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PREVALENCE ASSESSMENT OF GINGIVAL BLACK TRIANGLES FOLLOWING INVISALIGN ORTHODONTIC TREATMENT AMONG PATIENTS IN SAUDI ARABIA: A CROSS-SECTIONAL STUDY

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Abstract

Background: An essential component of restorative dental treatment is treating the black gingival triangle, also known as open gingival embrasures, which are a condition brought on by the loss of interdental papillae. It has an impact on the gingival's aesthetics and may worry patients about things like phonetics, food impaction, oral hygiene maintenance, and attractiveness. There is currently very little information available to address the subject of whether orthodontic treatment and gingival black triangles are related. **Objective:** The purpose of this study was to explore how common gingival black triangles were among Saudi Arabian patients who had undergone orthodontic treatment with Invisalign. **Methodology:** This study created use of a structured questionnaire that the authors created for an across-successional study questionnaire survey that would be carried out in Saudi Arabia (SA). **Results:** In a cross-sectional study involving 450 participants in Saudi Arabia, the prevalence of gingival black triangles following Invisalign orthodontic treatment was assessed. The mean age of participants was 26.5 years, with a majority being female (64.4%) and predominantly Saudi nationals (88.9%). Notably, 51.1% of respondents reported awareness of black triangles post-treatment, an increase from 25.8% pre-treatment. The study revealed significant associations between the occurrence of black triangles and factors such as age, residential region, nationality, chronic diseases, and treatment duration, highlighting a gap in communication regarding this aesthetic concern in dental care. **Conclusion:** The present study contributes to the growing body of literature on the prevalence of gingival black triangles following Invisalign orthodontic treatment. The findings underscore the need for increased awareness and education among both patients and dental professionals regarding the potential aesthetic and functional implications of orthodontic treatment.

Keywords*:* Black gingival triangle, Prevalence, Orthodontic, Invisalign.

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Introduction:

The area between two adjacent teeth is filled up by the interdental papilla of the gingiva. This papilla serves as a biological barrier to help protect the periodontal tissues underneath it and enhances the appearance of the gingiva. Loss of papilla can cause lateral food impaction, phonetic problems (where air or saliva can pass through), and cosmetic defects (often referred to as "black triangle disease"). A short or absent interdental papilla, which is crucial to anterior esthetics, can cause a black gingival triangle [1].

In healthy individuals, orthodontic therapy is usually associated with temporary discomfort and a small amount of periodontal damage. During orthodontic therapy, a healthy periodontium may withstand tooth motions without the periodontal tissues deteriorating. On the other hand, orthodontic therapy may also adversely affect periodontal tissues, resulting in gingival recession, root resorption, bone dehiscence, loss of soft tissue architecture, and the formation of gingival black triangles (GBT), all of which could significantly impair the aesthetic outcome. When a GBT (also called a "open gingival embrasure") occurs, the interdental papilla is lost. Furthermore, due to meal retention and somewhat difficult mechanical plaque control, GBT may develop periodontal problems [2].

A "black triangle" is any interproximal soft tissue loss caused by crown lengthening procedures, traumatic mechanical or chemical preparation, or periodontal disease [3].

The stretching of the interdental transseptal gingival fibers during orthodontic therapy is one of the many possible reasons of black triangles. The degree of crowding, age, alveolar bone height, periodontal response, tooth type, and angle created by the roots of nearby teeth can all be factors in open gingival embrasures.

Most previous studies that evaluated open gingival embrasures failed to consider the complex effects of tooth movement. Recent research indicates that the movement of teeth during orthodontic therapy may have an impact on the development of open gingival embrasures [4].

