnosis, interception, and treatment of occlusal anomalies. Orthodontic treatment can be fixed, removable or combination of the two types however, these appliances can cause stagnation of food and need preventive measures. The removable appliances have the superiority over the fixed ones regarding the performance on cleaning because removable appliance can be removed by the patient will during eating and be cleaned **(Levrini *et al*., 2015)**.

Removable appliance fabricated by different types of material like auto polymerizing acrylic resin, heat polymerizing acrylic resin, and light polymerizing acrylic resins. These materials have some built in characteristic make them prone to bacterial aggregation and biofilm formation. Different hygiene methods have been suggested to keep these appliances clean during the time of treatment, like tooth brushes, tooth paste, commercial mouthwash, denture cleansers and others **(Fathi *et al*., 2015)**.

However, Some patients have poor compliance in keeping good oral and appliance hygiene. To keep the appliances clean, good patient perception of the instruction is required **(Pathak and Sharma, 2013)**.

This questionnaire-based study was designed to find out the perception of the Iraqi orthodontists, orthodontic residents and the undergraduate dental students on to the hygiene methods applied for the removable orthodontic appliances.

Aim of the study

The aim of the current questionnaire was to assess the beliefs, despite scientific evidence, of the orthodontists, orthodontic residents and undergraduate students on cleaning of orthodontic removable appliance.

Chapter One: Review of literature

1.1 Orthodontic treatment

Humans have attempted to straighten the teeth for thousands of years before orthodontics became a dental specialty in the late Nineteenth Century. Proper alignment of the teeth has long been recognized to be an essential factor for esthetics, function and overall preservation of dental health. Malposed/ poorly aligned teeth may predispose to a number of unfavorable sequences such as poor oral hygiene which predisposing to periodontal diseases and dental caries, poor esthetics which may give rise to psychosocial problems, increased risk of trauma, abnormalities of function and temporomandibular joint (TMJ) problems **(Phulari, 2017)**.

Normal align of teeth not only contributes to the oral health but also goes a long way in overall well-being and personality of an individual. Correct tooth position is an important factor for esthetic, function and overall preservation or restoration of dental health. While most malocclusion may not adversely affect the health of an individual, they nevertheless, are capable of producing undesirable functional and esthetic imbalance **(Bhalajhi, 2006)**.

Once the occlusal problem is diagnosed and the etiological factors contributing to the existing malocclusion assessed, the next step is to carefully plan the orthodontic treatment. Treatment planning serves as a blueprint for the complete course of orthodontic treatment procedure and acts as a guide to achieve the desired results at the end of orthodontic therapy. Treatment should be done systematically and the stages of the assessment and planning may be considered as follows **(Phulari, 2017)**:

1. Summarizing the diagnostic findings and listing the orthodontic problems.
2. Assessment of the etiological factors and factors limiting the corrective treatment.

3. Setting the goals for orthodontic treatment.

4. Planning the actual treatment course.

1.2 Orthodontic treatment need

Orthodontic treatment need can be defined as the degree which a person needs orthodontic treatment because of certain features of his/ her malocclusion, functional impairment, dental health or aesthetic impairments, the negative psychological and social repercussions. There have been authors who have considered that malocclusion can lead to other problems, such as functional problems, temporomandibular dysfunction, and a greater propensity to trauma, caries, or periodontal disease. However, nowadays it is not so evident that these processes or diseases constitute indications for orthodontic treatment **(Cobourne and Dibiase, 2016)**.

1.3 Principle aims of orthodontic treatments

The principal aims of orthodontic treatment should relate to **(Agostino *et al*., 2014)**:

• Positioning the dentition within the skeletal and soft tissue environment for optimal facial and dental aesthetics.

• Achieving a stable and ideal static, and functional occlusion.

The extent to which these aims need to be considered will vary between patients and depend upon the diagnosis. The treatment required to achieve them may range from simple occlusal change to complex multidisciplinary intervention.

1.4 Orthodontic appliance

Orthodontic appliances can be described as devices, which produce and/or apply forces to a group of teeth and/or maxillofacial skeletal units in order to accomplish the treatment goals of functional efficiency, structural balance, and

esthetic harmony. Orthodontic appliances can be classified according to the patient's ability to remove the orthodontic appliance as removable, semi-fixed or fixed **(Singh, 2008)**.

1.4.1 Fixed orthodontic appliances

Most orthodontic treatment is carried out using fixed appliances that directly attached to the teeth. Development of these appliance systems began in the USA at the turn of the twentieth century and they have become progressively more sophisticated. A fixed orthodontic appliance has the capability of being fixed to teeth by either direct fixation by bonding to the enamel surface with composite cement or cemented via a band around the crown of a tooth **(Proffit et al., 2019)**.

The nature of the appliance prevents removal by the patient. In fixed braces type, the archwires are fixed to the brackets or tubes by clips, steel ligatures, or elastomeric O-rings to form the total fixed appliance that, when activated, leads to tooth movement **(Daskalogiannakis *et al.*, 2000)**.

Fixed appliances are use when multiple tooth movements are required for correction of malocclusion such as rotations and/or bodily movement of teeth. Its mechanotherapy allows fine finishing and settling of occlusion **(Archambaul *et al*., 2010)**.

1.4.1.1 Indications and contraindications for the use of fixed appliances

Littlewood and Mitchell (2019) suggested that fixed appliances are indicated when precise tooth movements are required. These include:

• Correction of mild to moderate skeletal discrepancies. Fixed appliances can be used to achieve bodily movement and it is possible, within limits, to compensate for skeletal discrepancies and treat a greater range of malocclusions.

• Intrusion/extrusion of teeth: Vertical movement of individual teeth, or tooth

segments, requires some form of attachments onto the tooth surface on which the force can act.

• Correction of severe rotations.

• Overbite reduction by intrusion of incisors.

• Multiple tooth movements required in one arch.

• Active closure of extraction spaces, or spaces due to hypodontia: The fixed appliances can be used to achieve bodily space closure and ensure a good contact point between the teeth.

However, **Phulari (2017)** suggested that there are contraindications when fixed orthodontic appliance. These include:

- Poorly motivated patients.
- Patients with poor dental health.
- Patients with poor periodontal health.

1.4.1.2 Advantages and disadvantages of fixed orthodontic appliance

The use of fixed orthodontic appliances have many advantages and disadvantages Phulri (2017).

1. Advantages of fixed orthodontic appliances are:

A. Retention presents no problem, since the appliance is cemented to the teeth.

B. Less skill is required from the patient in the management of the appliance.

C. Multiple tooth movements are possible with fixed orthodontic appliances.

2. Disadvantages of fixed removable appliances:

A. Difficult to maintain good oral hygiene during fixed orthodontic treatment.

B. Excessive force damages the supporting structures of the teeth.

C. The possibility of producing adverse tooth movements.

D. They can hamper aesthetics.

1.4.1.3 Components of fixed orthodontic appliance

Basically, there are two components that form any fixed orthodontic appliance system (Figure 1-1), depending upon their ability to generate forces. It may be categorized as active or passive components **(Littlewood and Mitchell, 2019):**

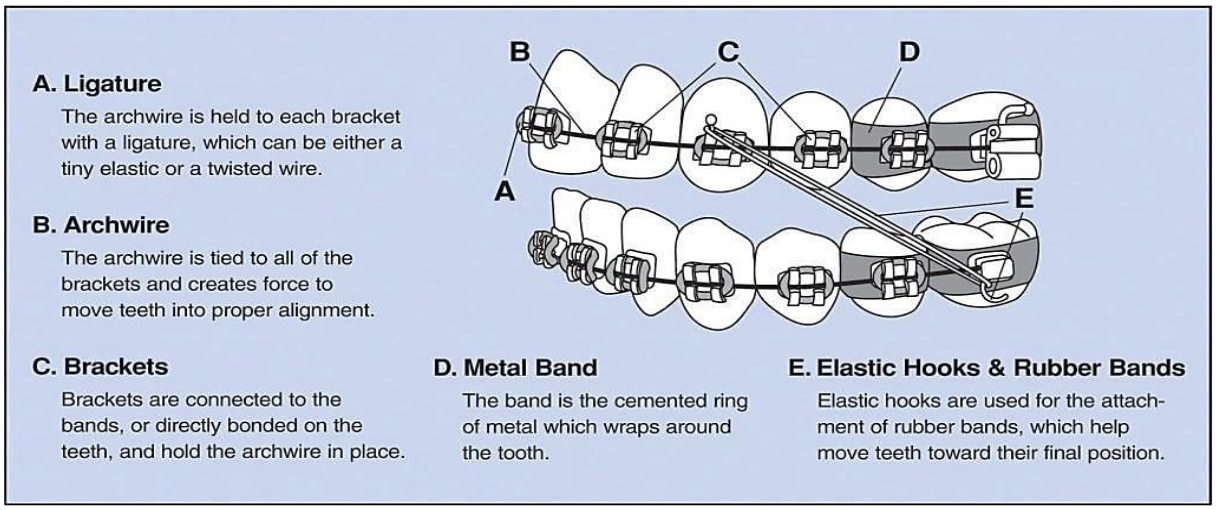

Figure 1-1: Components of fixed orthodontic appliances.

https://couserorthodontics.com/dental-dictionary

1.4.2 Removable orthodontic aappliances

These are appliances that are designed to be fitted and removed by the patient. It can provides two benefits: Firstly, it requires less dentist's chair time because its fabrication done in the laboratory and the adjustments can be performed extra orally; and, secondly, on socially critical events, they can be removed especially when the wires would be seen in the facial aspect of the teeth **(Proffit *et al.*, 2019)**.

