



Contents lists available at ScienceDirect

The Saudi Dental Journal

journal homepage: www.ksu.edu.sa
www.sciencedirect.com

Associations between maxillary labial frenum Morphology, Attachment, and Patient-Related clinical factors in Saudi Arabian Adults: Cross-sectional study

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ARTICLE INFO

Keywords:

Labial frenum
Occlusion
Frenum morphology
Frenum attachment
Periodontal findings

ABSTRACT

Objective: This study investigated the prevalence of maxillary labial frenum morphologies and attachment types and their associations with various patient-related clinical variables in a population of Saudi Arabian adults.

Methods: This study comprehensively examined 100 participants of both genders to categorize frenum types and attachment sites. The following clinical variables were recorded: probing depth, clinical attachment loss, attached gingiva width, overjet, overbite, diastema width, central incisor condition, occlusion, previous orthodontic treatment, and the incidence of gummy smile.

Results: The mean age was 32.6 years, and the average diastema width was 0.23 mm. The study found that the simple frenum type was the most common morphology (57 %), and gingival attachment was the most frequent attachment type (54 %). Simple frenum was significantly associated with class I occlusion ($p = 0.018$), and frenum with nichum was significantly associated with class II occlusion ($p = 0.019$). Females were more likely to exhibit simple frenum with nodule frenum than males ($p = 0.042$). Mucosal frenum attachment was significantly correlated with the absence of previous orthodontic treatment ($p = 0.042$).

Conclusion: The study identified a relationship between the features of the maxillary labial frenum and occlusion as well as previous orthodontic treatment. Our findings suggest that understanding each patient's unique frenum features can lead to more effective and personalized dental care, thus improving patient satisfaction.

1. Introduction

The frenum is a soft tissue structure in the oral cavity that connects the lips to the underlying periosteum; frenum types include the maxillary labial, mandibular labial, and lingual frenum (Priyanka et al., 2013). The maxillary labial frenum (MLF) is a mucosal band in the mid-maxilla that extends from the upper lip to the labial gingiva (Sadeghi et al., 1984). Histologically, it is composed of elastic and loose connective tissue fibers, mucous glands, and subcutaneous tissue (Gartner and Schein, 1991), which stabilize the maxillary lip and connect it to the alveolar process (Mintz et al., 2005).

Clinical issues associated with MLF include maxillary central incisor

diastemas, labial gingival recession, and orthodontic treatment relapse (Schuepbach et al., 2023). A previous study (Abrahams and Kamath, 2014) observed that a wide, thick MLF could contribute to midline diastema, which has a prevalence of 1.6 % to 25.4 %; furthermore, abnormal attachments may complicate orthodontic procedures and affect aesthetics (Upadhyay and Ghimire, 2012). In 1971, Sewerin classified labial frenum types into nine groups according to morphology (Sewerin, 1971); in addition, Placek et al. (Mirko et al., 1974) delineated four insertion sites; these classifications have been essential to understanding frenum variations.

Papillary and papilla penetrating frenum attachment are pathological and can cause gingival recession, diastema, difficulty brushing, and

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<https://doi.org/10.1016/j.sdentj.2024.02.002>

Received 7 December 2023; Received in revised form 2 February 2024; Accepted 11 February 2024

Available online 16 February 2024

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tooth misalignment, and they may interfere with denture retention (Priyanka et al., 2013).

Eman et al. (Eman et al., 2017) and Taran et al. (Taran et al., 2023) reported that gingival (46 %) and papillary penetrating (13 %) attachment were the most the least common attachment types in children, respectively, and mucosal types were correlated with lower plaque and gingival indices.

According to a prevalence study in Abha, Saudi Arabia (Eid, 2014), the attachment type represented by the highest percentage of patients with anterior gingival recession was normal frenal attachment. Another study (Mohan et al., 2014) conducted in India reported that simple single frenum was the most common type. Moreover, they found that tectolabial frenum with nodule and inverted 'Y' frenum were significantly more prevalent in male patients, whereas bifid frenum was more prevalent in female patients.

Another study (Rajani et al., 2018) involving 150 Indian adults found that the most prevalent frenum type in the class I and II skeletal patterns was the mucosal type, whereas the gingival type was the most prevalent in skeletal class III. Furthermore, they observed that the papillary and papillary penetrating types were significantly associated with the skeletal class III pattern and midline diastema.

However, the prevalence of different MLF morphologies and their associations with dental occlusion in adults in Saudi Arabia have not been unexplored. This study aimed to fill this gap by examining MLF characteristics in the Saudi Arabian adult population and their relationship with patient-related clinical factors.

2. Materials and Methods

This cross-sectional study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The Institutional Review Board of Imam Abdulrahman Bin Faisal University (IAU) approved the study proposal (IRB-2020-02-282), and informed consent was obtained from all participants. The study was conducted in accordance with the Declaration of Helsinki.