To accommodate changes in esthetic and functional properties, connections between the soft tissue and underlying bone are changed during orthodontic treatment, moving teeth into new positions [5]. After orthodontic treatment, a significant incidence of gingival black triangles (between 38% and 43.7%) has been reported. This phenomenon is not consistent with the modern aesthetic standards for adolescents receiving orthodontic treatment [6, 7]. When gingival tissue does not completely occupy the interdental space, it might cause open gingival embrasure and perhaps trap food particles. Particularly in older individuals with a history of bone loss, this condition may have a detrimental effect on periodontal health [8]. Both the general public and general dentistry professionals found open gingival embrasures larger than 3 mm to be less cosmetically attractive [9, 10]. A 2018 study carried out in Spain [11] found no differences in the patients' perceptions of any alterations of the black triangle before and after orthodontic treatment. According to a 2021 investigation, follow-up gingival recession and detectable inflammation were substantially worse than-pre-treatment-values [12].

An additional Indian study conducted in 2022 demonstrates that, on average, 36.42 percent of patients in the adult orthodontic population in India have open gingival embrasures following orthodontic treatment [13].

Because of to a restricted number of participants, especially in Saudi Arabia, prior research has employed a small number of samples and yielded a diverse set of results. Research findings that associate orthodontic therapy with the development of open gingival embrasures (OGEs) are contradictory. Gingival black triangles are linked to orthodontic treatment, according to some research, but interdental papilla growth stimulation appears to be a preventive measure for this problem. To the best of our knowledge, the available data and published studies barely address the question of whether orthodontic treatment and the increasing incidence of gingival black triangles are associated. The

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purpose of this study is to determine how often gingival black triangles are among Saudi Arabian patients who have received Invisalign orthodontic treatment.

Materials And Methods:

Study Design:

A structured questionnaire created by the authors is used in a cross-successional investigation. Patients from Saudi Arabia who received orthodontic treatments made up the study's population. The Saudi patients included in the study were all adults, meaning they were at least eighteen years old. The study sample was drawn from patients undergoing orthodontic treatment at several orthodontic clinics located in different parts of Saudi Arabia.

Sample Size:

The sample size was estimated using the following formula with a 95% confidence level and 5% margin of error:
n = (Z^2 * P(1-P)) / d^2
Where:
- n = Calculated sample size
- Z = Z-value for 95% confidence level (1.96)
- P = Estimated prevalence (0.50)
- d = Maximum acceptable error (0.05)

Plugging in the values:
n = (1.96)^2 * 0.50 * (1 - 0.50) / (0.05)^2
n = 384 participants
The calculated minimum sample size was 384 participants.

Inclusion and exclusion Criteria:

A minimum of 384 post-treatment patients was selected based on the following criteria: they were at least 18 years old and consent to participate in our study. Patients who had black triangles before starting Invisalign Orthodontic Treatment, patients who did not finish Invisalign Orthodontic Treatment, and patients undergoing Fixed orthodontic treatment or intermaxillary fixation after accidents and fractures was excluded.

Method for Data collection and Instrument (*Data collection technique and tools*):

A structured questionnaire was employed as a measurement tool to assess the prevalence of Gingival Black Triangles Following Fixed Orthodontic Appliance Treatment Among Patients in Saudi Arabia. Google Forms were utilized to create the questionnaire and collect data. To assess the appropriateness, relevance, clarity, and adequacy of the questions, the questionnaire was reviewed by orthodontists. The questionnaire was initially designed in English and subsequently translated into Arabic, the native language of the participants. To gauge the appropriateness, relevance, clarity, and adequacy of the Arabic version, it was evaluated by experts who were native Arabic speakers and volunteers from the general population. Necessary modifications to the Arabic questionnaire were implemented based on the feedback provided by the experts and volunteers. The final version of the questionnaire comprised 19 questions categorized into five main sections. The first section ensures that the participant sample precisely aligns with the research objective. Participants are asked to specify the type of orthodontic

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appliance used, either a fixed metal appliance, or a clear appliance, and whether they have completed their orthodontic treatment.

The second section includes personal information. The demographic section of the survey offers important information into the characteristics of the participants, such as gender, age, nationality, and Saudi Arabian region of residency. In order to better understand how their condition might be impacted by any underlying medical conditions, participants are further asked to elaborate. This data advances our comprehension of the study's sample population in a thorough manner.