Removable orthodontic appliances (ROAs) are classified in two type

according to the mode of action; the active or passive appliances. The active ones are capable for exerting pressure and perform tooth movement, however, its use limited to tipping and simple rotational movements of teeth, which are sufficient for many simple orthodontic treatment models. They depend on patient's cooperation and a certain degree of skill. The use of removable appliances requires careful case selection for the success of the treatment **(Phulari, 2017)**.

While the passive appliances remain passive in the mouth and exert no active pressure such as space maintainers, following permanent tooth extractions, and retention appliances following fixed appliance treatment **(Littlewood and Mitchell, 2019)**.

1.4.2.1 Indications and contraindications of removable orthodontic appliance

Removable orthodontic appliances require careful patient's selection. It is mainly indicated when minor tooth movement is requires. Additionally, it may be used as an adjunct to fixed orthodontic appliance treatment **(Bhalajhi, 2006)**. However, there are contraindications of removable orthodontic appliance.

The contraindication of removable orthodontic appliances can be listed as below **(Singh, 2008)**:

1. In cases where bodily movement of the teeth is required.
2. Systemic diseases for example epilepsy, blood diseases (anemia, polycythemia) and infectious disease.
3. Multiple rotations cannot be treated.
4. In complex cases, treatment is prolonged, as only few movements can be carried out at a time.

1.4.2.2 Advantages and disadvantages of removable orthodontic appliance

1. Advantages of removable orthodontic appliances are as followed **(Singh, 2008; Phulari, 2017)**:

a. Removable appliances permit easy cleaning than fixed appliances. The patient can continue with routine oral hygiene procedures without any hindrance.

b. They need less chair side time.

c. They are good for overbite reduction.

d. They can tip the teeth efficiently.

e. These appliances are relatively cheap as compared to the fixed appliances.

f. Useful as passive retainer or space maintainer.

2. Disadvantages of removable orthodontic appliances:

(Phulari, 2017) (and Littlewood and Mitchell (2019) reported that the disadvantages of the removable orthodontic appliances are:

1. A limited type of tooth movement can be achieved.

2. A high degree of cooperation and a certain amount of skill is required from the patient, who has to remove, clean and replace the appliance at frequent interval.

3. A good technician is require.

4. Removable orthodontic appliance can hamper the phonation.

5. It need oral hygiene care as it may cause dental and prosthesis biofilm.

1.4.2.3 Components of removable orthodontic appliance

The design and construction of any removable appliance must begin with a detailed plan of the tooth movement that is to be carried out. It should consider the morphologic characteristics, the age and eruption status of the patient, the psychological findings and the treatment objectives **(Snigh, 2007)**.

The removable orthodontic appliances are made up of three components (Figure 1-2):

1. Force or active components: These include the springs, screws or elastics.

2. Fixation or retentive components: Which include clasps.

3. Base plate or frameworks: Which can be made of autopolymerise, light polymerized and heat cure acrylic.

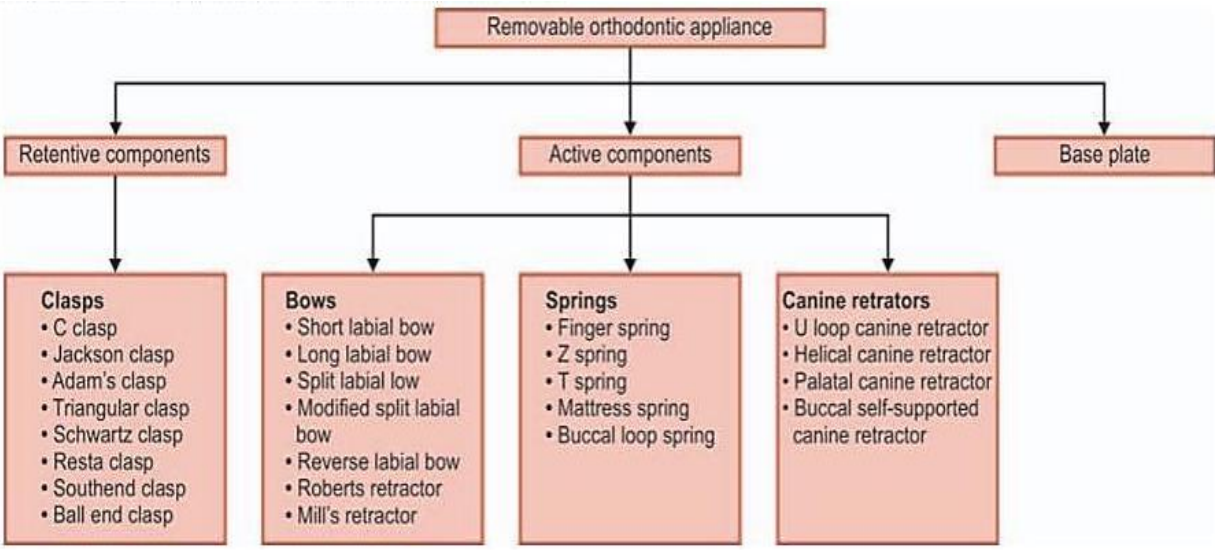

Figure 1-2: Components of removable orthodontics appliances (Snigh, 2007).

1.5 Biofilm

Biofilms are often defined as communities of surface-attached bacteria and are typically depicted with a classic mushroom-shaped structure. Biofilm is

formed by the adhesion of bacterial colonies and the extracellular polymeric substances (EPS) such as polysaccharides, nucleic acids, and proteins secreted by bacteria during the growth process **(Paranhos *et al*., 2007)**.

As result of this mushroom like structure, the bacteria can be attached to both biotic and abiotic surfaces. The formation of pathogenic biofilm plays an important role in causing chronic persistent infection i.e. dental biofilms can cause major oral diseases like gingivitis, periodontitis, and caries. Orthodontic appliances may promote supra- and subgingival biofilm accumulation, alter the oral microbiome, and hamper oral hygiene; therefore, in cirtain circumstances, orthodontic treatment can be associated with adverse effects, such as enamel decalcification, gingivitis, and periodontal disease **(Guilhen *et al*., 2017)**.

1.5.1 Biofilm formation

Generally, biofilm formation by bacterial pathogens on any substratum/layer involves five major stages as shown in Figure 1-3 **(Kostakioti *et al*., 2013, Yin *et al*., 2019)**:

(**1) Attachment**: At an initial stage, free-swimming planktonic cells reversibly attach to the biotic or abiotic surfaces through weak interactions such as acid-base, hydrophobic, Van der Waals, and electrostatic forces.

(2) Colonization: bacterial pathogens irreversibly attach to the surface through stronger interactions such as collagen-binding adhesive proteins, lipopolysaccharides, flagella, and pili.

(3) Proliferation: the multilayered bacterial cells are profoundly accumulated, and the enormous amounts of extracellular polymeric substance (EPS) are produced.

(4) Maturation: The attached multilayered bacterial cells grown into the matured biofilm with the typical 3D biofilm structure.

(5) Dispersion: after the complete development of biofilm, it can be

disassembled or dispersed using mechanical and active processes.

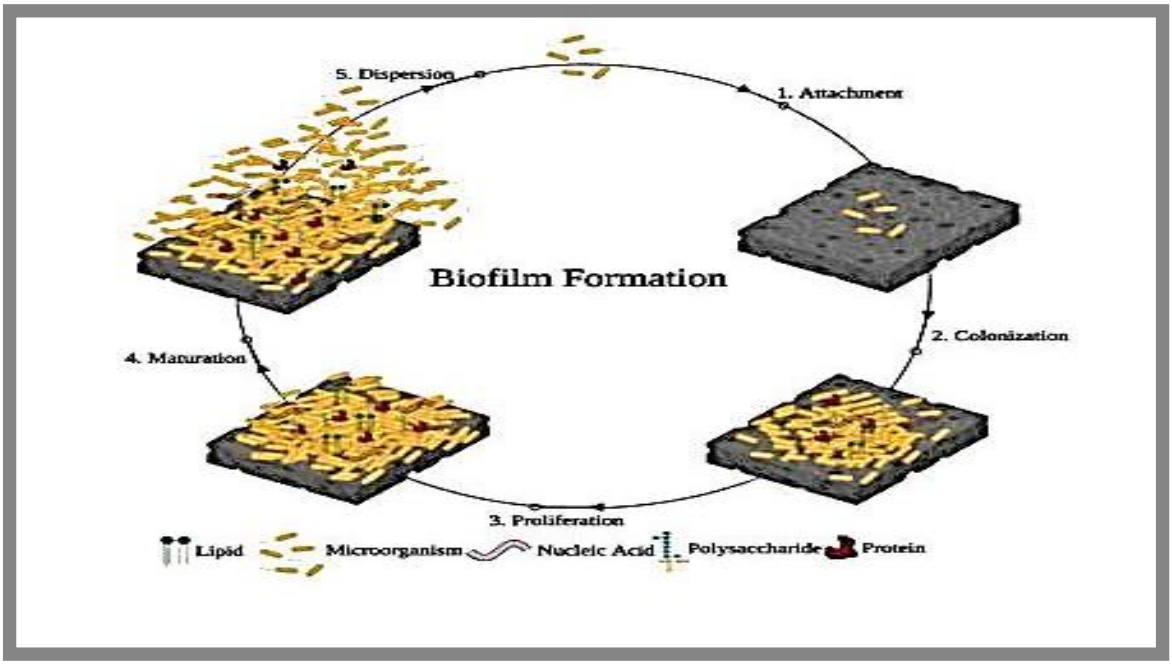

Figure 1-3: Developmental stages of bacterial biofilm formation (Kostakioti *et al.*, 2013, Yin *et al*., 2019).