Treatment and experience information are covered in the third part. Participants must give specific information in this section regarding the length of their orthodontic treatment and whether they have had orthodontic treatment more than once. In addition, they are requested to provide details on how satisfied they are with the way their smile looks after orthodontic treatment and whether or not they see any black triangles following orthodontic treatment.

Information regarding the gingival black triangle problem is provided in the fourth section. Questions about the existence of a family history of gingival black triangle difficulties, the location, quantity, and problems that come from gingival black triangles, and how these triangles are found are addressed in this section.

During and after orthodontic treatment, oral care is the main topic of the fifth segment. In this segment, we delve deeper into the participants' oral hygiene practices both during and after orthodontic treatment, with a focus on the ongoing usage of retainers.

Methods of Analysis and Data Entry:

Data was entered using the computer's "Microsoft Office Excel Software" (2013) Windows software. After that, the data was statistically examined using the SPSS software, version 20 (IBM SPSS Statistics for Windows, Version 20.0; Armonk, NY: IBM Corp.).

Results:

Table (1) displays various demographic parameters of the participants with a total number of (450). Participants have a mean age of 26.5 years, standard deviation 6.8, and are thus a fairly young population with a majority (32.2%) being 24 years or younger (25.6%). Interestingly, majority of the sample is female (64.4%) and male representation is lower (35.6%). Geographical distribution shows that the highest percentage of participants (i.e., 33.8%) are based in the Southern region while the Northern and Western regions had comparable percentages of 20.9% and 25.6% of participants respectively. It is also worth noticing that 88.9% of the participants were Saudis nationals which, proves, a leading demographic. Prevalence of chronic disease is markedly low, with 3.3% of participants reporting any chronic conditions, a generally healthy cohort.

Table (1): Sociodemographic characteristics of participants (n=450)

Parameter		***No.***	***Percent (%)***
Age (Mean:26.5, STD:6.8)	23 or less	115	25.6
	24 years	145	32.2
	26 to 30	110	24.4
	34 or more	80	17.8
Have you finished your orthodontic treatment?	No	0	0
	Yes	450	100.0

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Gender	Female	290	64.4
	Male	160	35.6
Residential region	Northern region	94	20.9
	Southern region	152	33.8
	Central region	89	19.8
	Western region	115	25.6
Nationality	Saudi	400	88.9
	Non-Saudi	50	11.1
Do you have any chronic diseases?	No	435	96.7
	Yes	15	3.3

As shown in figure 1, The data presented report the frequency of orthodontic treatment durations for the total sample of 450. Approximately 68.9% (310 participants) were involved in such orthodontic treatment in a period of one to three years, which might characterize the nature and severity of dental problem treated at this period. By contrast, 31.1% of the sample, that is, 140 people, completed their treatment within a year, offering some indication that there is a subset of cases which may have benefitted from simple interventions or early orthodontic assessment.

Figure (1): Illustrates orthodontic treatment period among participants.