1.5.2 Oral biofilm and orthodontic treatment

Placement of an orthodontic appliance consisting of metals and polymers, is accompanied by the creation of surfaces with properties, alien to those of the natural oral hard and soft surfaces **(Soro *et al.*, 2014)**. In addition, the number of retention sites is much larger in orthodontic patients. These special features not only increase the amount of biofilm, but also the prevalence of cariogenic bacteria such as mutans streptococci and periodontopathic bacteria such as *Porphyromonas gingivalis*, *Prevotella intermedia*, *Prevotella nigrescens*, and Fusobacterium species **(Wang *et al*., 2019)**.

Moreover, orthodontic appliances greatly compromised the efficacy of natural oral cleansing forces and the mechanical biofilm removal by tooth brushing. The variety of alien surfaces introduced by orthodontic intervention

provides numerous additional surfaces to which microorganisms can adhere and form a biofilm. It was found that banding induced more biofilm formation at the gingival margin **(Karygianni *et al.*, 2020)**.

The biofilm formation and adherence depend on surface characteristics, surface area, and chemical composition. On the other hand, the orthodontic appliances themselves decrease salivary wash and buffering capacity on dental and periodontal structures. Moreover, orthodontic appliances are factors that act as new niches to which microorganisms can adhere and result in biofilm **(Martino, 2018)**.

Microbial adherence on the abiotic surface is the early step of biofilm development, particularly after applying orthodontic appliances or implants **(Busscher *et al.*, 2012)**.This step of biofilm formation can be affected by several chemical or physical factors like chemical composition, surface roughness, surface free energy, and surface tension, affecting wettability and salivary protein adhesion. Studies demonstrated that hydrophobic and electrostatic interactions are responsible for initial bacterial attachment to abiotic surfaces as different bracket materials due to their surface properties or even tissue surface **(Tektas *et al*., 2020)**.

1.6 Oral hygiene and orthodontic appliances

Oral hygiene has always been a challenge in orthodontics and the relationship between orthodontic treatment and caries development, or periodontal diseases has been well studied **(Alfuriji *et al*., 2014)**. Oral hygiene instructions for patient self-care and for ROA cleaning are important activities to promote oral health and prevent diseases.

Healthy behaviors can prevent future oral problems, and dental practitioners could influence the patient behaviors **(Madan *et al.*, 2014)**. It was proposed that

the importance of a correct hygiene relies on adequate control of the biofilm on the surfaces, especially for children undergoing orthodontic treatment **(Duyck *et al*., 2016)**. It is necessary to learn the habits of 'children at risk' to implement adequate oral health education programs. Adolescence oral hygiene behavior could modulate and promote the increment of microorganism in the oral environment and increase the risk for caries and gingivitis **(Pathak and Sharma, 2013; Maia and Silva, 2014)**.

The cost of the hygiene materials seems to be an important factor that determines dentists' recommendations for cleaning the ROA by patients **(Eichenauer *et al*., 2011)**. Proper oral hygiene could control and prevent the following diseases/ disorders **(Littlewood and Mitchell, 2019)**:

A. Dental plaque: Which is considered as the most direct measure of oral hygiene.

B. Periodontal diseases (gingivitis and periodontitis): This can be assessed by looking at the physical condition of the gums.

C. White spot lesions (enamel demineralization) and dental caries.

Orthodontic treatment induces several alterations in of the oral environment, including a decrease in salivary pH **(Mehrizi *et al*., 2016)**, a facilitation of dental biofilm adherence on the orthodontic surface appliance and an increase in cariogenic (*S. mutans*, Lactobacillus sp.) and periodontal pathogenic microorganisms levels (*A. actinomycetemcomitans*) **(Topaloglu *et al*., 2011)**.

Orthodontic treatments by removable orthodontic appliance, mainly constituted with Poly methyl meth acrylate (PMMA), imposes many issues related to hygiene squeal. Firstly, patients treated by removable appliances demonstrated proliferation of *C. albicans* salivary levels, responsible of increasing the risk of candidiasis and stomatitis **(Hibino *et al*., 2009)**.

Furthermore, biofilm developing directly on acrylic resin of the removable appliances contains a majority of non-streptococci anaerobic bacteria, Streptococcus spp., Enterobacteriaceae, and Lactobacillus spp **(pathak and Sharma, 2013)**. Furthermore, there is a direct relationship between removable orthodontic treatment and an increase in the amount of periodontal pathogenic microorganisms **(Charman *et al*., 2009)**.

Several factors seems to directly influence bacterial and fungal attachments including surface roughness, incomplete polymerization, or wear caused by daily brushing of the appliance **(Fernández *et al*., 2011)**. Additionally, orthodontic treatment by removable acrylic appliance involves not only perfect oral hygiene maintenance but also a cleaning protocol for the appliance itself **(Topaloglu *et al*., 2011)**.

If good oral hygiene is to be maintained, the proper cleaning of removable orthodontic appliances can reduce the risk of caries, Candida-associated stomatitis and halitosis, in addition to inhibiting reinfection from the ROA, especially in immunodeficiency patients **(Arab *et al*., 2016)**.

1.6.1 Cleaning removable orthodontic appliances

Orthodontic appliances change the microbial ecosystem of the oral cavity by inducing bacterial growth and increasing the risk of conditions such as halitosis, periodontal disease, and caries. Some studies have already been conducted in order to investigate the effects of different cleaning protocols for acrylic removable orthodontic appliances to reduce the risk of oral diseases related to biofilm growth. Some different processes have been described such as denture cleaners, enzymatic solutions, chlorhexidine, sodium hypochlorite, or "homemade" solutions containing vinegar or citric acid **(Eichenauer *et al*., 2011)**. Furthermore, professional methods performed by orthodontists, such as ultrasounds has been used **(Muscat *et al*., 2018)**.

Cleaning of removable orthodontic appliances can be divided into three

types. The chemical (mouth wash, tablet…etc.) and mechanical maneuvers like tooth brush and paste or a combination of these methods.

Studies showed that dental cleansers remove most of the attached plaque, even at critical sites, mainly through the release of oxygen and enzymatic proteolysis **(Kaur *et al*., 2011)**. However, the immersion in dental cleaners can cause changes in the structure of acrylic resin, while sprays with chlorhexidine solutions provide rapid inactivation of pathogen microorganisms without causing adverse effects to the appliance frame **(Nalbant *et al*., 2008)**.

Brushing with a fluoride dentifrice can be an effective means of controlling the biofilm that forms on the surface of ROA. However, lack of manual dexterity and inappropriate frequency are factors that compromise the efficacy of the mechanical control of plaque. Furthermore, clasps, expansion screws, marginal crevices and surface indentations are often nearly inaccessible to the toothbrush **(Al-Musallam *et al*., 2006)**. Moreover, being unable to clean dental plaque on the concave and hard-to-reach areas of ROAs by toothbrush can lead to the roughness of the acrylic surface and will rise to plaque accumulation. Rough acrylic surfaces would enhance plaque accumulation such that the presence of porosities deeper than 0.2 μm would cause microbial adhesion. The microporosities of the material can serve as a microbial source, and microorganisms mainly spread in the acrylic base. **(Lima *et al*., 2006)**.

Care should be taken while using a toothbrush along with toothpaste as it can results in more abrasion of the acrylic base when compared to using a toothbrush with water only or with cleaning tablets **(Shay, 2000)**.

It was recommended that the ROA should be removed after every meal and rinsed under a tap to remove food debris. It should be cleaned using a toothbrush and toothpaste, preferably over a bowl of water to prevent damage from the appliance being dropped in to a porcelain wash basin this should be carried out at least three times a day i.e. after each meal **(Eichenauer *et al*., 2011)**.

Chapter Two: Material and Method

2.1 Material

The study was approved by the scientific committee of the Department of Orthodontics, College of Dentistry/ University of Baghdad.

A questionnaire was developed to assess the belief of orthodontic specialists, orthodontic residents (age range of 27-50) and senior undergraduate dental students (age range of 21-24 years) on the cleaning of removable orthodontic appliances (see appendix 1).

A short explanation of the study was provided on the front page of the survey, which requested the participants' voluntary participation. The participants' responses were kept anonymously.

The survey took four weeks from February 2023 to March 2023 and the participants were advised to contact the authors for inquiries related to the questionnaire.

The questionnaire consisted of the following questions:

1. Questions related to participant general information, i.e. gender, age, academic title, years of experience and occupations.
2. Question about the current materials used to fabricate the removable orthodontic appliances.
3. Question about the proposed daily wear of removable orthodontic appliances.
4. Additionally, questions related to participants' belief regarding methods, materials and frequency of cleaning.

2.2 Methods

The questionnaire was sent via e-mail to the participants' correspondent groups and the social network apps such as Telegram. The e-mail and social network messages explained the survey objectives and contained an online 'link' to direct the respondents to the website where the questionnaire can be answered i.e. Google forms. Each participant allowed to answer the questions once. To avoid participating individuals not from the selected categories above, obligatory filter questions were designed and applied as a mandatory task before start answering the questionnaire. These filter questions disabled respondent who answered "No" from participating.

2.3 Statistical analysis

After collecting the data, the response rate of each question or category was obtained. Descriptive statistic was used to analyze the percentages of respondents who were in favor of each of the survey questions. This was presented using histogram and tables. Pearson Chi-square test was used to find the differences between the respondents' beliefs. The significant level was set as 0.05.

Chapter Three: Results

3. Results

The questionnaire was responded by 276 participants out of 200 orthodontic specialists, 54 orthodontic residents and 230 undergraduate students rendering the overall respond rate to 57%. Fifty respondents were University professors and 27 of them were orthodontic specialists; in addition to 37 orthodontic residents and 159 undergraduate students.

3.1 Distribution of participant's age, gender and orthodontic professionalism.

All participant were using removable orthodontic appliances. Figure (3-1) shows that female participants dominated the respondents (65%), however, the respondent rate of male was slightly higher in orthodontist's category.

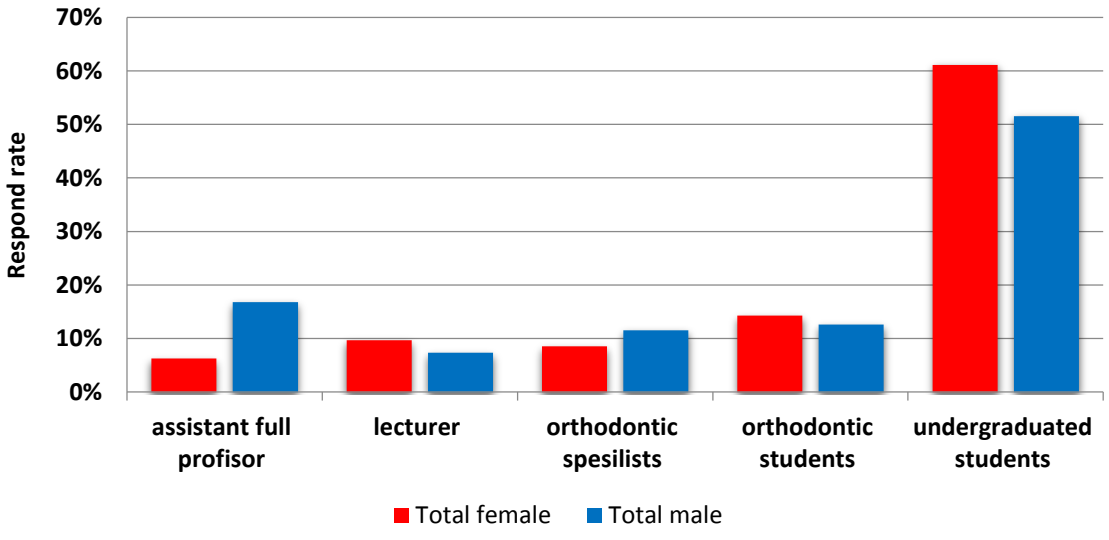

Figure 3-1: Gender distribution of the respondents.

Furthermore, the data showed that the majority of participant's age was below 30 years as shown in figure (3-2).

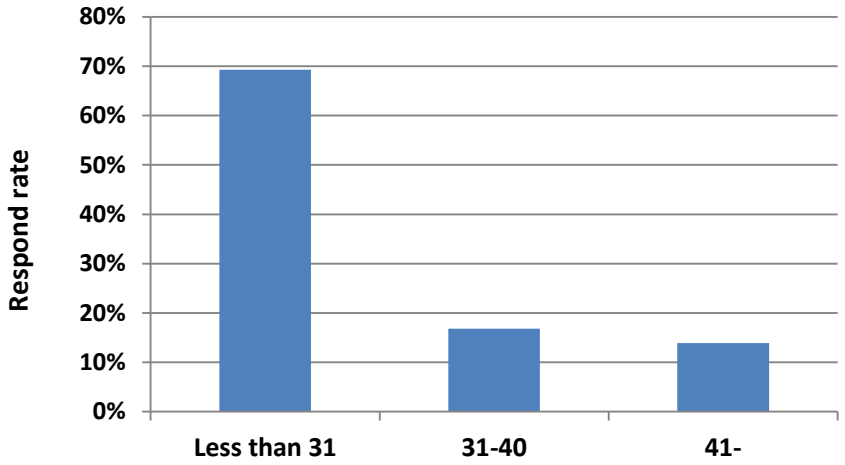

Figure 3-2: Age distribution of participants.

Figure (3-3) shows the years of experience of the participants according to professionalism. The majority of the participants were senior dental students which represented 93.6% of the respondents, followed by University professors (5.5%).

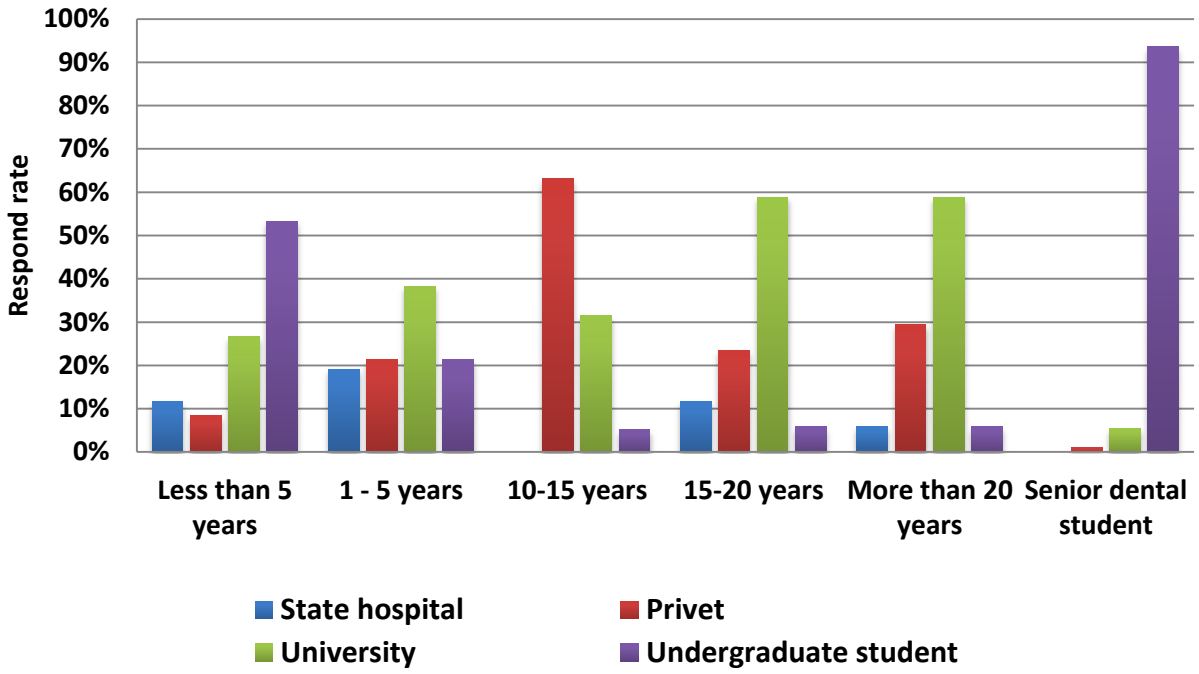

Figure 3-3: Histogram representation of the professionalism and the years of experience among participants.

3.2 Participant's preference of the materials used for fabrication of the removable orthodontic appliances.

The majority of participants prefer to use auto-polymerizing acrylic resin for fabricated of removable orthodontic appliances followed by the heat polymerizing acrylic resin. The light polymerizing acrylic resin was the material of choice for 18.5% of the participants as shown in figure (3-4).

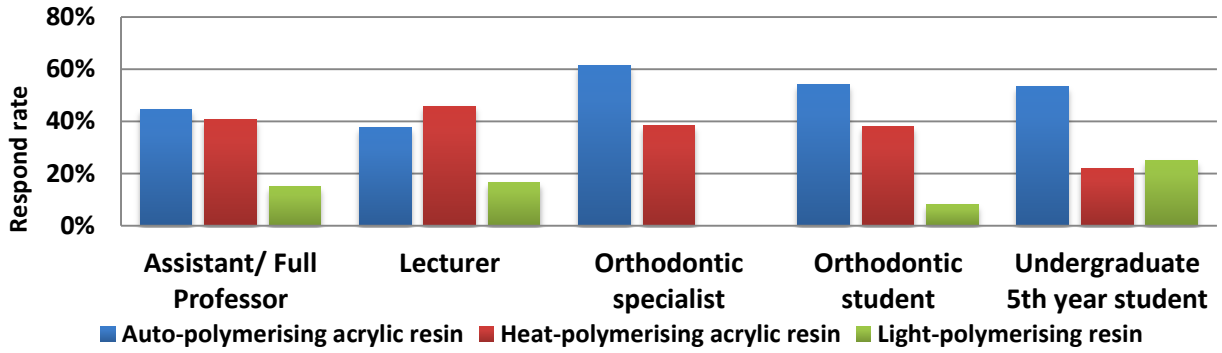

Figure 3-4: Participant's preference of the materials used for fabrication of the ROA.