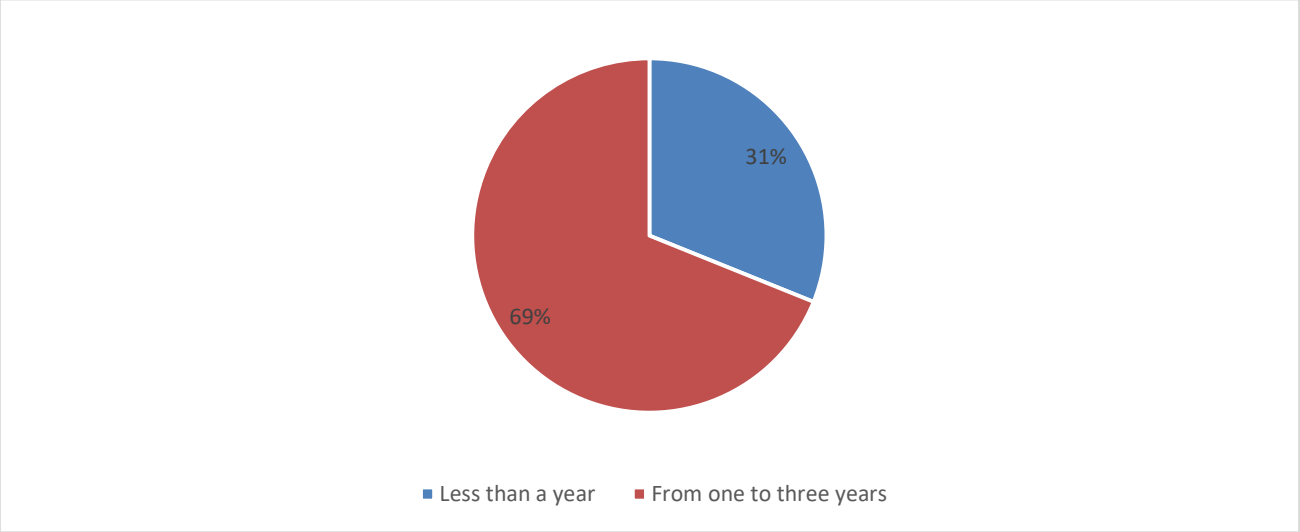

Table 2 shows a summary of data of a cohort of 450 subjects who have undergone Invisalign orthodontic treatment. Furthermore, it is noteworthy how exclusive the use of Invisalign had over traditional metal braces majority trusts in aesthetic and comfort centric orthodontic solutions. Treatment duration, in general, is strongly skewed, with only 31.1% of treatment spanning 1 to 3 years, which may suggest that the intrinsic nature of reaching ideal dental alignment will involve longer treatment periods with clear aligner systems. Presence of tooth crowding, both with and without extraction needs, is shown to be a major reason for starting treatment (43.4%), highlighting the prevalence of orthodontic problems. Moreover, a large amount (54.4%) of respondents had a history of orthodontic treatment, indicating a pattern of re-treatment to refine or adjust a prior outcome.

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Table (2): Parameters related to history of Invisalign orthodontic treatment (n=450).

Parameter		***No.***	***Percent (%)***
Type of Orthodontic Treatment	Invisalign	450	100.0
	Metal braces	0	0
Orthodontic treatment period	Less than a year	140	31.1
	From one to three years	310	68.9
Reason for starting orthodontic treatment	Crowding of teeth that requires extraction	165	36.7
	Crowding of teeth without the need for extraction	30	6.7
	Problems of tooth advancement or recession	110	24.4
	Presence of spaces between teeth	95	21.1
	Other	50	11.1
Have you had orthodontic treatment more than once?	No	205	45.6
	Yes	245	54.4
How satisfied are you with the attractiveness of your smile after braces?	Very satisfied	240	53.3
	Moderately satisfied	110	24.4
	Neutral	100	22.2

As shown in figure (2), Intriguing insight into how participants (n=230) become aware of black triangles is given by data regarding participants' awareness of this dental phenomenon. Fifteen participants, about 6.5% as percentage of the total, indicated that they had been told of black triangles by their dentist, suggesting a communication gap within dental care. More than half of respondents (or about 115 people), identified these triangles themselves, usually noticed when you are brushing, flossing, or looking at your teeth in the mirror. Additionally, one hundred (roughly 43.5%) were alerted to the black triangles by means of tactile sensation — or the sensation of feeling the triangles with one's tongue.

Figure (2): Illustrates knowing about black triangles among participants.