Table 3.1 shows that there was a non-significant difference between orthodontists' perspectives regarding the material preference for removable orthodontic appliance construction. However, comparing the response between the undergraduate students and the specialists (collectively) revealed a significant difference their perspectives (p=0.006).

Table 3-1: Comparison between the materials used for fabrication of removable orthodontic appliance between orthodontic specialists and undergraduate students using Pearson Chi square test.

Academic title	Material						Statistical analysis		
	Auto-polymerizing		Heat-polymerizing resin		Light-polymerizing resin				
	N	%	N	%	N	%	X^2	df	p
Orthodontic specialists	38	49.4	32	41.6	7	9.1	**10.213**	**2**	**0.006**
Students	103	53.4	48	24.9	42	21.8			

3.3 Participant's belief on the daily wearing time of the appliances

Apart from senior dental students, all respondents recommended 16-24 hours/day wearing time. However, more than 83% of the undergraduate students believed that the removable orthodontic appliances should be worn either for (8-16 hours/day) or (16-24hours/day).

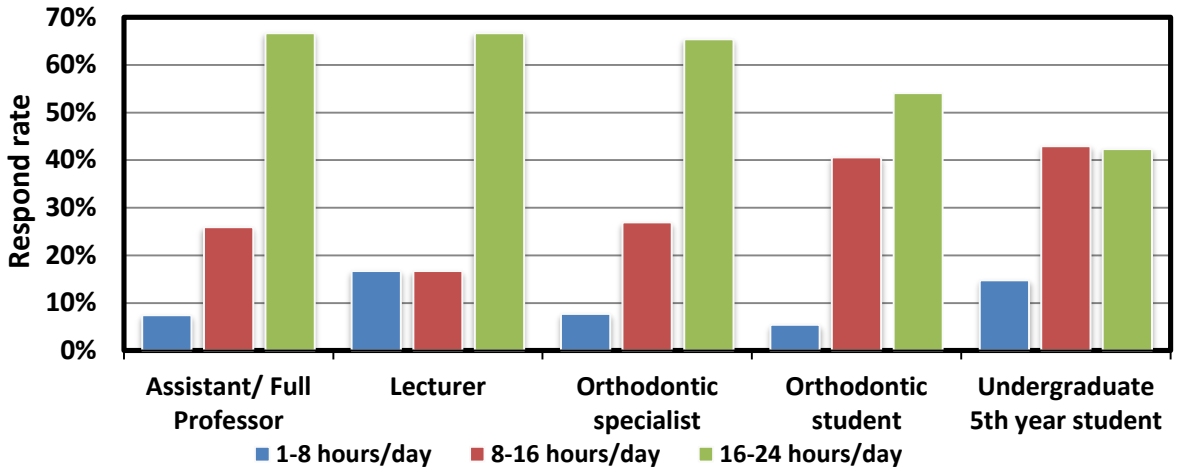

Figure 3-5: Participant belief of daily wear of the ROA.

Table (3-2) shows that that there was a significant difference between the students' beliefs and specialists' belief, the mean response rate of professors, lecturers and orthodontic specialists, regarding the wearing time for the removable orthodontic appliances (p=0.004).

Table 3-2: Comparison between the undergraduate students' and specialists' belief on wearing time of the ROA using Pearson Chi square test.

Academic title	Wearing time						Statistical analysis		
	1-8 hours/ day		8-16 hours/day		16-24 hours/day		X^2	df	*P*
	N	%	n	%	N	%			
Orthodontic specialists	8	10.4%	8	23.4%	51	66.2%	**10.819**	**2**	**0.004**
Students	25	13%	82	42.5%	86	44.6%			

3.4 Participant's respond on the age of the patients for removable orthodontic appliances

The majority of participants responded that the suitable age group where the removable orthodontic appliance is 9-13 years. The undergraduate students believed that patients above 14 years old compromised 40% of those patients.

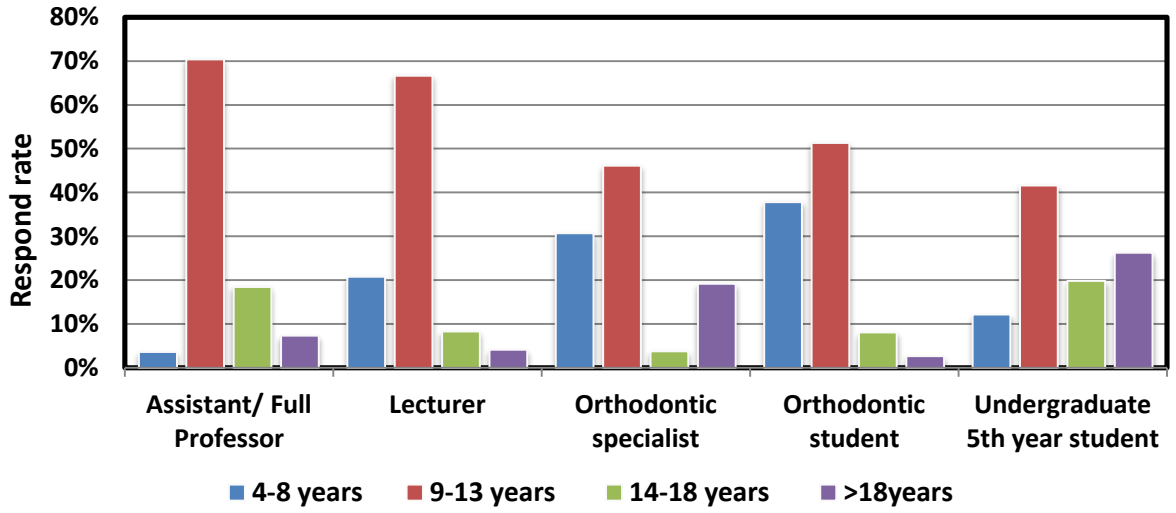

Figure 3-6: Participant respondents regarding the suitable age of the patients for ROA.

Table (3-3) relaved that there was a significant differense between the spesilists and students' belief regarding the age group suitable for removaple orthodontic appliances (p= 0.027).

Table (3-3): Comparison between the respondents' belief regarding the age group suitable for the ROA using Pearson Chi square test.

Academic title	Age of patient use removable orthodontic appliances								Statistical analysis		
	4-8 years		9-13 years		14-18 years		>18 years				
	n	%	N	%	n	%	N	%	X^2	Df	*P*
Orthodontic specialists	14	18.2%	47	61%	8	10.4%	8	10.4%	**9.209**	**3**	**0.027**
Students	33	17.1%	84	43.5%	34	17.6%	42	21.8%			

3.5 Participant's belief regarding the use of brushing as a cleaning method for the removable orthodontic appliances

All participants believed that brushing is the primary cleaning method for removable orthodontic appliances (Figure 3-7). Thaere was there was no significant differences between the respondents regarding the use of brush as a primary method of cleaning using person chi-square (p= 0.487) as shown in table (3-4).

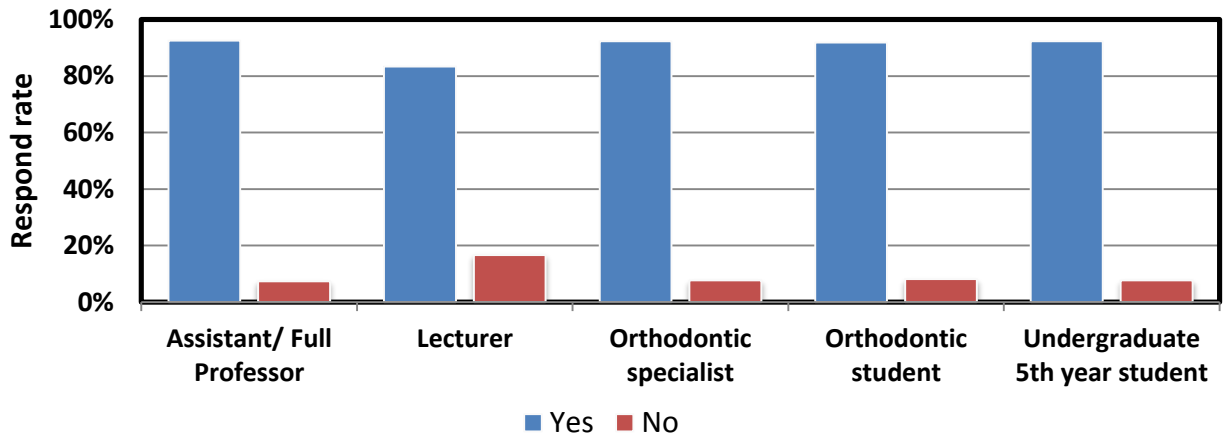

Figure (3-7): Participant response regarding the use of brushing as a primary method for cleaning the ROA.