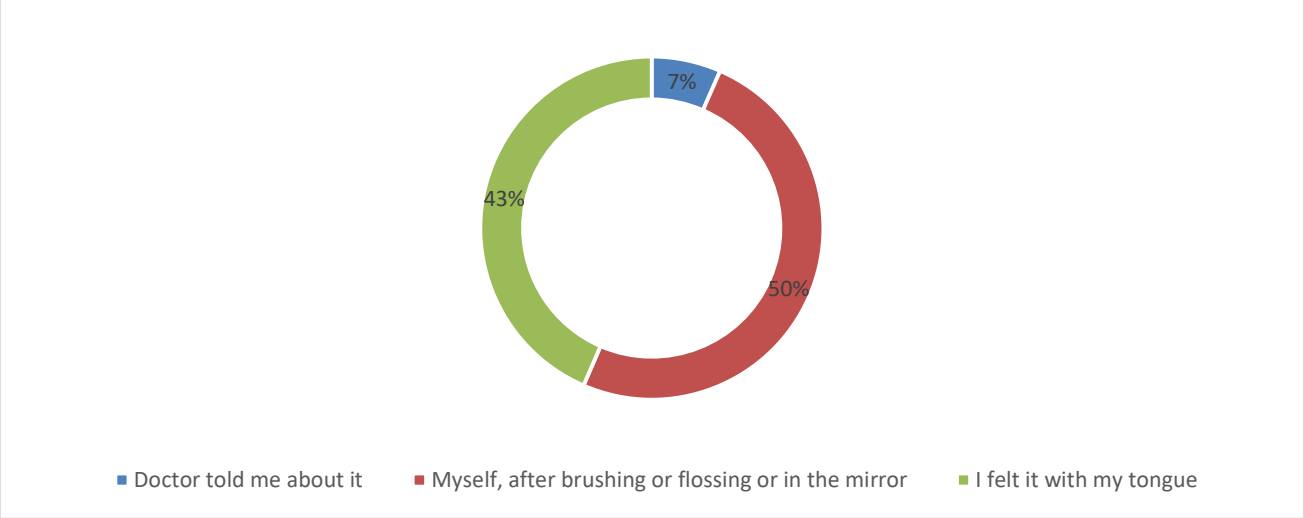

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Table 3 provides us with data that provides insight into whether participants were made aware of this problem and the effect that Invisalign orthodontic treatment has had on prevalence. The Black triangle phenomenon was noted by 51.1% respondents, which marked from 25.8% pretreated to 30.2% when the procedure was already completed. This means that the majority reported these gaps themselves as they didn't seem to use proactive communication provided by dental professionals about such common occurrence. The data also suggests that most of the black triangles occurred between the upper front teeth, potentially having significant aesthetic consequences for patients. It is interesting that quite a few participants (28.3%) admitted encountering trades of food impaction, lime buildup, and aesthetic problems that might possibly affect oral hygiene and general fullness contentment with orthodontic culmination. In addition, retirees were distributed equally (50% regular, 50% sometimes) which indicates the necessity of better patient education about how important retainer wear is to avoid complications such as this.

Table (3): participants' prevalence assessment of gingival black triangles following Invisalign orthodontic treatment (n=450).

Parameter		***No.***	***Percent (%)***
Have you noticed black triangles after orthodontic treatment?	No	220	48.9
	Yes	230	51.1
How did you know about the black triangles? (n=230)	Doctor told me about it	15	6.5
	Myself, after brushing or flossing or in the mirror	115	50.0
	I felt it with my tongue	100	43.5
Did any of your parents or relatives have clear braces and develop black triangles between their teeth? (n=230)	Yes	65	28.3
	Neither of them had orthodontic treatment	65	28.3
	I don't know	50	21.7
	No	50	21.7
Where are the black triangle gaps in your mouth that appeared after braces? * (n=230)	Between the front teeth in the lower jaw	195	84.8
	Between the front teeth in the upper jaw	230	100.0
How many black triangles between teeth can you see after orthodontic treatment? (n=230)	In two to three places	230	51.1
	In one place	0	0
What problems are caused by black triangle spaces between teeth? * (n=230)	Food impaction problems	65	28.3
	Lime and lime buildup problems	65	28.3
	Appearance problems	65	28.3
	None	65	28.3
How regularly do you use your retainer after completing orthodontic treatment? (n=230)	Regular	115	50.0
	Sometimes Regular	115	50.0
Which of the following do you use to clean your teeth? * (n=230)	Regular toothbrush and toothpaste	145	63.0

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	Electronic toothbrush and toothpaste	50	21.7
	Water floss	165	71.7
	Mouthwash	50	21.7
	Water and salt	100	43.5
	Miswak	50	21.7
	Toothpick	65	28.3

Table (4) shows that noticing black triangles after orthodontic treatment has statistically significant relation to age (P value=0.0001), residential region (P value=0.0001), nationality (P value=0.0001), having chronic diseases (P value=0.0001), and orthodontic treatment period (P value=0.0001). It also shows statistically insignificant relation to gender.