Table (3-4): Comparison between the respondents'belief regarding the use of brushing as a primary method for cleaning the ROA using Pearson Chi square test.

Academic title	Use brush as primary method for cleaning				Statistical analysis		
	Yes		No		X^2	Df	*P*
	N	%	N	%			
Orthodontic specialists	69	89.6%	8	10.4%	**0.484**	1	**0.487**
Students	178	92.2%	15	7.8%			

3.6 The use of an extra brush and type of brush used

Figure 3-5 shows that most of the respondents answer positively to the question regarding the use of an extra brush as an adjunctive tool for cleaning the removable orthodontic appliances. There was no significant difference between the respondents' belief as shown in table (3-5).

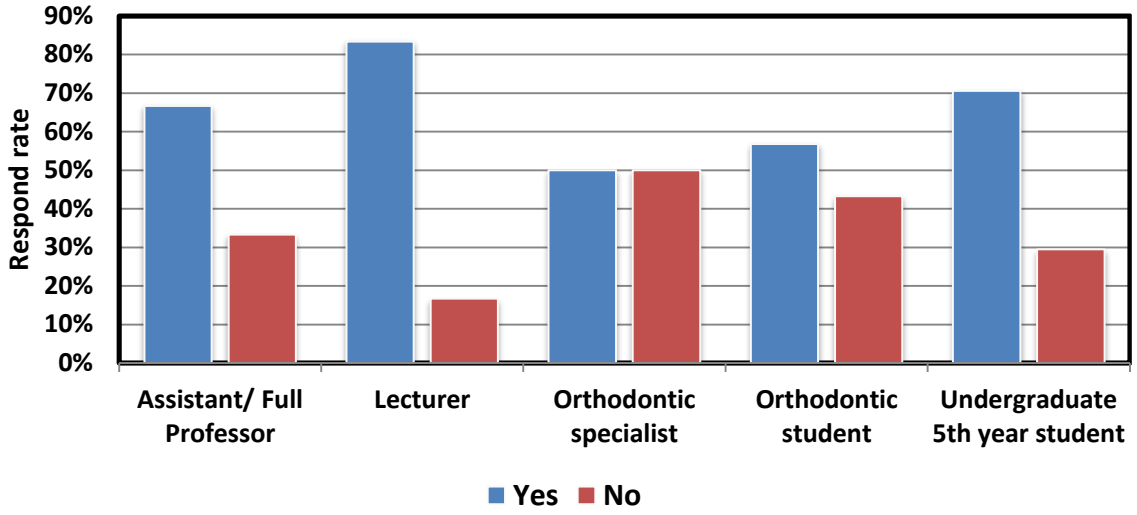

Figure 3-8: Participant response about the use of extra brush.

Table 3-5: Comparison between the respondents' belief regarding the use of an extra brush for cleaning the ROA using Pearson Chi square test.

Academic title	Use of extra brush method for cleaning				Statistical analysis		
	Yes		No		X^2	Df	*P*
	N	%	N	%			
Orthodontic specialists	45	58.4%	32	41.6%	**2.159**	**1**	**0.142**
Students	131	67.9%	62	32.1%			

The use of soft and medium type brush represented the choice of the majority of the respondents regardless of the professionalism or Tears of experience (Figure 3-9). There was no significant difference between the respond rate among the respondents (p=0.144).

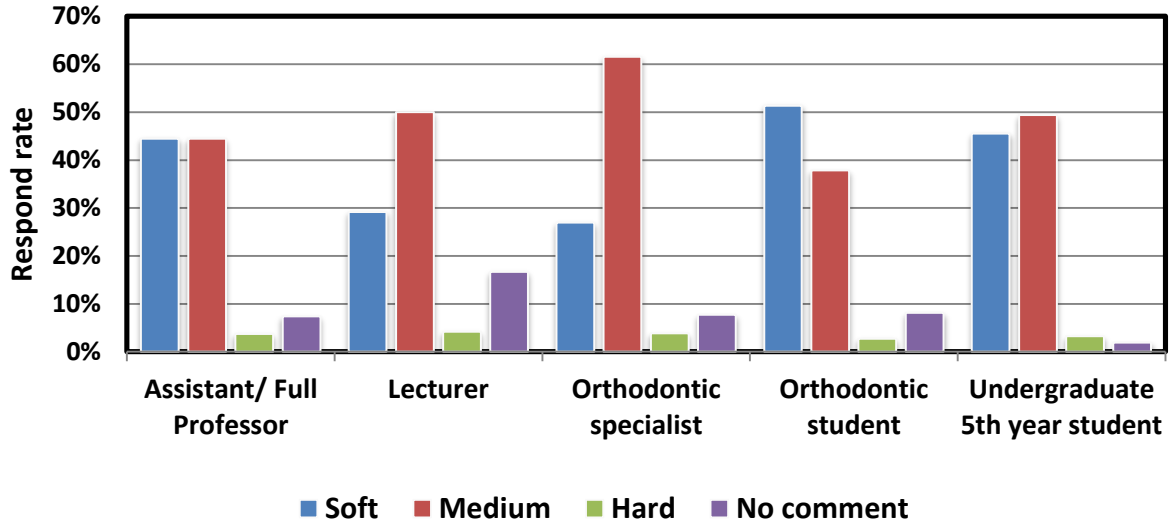

Figure 3-9: Participant response about the type of brush used for cleaning the ROA.

3.7 The use of other cleaning methods and the frequency of cleaning used for ROA

Figure (3-9) shows that most of the respondents believed that the ROA should be cleaned more than twice a day. Additionally, they recommended the use of tooth paste (53.7%) as an adjunctive mean for cleaning followed by immersion of the appliances (37.4%) in denture cleaners (Figure 3-11).

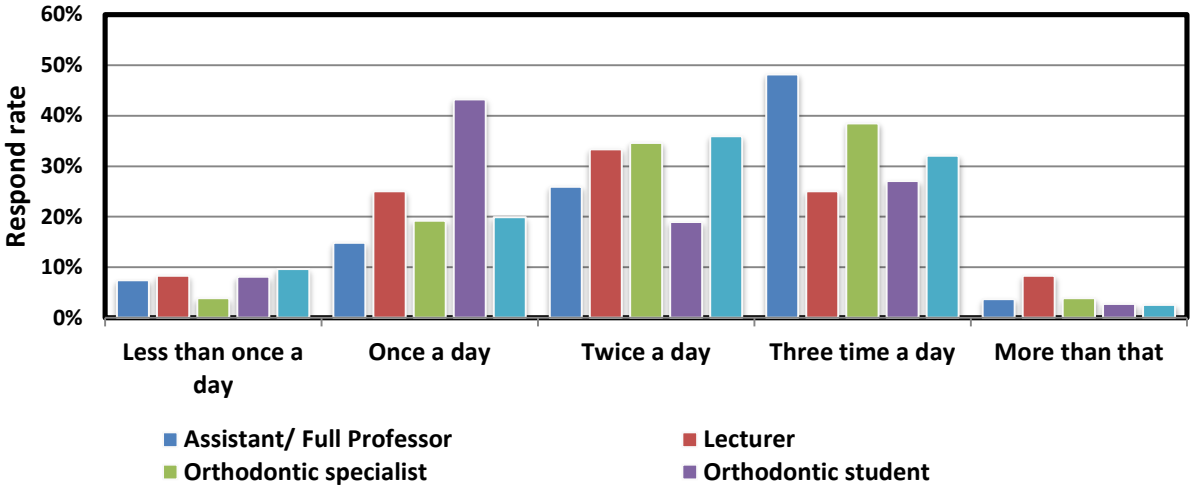

Figure 3-10: Participant response regarding the frequency of cleaning the ROA.

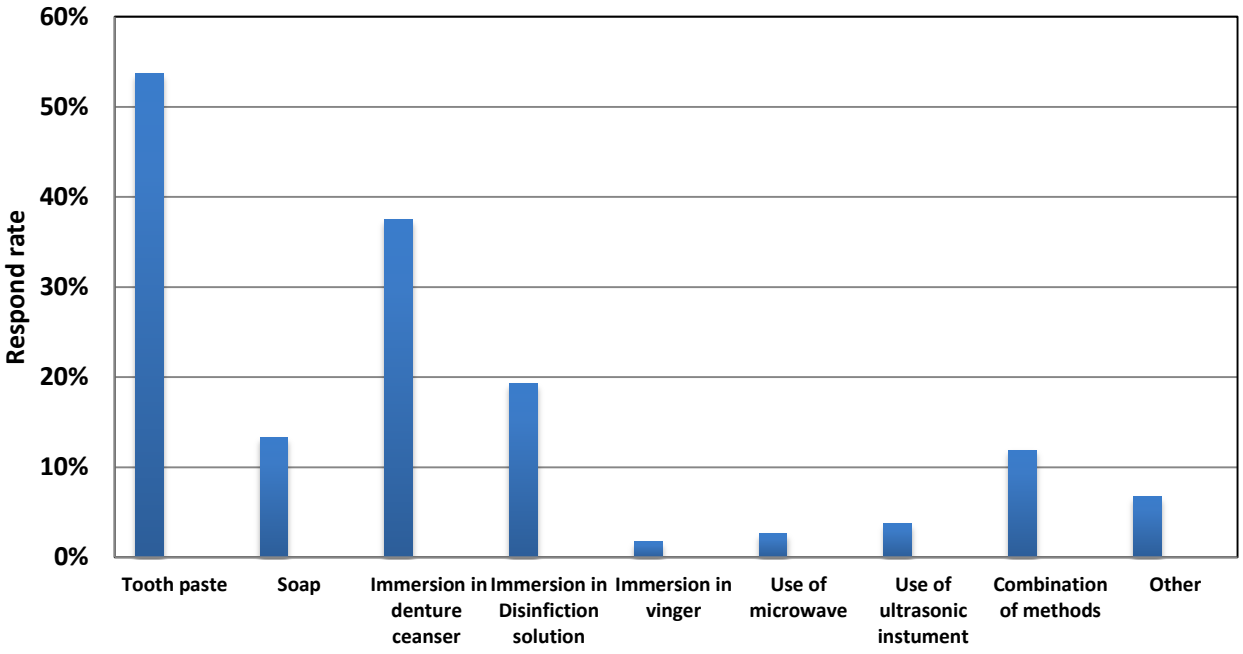

Figure 3-11: Participant belief about other cleaning methods used for cleaning the ROA.

Chapter Four: Discussion

This survey study design to assess the belief of orthodontist specialists, orthodontist residents and 5th year under-graduated dental students on the cleaning methods for removable orthodontic appliances.

Although the use of questionnaires is fundamental for knowledge and perceptive research, it may have some limitations, such as poor adhesion of participants, which reduces the number of answers, low response rate and, sometimes, inconsistency of the answers **(Martins *et al*., 2011)**. The authors tried to reduce these issues by using the web-based questionnaire **(Ebert *et al*., 2018)**.

The results of the current survey showed an agreement among the respondents in many chosen questions and that the overall response rate for orthodontists, residents and dental students was 57% (38%, 68% and 69%, respectively). This comes in accordance with previous questionnaire on tempro-mandibular joint dysfunction treatment perspectives **(Al-Groosh *et al*., 2022)**. The results of the current survey showed that the response rate was higher than previous survey conducted on orthodontists **(Coêlho da Silveira and Caracas., 2015)**. This comes in accordance with **Saleh and Bista (2017)**, who reported that the participation rate was higher in online based surveys compared to the conventional ones. This could be due to several influencing factors such as survey structure, communication methods, professionalism (target group) and simplicity of the questions. The setup of questions and question-answering process in online based questionnaire made handling the survey questions an easy task.

The results showed that female participants dominated the respondents (65%) and the 5th year undergraduate students dominated the other respondents. this could be due to that these categories have reacted more positively than others due to that they are more likely to possess or value characteristics more

consistent with connective selves, such as empathy or emotional closeness. This comes in accordance with **Smith *et al.*, (2008)**.

Most participant believe that auto-polymerizing acrylic resin dominated the materials used for fabricating the removable orthodontic appliances.

The results of the current study showed that most of the respondents believed that the tooth brush is the recommended daily, and the majority proposed 2-3 times a day, for cleaning of removable orthodontic appliances. Indeed, this method was reported to be effective to maintain the health of mucosa in contact with acrylic appliances **(Rossato *et al.*, 2011)**.

The respondent believed that the combination of cleaning methods such as the use of tooth paste and cleaning tablets is better than one method alone. It was suggested that the use of brushing alone could result in poor biofilm removal from acrylic surface, especially in the protected niches with the porous surfaces, and improper control of microbial load **(Paranhos *et al.*, 2009)**. This agreed with **Farhadifard *et al*,. (2021)** found that the effectiveness of brushing and denture cleaning tablet method in cleaning removable orthodontic appliances was higher than brushing alone. In fact, the combination between a mechanical and a chemical method reduced significantly the presence of microorganisms from removable appliances compared with other methods **(Nisayif, 2009; Salas *et al*., 2014)**.

Having said that there was a significant difference between the undergraduates and specialists belief regarding the age group suitable for ROA and the wearing time per day. This could be explained by the lack of sufficient informations regarding the removable orthodontic appliance wearing time and patients' category in the teaching curriculum.

Chapter five: Conclusions and Suggestions

Conclusion

1- The respondents' opinions and perceptions about cleaning ROA was consistent with the available published evidence.

2- The majority of orthodontic specialists and undergraduate dental students believed that the use of tooth brush is a primary method of cleaning and a combination of brushing and tooth baste or cleaning tablets is preferable over the use of single cleaning method.

3- Most respondent a part from the undergraduate students suggested the daily wear of appliances was 16-24 hours /days.

Suggestions

1 - Updating the orthodontic training program is required to describe the patients' category suitable for removable orthodontic appliance and the instruction of its use and maintenance.

2 - Raising the undergraduates', dentists' and patients' awareness by using instructions leaflets and verbal communication through webinars and other social media network.

References

- Agostino, P., Ugolini, A., Signori, A., et al., (2014) Orthodontic treatment for posterior crossbites. *Cochrane Database Systematic review.*
- Alfuriji, S., Alhazmi, N., Alhamlan, N., Al-Ehaideb, A., Alruwaithi, M., Alkatheeri, N., & Geevarghese, A. (2014) The effect of orthodontic therapy on periodontal health: a review of the literature. *International Journal of Dentistry*.
- Al-Groosh, D. H., Abid, M., & Saleh, A. K. (2022). The relationship between orthodontic treatment and temporomandibular disorders: A dental specialists' perspective. *Dental Press Journal of Orthodontics*, *27*.
- Al-Musallam, T. A., Evans, C. A., Drummond, J. L., Matasa, C., & Wu, C. D. (2006) Antimicrobial properties of an orthodontic adhesive combined with cetylpyridinium chloride. *American Journal of Orthodontics and Dentofacial Orthopedics*, 129(2), 245-251.
- Arab, S., Malekshah, S. N., Mehrizi, E. A., Khanghah, A. E., Naseh, R., & Imani, M. M. (2016) Effect of fixed orthodontic treatment on salivary flow, pH and microbial count. *Journal of dentistry* 13(1), 18.
- Archambault, A., Lacoursiere, R., Badawi, H., Major, P. W., Carey, J., & Flores-Mir, C. (2010) Torque expression in stainless steel orthodontic brackets: a systematic review. *The Angle Orthodontist*, 80(1), 201-210.
- Bhalajhi, S.I. (2006) Orthodontics: *The Art and Science*. 3rd Edition, Arya (Medi) Publishing House, New Delhi.
- Busscher, H. J., van der Mei, H. C., Subbiahdoss, G., Jutte, P. C., van den Dungen, J. J., Zaat, S. A., ... & Grainger, D. W. (2012) Biomaterial-associated infection: locating the finish line in the race for the surface. *Science translational medicine*, 4(153), 153rv10-153rv10.

- Charman, K. M., Fernandez, P., Loewy, Z., & Middleton, A. M. (2009) Attachment of Streptococcus oralis on acrylic substrates of varying roughness. *Letters in applied microbiology*, 48(4), 472-477.
- Cobourne, M.T. and Dibiase, A.T. (2015) *Handbook of Orthodontics* . Elsevier Health Sciences.
- Coêlho, T. G. D. S., & Caracas, H. C. P. M. (2015) Perception of the relationship between TMD and orthodontic treatment among orthodontists. *Dental press journal of orthodontics*, *20*, 45-51.
- Daskalogiannakis, J., Miethke, R. R., & McNamara, J. A. (2000) *Glossary of orthodontic terms* (p. 79). Batavia, IL, USA: Quintessence Publ..
- Di Martino, P. (2018) Extracellular polymeric substances, a key element in understanding biofilm phenotype. *AIMS microbiology*, *4*(2), 274.
- Duyck, J., Vandamme, K., Krausch-Hofmann, S., Boon, L., De Keersmaecker, K., Jalon, E., & Teughels, W. (2016) Impact of denture cleaning method and overnight storage condition on denture biofilm mass and composition: a cross-over randomized clinical trial. *PLoS One*, *11*(1), e0145837.
- Ebert, J. F., Huibers, L., Christensen, B., & Christensen, M. B. (2018) or web-based questionnaire invitations as a method for data collection: cross-sectional comparative study of differences in response rate, completeness of data, and financial cost. *Journal of medical Internet research*, *20*(1), e24.
- effects of orthodontic appliances on Candida in the human mouth. *International journal of paediatric dentistry*, 19(5), 301-308.
- Eichenauer, J., Serbesis, C., & Ruf, S. (2011) Cleaning removable orthodontic appliances-a survey. *Journal of Orofacial Orthopedics/Fortschritte der Kieferorthopadie*, *72*(5).