Table (4): Relation between noticing black triangles after orthodontic treatment and sociodemographic characteristics.

Parameters		***Have you noticed black triangles after orthodontic treatment?***		***Total (N=450)***	***P value****
		No	**Yes**		
Gender	Female	140	150	290	0.726
		63.6%	65.2%	64.4%	
	Male	80	80	160	
		36.4%	34.8%	35.6%	
Age	23 or less	65	50	115	0.0001
		29.5%	21.7%	25.6%	
	24 years	95	50	145	
		43.2%	21.7%	32.2%	
	26 to 30	30	80	110	
		13.6%	34.8%	24.4%	
	34 or more	30	50	80	
		13.6%	21.7%	17.8%	
Residential region	Northern region	82	12	94	0.0001
		37.3%	5.2%	20.9%	
	Southern region	65	87	152	
		29.5%	37.8%	33.8%	
	Central region	33	56	89	
		15.0%	24.3%	19.8%	
	Western region	40	75	115	
		18.2%	32.6%	25.6%	
Nationality	Saudi	220	180	400	0.0001
		100.0%	78.3%	88.9%	
	Non-Saudi	0	50	50	
		0.0%	21.7%	11.1%	
Do you have any chronic diseases?	No	205	230	435	0.0001
		93.2%	100.0%	96.7%	

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	Yes	15	0	15	
		6.8%	0.0%	3.3%	
Orthodontic treatment period	Less than a year	125	15	140	0.0001
		56.8%	6.5%	31.1%	
	From one to three years	95	215	310	
		43.2%	93.5%	68.9%	

P value was considered significant if ≤ 0.05.

Table (5) shows has statistically significant relation to gender (P value=0.001), residential region (P value=0.0001), nationality (P value=0.0001), having chronic diseases (P value=0.035), and orthodontic treatment period (P value=0.0001).

Table (5): Satisfaction with smile after braces in association with sociodemographic characteristics.

Parameters		***How satisfied are you with the attractiveness of your smile after braces?***		***Total (N=450)***	***P value****
		Neutral	**Satisfied**		
Gender	Female	50	240	290	0.001
		50.0%	68.6%	64.4%	
	Male	50	110	160	
		50.0%	31.4%	35.6%	
Age	23 or less	50	65	115	N/A
		50.0%	18.6%	25.6%	
	24 years	0	145	145	
		0.0%	41.4%	32.2%	
	26 to 30	0	110	110	
		0.0%	31.4%	24.4%	
	34 or more	50	30	80	
		50.0%	8.6%	17.8%	
Residential region	Northern region	0	94	94	0.0001
		0.0%	26.9%	20.9%	
	Southern region	41	111	152	
		41.0%	31.7%	33.8%	
	Central region	12	77	89	
		12.0%	22.0%	19.8%	
	Western region	47	68	115	
		47.0%	19.4%	25.6%	
Nationality	Saudi	50	350	400	0.0001
		50.0%	100.0%	88.9%	
	Non-Saudi	50	0	50	
		50.0%	0.0%	11.1%	
Do you have any chronic diseases?	No	100	335	435	0.035
		100.0%	95.7%	96.7%	
	Yes	0	15	15	

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		0.0%	4.3%	3.3%	
Orthodontic treatment period	Less than a year	0	140	140	0.0001
		0.0%	40.0%	31.1%	
	From one to three years	100	210	310	
		100.0%	60.0%	68.9%	

P value was considered significant if ≤ 0.05.

Discussion:

The main objective of the present study was to determine prevalence of gingival black triangles after Invisalign orthodontic treatment among those who received treatment in Saudi Arabia. This found a high incidence of gingival black triangles among the younger patients, and a strong correlation between the awareness of these conditions and a number of demographic factors. We compare these findings to the existing literature, discussing the implications of orthodontic treatment on gingival health and aesthetics, the limitations of the study as well as this discussion.