- Farhadifard, H., Soheilifar, S., & Bakhshaei, A. (2021) Plaque Removal Efficacy of 3 Cleaning Methods for Removable Orthodontic Appliances: A Crossover Randomized Clinical Trial. *Turkish Journal of Orthodontics*, 34(3), 170.
- Fathi, H., Martiny, H., & Jost-Brinkmann, P. G. (2015) Efficacy of cleaning tablets for removable orthodontic appliances. *Journal of Orofacial Orthopedics/Fortschritte der Kieferorthopadie*, *76*(2)
- Fernández, I. C. S., Busscher, H. J., Metzger, S. W., Grainger, D. W., & van der Mei, H. C. (2011). Competitive time-and density-dependent adhesion of staphylococci and osteoblasts on crosslinked poly (ethylene glycol)-based polymer coatings in co-culture flow chambers. *Biomaterials*, *32*(4), 979-984.
- Flemming, H. C., Baveye, P., Neu, T. R., Stoodley, P., Szewzyk, U., Wingender, J., & Wuertz, S. (2021) Who put the film in biofilm? The migration of a term from wastewater engineering to medicine and beyond. *npj Biofilms and Microbiomes*, *7*(1), 10.
- Guilhen, C., Forestier, C., & Balestrino, D. (2017) Biofilm dispersal: multiple elaborate strategies for dissemination of bacteria with unique properties. *Molecular microbiology*, *105*(2), 188-210.
- Hibino, K., Wong, R. W., Haegg, U., & Samaranayake, L. P. (2009) The
- https://couserorthodontics.com/dental-dictionary
- Karygianni, L., Ren, Z., Koo, H., & Thurnheer, T. (2020) Biofilm matrixome: extracellular components in structured microbial communities. *Trends in Microbiology*, *28*(8), 668-681.
- Kaur, R., Jain, A. K., Ansari, A., & Garg, N. (2011) Potential iatrogenic responses to orthodontic treatment. *JIDA; 5 (1)*, 109-111.
- Kaur, S., Singh, R., Soni, S., Garg, V. and Kaur, M. (2018) Esthetic

orthodontic appliances–A review. *Annals of Geriatric Education and Medical Science*s, 5(1), 11-14.

- Kostakioti, M., Hadjifrangiskou, M., & Hultgren, S. J. (2013) Bacterial biofilms: development, dispersal, and therapeutic strategies in the dawn of the postantibiotic era. *Cold Spring Harbor perspectives in medicine*, *3*(4), a010306.
- Levrini, L., Novara, F., Margherini, S., Tenconi, C., & Raspanti, M. (2015) Scanning electron microscopy analysis of the growth of dental plaque on the surfaces of removable orthodontic aligners after the use of different cleaning methods. *Clinical, cosmetic and investigational dentistry*, 125-131.
- Lima, E. M. C. X., Moura, J. S., Del Bel Cury, A. A., Garcia, R. C. M. R., & Cury, J. A. (2006) Effect of enzymatic and NaOCl treatments on acrylic roughness and on biofilm accumulation. *Journal Of Oral rehabilitation*, 33(5), 356-362.
- Littlewood, S. J., & Mitchell, L. (2019) *An introduction to orthodontics*. Oxford university press.
- Madan, C., Arora, K., Chadha, V. S., Manjunath, B. C., Chandrashekar, B. R., & Moorthy, V. R. R. (2014) A knowledge, attitude, and practices study regarding dental floss among dentists in India. *Journal of Indian Society of Periodontology*, *18*(3), 361.
- Martins Junior, R. L., Kerber, F. D. C., & Stuginski-Barbosa, J. (2011) Attitudes of a group of Brazilian orthodontists towards the diagnosis and management of primary headache (migraine): an electronic-based survey. *Journal of Applied Oral Science*, *19*, 674-678.
- Muscat, Y., Farrugia, C., Camilleri, L., Arias-Moliz, M. T., Valdramidis, V., & Camilleri, J. (2018) Investigation of acrylic resin disinfection using chemicals and ultrasound. *Journal of Prosthodontics*, *27*(5), 461-468.

- Nalbant, A. D., Kalkanci, A., Filiz, B., & Kustimur, S. (2008) Effectiveness of different cleaning agents against the colonization of Candida spp and the in vitro detection of the adherence of these yeast cells to denture acrylic surfaces. *Yonsei medical journal*, *49*(4), 647-654.
- Nisayif, D. H. (2009) The effects of removable orthodontic appliance hygiene on oral flora. *Journal of baghdad college of dentistry*, *21*(2).
- Oliveira Paranhos, H. F., Silva-Lovato, C. H., De Souza, R. F., Cruz, P. C., De Freitas-Pontes, K. M., Watanabe, E., & Ito, I. Y. (2009). Effect of three methods for cleaning dentures on biofilms formed in vitro on acrylic resin. *Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry*, *18*(5), 427-431.
- Paranhos, H. F. O., SILVA-LOVATO, C. H., Souza, R. F., Cruz, P. C., Freitas, K. M., & Peracini, A. (2007) Effects of mechanical and chemical methods on denture biofilm accumulation. *Journal of oral rehabilitation*, *34*(8), 606-612.
- Pathak, A. K., & Sharma, D. S. (2013) Biofilm associated microorganisms on removable oral orthodontic appliances in children in the mixed dentition. *Journal of Clinical Pediatric Dentistry*, *37*(3), 335-340.
- Phulari, B.S. (2017) *Orthodontics: Principles and Practice*. 2nd ed. New Delhi, Jaypee Brothers Medical Publishers.
- Proffit, W.R., Fields, H.W., Larson, B., & Sarver, D.M. (2019) *Contemporary orthodontics*. Elsevier Health Sciences.
- Rossato, M. B., Unfer, B., May, L. G., & Braun, K. O. (2011) Analysis of the effectiveness of different hygiene procedures used in dental prostheses. *Oral Health Preventive Dentistry*, 9(3), 221-7.
- Saleh, A., & Bista, K. (2017) Examining factors impacting online survey

response rates in educational research: Perceptions of graduate students. *Online Submission*, *13*(2), 63-74.

- Sampaio-Maia, B., & Monteiro-Silva, F. (2014) Acquisition and maturation of oral microbiome throughout childhood: An update. *Dental research journal*, *11*(3), 291.
- Shay, K. (2000) Denture hygiene: a review and update. *The Journal Of Condemnatory Dental Practice*, 1(2), 28-41
- Singh, G. (2008) *Textbook of orthodontics*. Jaypee Brothers Publishers.
- Smith, W. G. (2008) Does gender influence online survey participation? A record-linkage analysis of university faculty online survey response behavior. *Online submission.*
- Soro, V., Dutton, L. C., Sprague, S. V., Nobbs, A. H., Ireland, A. J., Sandy, J. R., ... & Jenkinson, H. F. (2014) Axenic culture of a candidate division TM7 bacterium from the human oral cavity and biofilm interactions with other oral bacteria. *Applied and environmental microbiology*, 80(20), 6480-6489.
- Tektas, S., Thurnheer, T., Eliades, T., Attin, T., & Karygianni, L. (2020) Initial bacterial adhesion and biofilm formation on aligner materials. *Antibiotics*, 9(12), 908.
- Topaloglu-Ak, A., Ertugrul, F., Eden, E., Ates, M., & Bulut, H. (2011) Effect of orthodontic appliances on oral microbiota—6 month follow-up. *Journal of Clinical Pediatric Dentistry*, *35*(4), 433-436.
- Wang, Q., Ma, J. B., Wang, B., Zhang, X., Yin, Y. L., & Bai, H. (2019) Alterations of the oral microbiome in patients treated with the Invisalign system or with fixed appliances. *American Journal of Orthodontics and Dentofacial Orthopedics*, *156*(5), 633-640.

Appendix I : the survey questioner

Collage of dentistry university of Baghdad

Cleaning removable orthodontic appliances survey, Orthodontic specialist's and dental student perception

Rawan osamah zaki

5th year undergraduate student

1.Participant gender

- Female
- Male

2.Participant age

- Less than 30
- 31- 40
- 41 –

3.Academic title

- Assistant/ full Professor
- Lecturer
- Orthodontic Specialist
- Orthodontic Student
- Undergraduate 5th year student

4.Years of experience

- Less than 5 years
- 1 - 5 years
- 10 - 15 years
- 15 - 20 years

- More than 20
- Senior dental student

5.Occupation

- State hospital
- Privet
- University
- Undergraduate student

6.Which of the following materials do you use for the fabrication of the removable orthodontic appliance?

- Auto-polymerizing acrylic resin
- Heat-polymerizing acrylic resin
- Light-polymerizing resin

7.What is your suggested daily wear time for the appliances?

- 1-8 hours/day
- 8 - 16 hours/day
- 16 - 24 hours /day

8.In which age group do you mostly use these appliances? (more than one answer)

- 4 - 8 years
- 9 -13 years
- 14 - 18 years
- >18 years

9.Do you recommend the use of brushing as a primary way of cleaning?

- Yes

- No

10.Do you recommend the use of an extra brush?

- Yes
- No

11.What type of brush do you recommend?

- Soft
- Medium
- Hard
- No comment

12.Do you recommend the use of other cleaning agents besides brushing?

- Yes
- No

13.Which is your suggested cleaning/disinfecting method for these appliances?

- Tooth paste
- Soap
- Immersion in denture cleansers (e.g. effervescent tablets)
- Immersion in disinfecting solution (e.g. chlorhexidine, Listerine, hypochlorite)
- Immersion in vinegar
- Use of microwaves
- Use of ultrasonic instruments
- Combination of the above methods
- Other

14. How often do you recommend the cleaning frequency?

- Less than once a day
- Once a day
- Twice a day
- Three time a day
- More than that