The current study concurs with previous research indicating that open gingival embrasures are common results of orthodontic treatment, being present in the prevalence of the current study. For example, Sharma and Park mentioned that open gingival embrasures may range from 0 percent to 38 percent in adults under orthodontic intervention [14]. In a similar line, more than one third of adults reported open gingival embrasures post treatment in their report by Zhang et al [15] showing the aesthetic and functional burden which embrasures represent. The findings of the present study, however, support these statistics and support the need for increased awareness among both patients and practitioners of this potential outcome of orthodontic treatment, as 51.1% reported seeing black triangles.

Additionally, the demographic analysis of the study showed that the participants were a large number of young adults with mean age of 26.5 years. The findings based on this demographic trend are consistent with Ko-Kimura's finding, in which younger patients were especially prone to developing open gingival embrasures after orthodontics [16]. These findings are important given that they indicate that orthodontic practitioners need to be particularly sensitive to the presence of gingival recession and black triangles in younger patients, particularly in the context of clear aligners such as Invisalign, where biomechanical forces on the periodontal tissues may be unique.

It also revealed a troubling gap in patient awareness regarding gingival black triangles, with only 6.5 per cent of participants being aware of this problem informed by their dentist. This result agrees well with Al-Saleh et al, who reported that many layman and general dentists had problems identifying if the open gingival embrasures they view exceed 3mm [17]. One of the most important aspects of the current study is that at least half of the respondents became aware of black triangles by their own observations rather than by the guidance of a professional. Improvement in patient satisfaction and outcomes of treatment could be made by a dramatic increase in patient education regarding possible aesthetic and functional implications of orthodontic treatment.

Generally speaking, the findings of the present study agree with those of Naorungroj (19) reporting that open gingival embrasures are found unattractive by general dentists and lay people. Black triangles which occurs between the upper front teeth, have profound aesthetic implications, as these areas are highly visible during social interaction. The work of Hussien et al. [20] in addition supports the aesthetic concern with the argument that black triangles should be addressed in restorative dentistry for patient satisfaction. Results of the present study, whereby 28.3% of participants reported having aesthetic concerns with black triangles, suggest that orthodontists should take into account the long term aesthetic

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outcome from treatment on the gingival level.
In the present study, we conducted statistical analyses and found that there were significant relationships between the presence of black triangles and demographics such as age, residence area, nationality, chronic disease status and treatment duration. Those findings are in line with the research of An et al. et al. who found similar risk factors for open gingival embrasures post treatment [21]. Our finding that treatment duration correlates with black triangles prevalence suggests that orthodontic intervention can exasperate the risk of developing such conditions; an effect noted by Kurth and Kōkich who found that longer treatment times may cause additional periodontal complications [22].
Some limitations are acknowledged though, and this study provides valuable insights. Self-reported data at best introduces bias because participants may not accurately recall their experiences or simply underreport problems with gingival health. Furthermore, because this was a cross-sectional study, no causal relationships could be established between orthodontic treatment and the formation of black triangles. Further understanding of the temporal dynamics of gingival health with orthodontic interventions is warranted by future longitudinal studies. In addition the study sample was derived from specific areas of Saudi Arabia, which may result in the study findings being not generalizable to wider populations.

Conclusion:
This study is of relevance to other existing literature on the existence of gingival black triangles associated with Invisalign orthodontic treatment. The findings highlight the importance of raising awareness and education of both patient dentists in the possibility of aesthetic and functional aspects that could arise due to orthodontic treatment. Orthodontists can promote better communication between patients and themselves on these issues, thus improving patient satisfaction as well as outcomes and ultimately gingival health and aesthetic outcomes in orthodontic care.

Acknowledgement:

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Ethical approval

An informed consent was obtained from each participant after explaining the study in full and clarifying that participation is voluntary. Data collected were securely saved and used for research purposes only.

Funding

There was no external funding for this study.

Conflict of interests

The authors declare no conflict of interest.

Informed consent:

Written informed consent was acquired from each individual study participant.

Data and materials availability

All data associated with this study are present in the paper.

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