The study recruited 100 adults seeking dental treatment in the outpatient clinics of the College of Dentistry, IAU, Eastern Province, Saudi Arabia, from October 2022 to October 2023. The inclusion criteria were as follows: patients were systemically healthy, were over 20 years old, were not undergoing orthodontic treatment, had no prior surgical intervention for periodontal problems in the maxillary incisors, had no history of fracture in the premaxilla or surgical intervention in the premaxillary region, and had no congenital or developmental defects. The exclusion criteria were as follows: patients were younger than 20 years old, had a history of orthognathic or frenal surgeries, had missing premolars or molars, or were under any medication known to affect the gingival tissues. Demographic details, such as age and gender, were recorded. The clinical examination of the frenum was conducted in a dental chair under adequate light by two pre-calibrated examiners who had been tested for inter-examiner agreement before the study; this was accomplished by the examination of 10 randomly selected adults to reach an agreement level of 0.95.

The attachment site of the frenum was classified according to Placek et al. (Mirko et al., 1974), and its morphology was classified according to Sewerin (Sewerin, 1971); examinations of all study participants were performed with a direct visual method through the upward distension of the upper lip, after which intraoral photographs were taken. The two examiners identified both frenum morphology and attachment, and in case of disagreement, the patient's photograph was examined again after 15 min to reach a consensus. If the disagreement was not resolved, a third examiner was consulted to examine the patient.

The clinical examination for the maxillary central incisors was conducted with a dental mirror, an explorer, and a UNC15 probe (Hu-Friedy, Chicago, IL, USA) to identify the tooth condition (missing, sound, restored with crown, abutment for FPD, and with composite restoration or veneer). Then, the periodontal probing depth (PPD), clinical

attachment level (CAL), the amount of gingival recession (GR), and the amount of attached gingiva were measured.

The lip line condition (Tjan and Miller, 1984) (the extent of vertical tooth display while smiling or the elevation of the upper lip in relation to the maxillary incisors); lip muscle tone (Proffit et al., 2018); the presence or absence of gummy smile (Kokich, 1996) (3 to 4 mm of gingival tissue exposed when smiling); the amount of gingival display (Suzuki et al., 2011) measured by a periodontal probe in mm (the distance between the gingival margin of the maxillary central incisors and the lower contour of the upper lip); and the presence or absence of mouth breathing (Pacheco et al., 2015), whether habitual or pathologic, were recorded.

The patient's dental occlusion was determined using Angle's (Angle, 1899) classification by assessing the anteroposterior molar relationship on both the right and left sides when the teeth were in occlusion. Specifically, the relationship between the mesiobuccal cusp tip of the permanent maxillary first molar and the buccal groove of the permanent mandibular first molar was evaluated. Patients with missing premolars or molars were excluded because this can affect the molar relationship. Class I occlusion was noted when the mesiobuccal cusp tip aligned with the buccal groove. In cases in which the cusp tip was mesial to the buccal groove, class II occlusion was recorded, and when the cusp tip was distal to the buccal groove, class III occlusion was identified. The presence of a midline diastema (Keay et al., 1993) of over 1 mm between the two permanent maxillary incisors, the amount of overjet (the distance from the labial-incisal edge of the most prominent maxillary incisor to the labial surface of the corresponding mandibular incisor) (Keay et al., 1993), and the vertical overbite (Keay et al., 1993) were measured with the UNC15 probe to the nearest mm. Each patient's history of previous orthodontic treatment was also recorded.

A power analysis was conducted with G*Power software (Faul et al., 2007) to determine the sample size necessary to achieve 80 % power in detecting a medium effect size at the 0.05 alpha level; the analysis indicated that a sample size of 64 would be adequate. We increased the sample to 100 to account for potential dropouts and enhance the precision of the estimates, allowing for a more in-depth exploration of the associations between MLF characteristics and clinical variables.

Descriptive statistics (frequencies, percentages, means, and standard deviations) were computed. Chi-square tests were used to assess relationships between categorical variables. All p-values less than 0.05 were considered statistically significant.

3. Results

The study included 100 participants (62 % female and 38 % male). The age of the participants ranged from 20 to 45 years, and the average age was 32.6 years. The diastema width varied widely (mean 0.23 ± 0.58 mm). The width of attached gingiva s for tooth 11 and tooth 21 were similar, with mean values of 4.88 ± 1.53 and 4.8 ± 1.55 mm, respectively. The probing depths (PDs) for tooth 11 and tooth 21 were also similar (2.5 ± 1.48 and 2.5 ± 1.45 mm, respectively) (Table 1).

Various frenum types were observed; simple frenum was the most common (57 %), followed by simple with appendix (15 %) and simple with nodule (14 %). Gingival attachment was the most prevalent frenum attachment type, accounting for 54 % of the cases, followed by mucosal (39 %) and papillary (7 %) attachment (Fig. 1).

The overjet had a mean value of 3.0 ± 1.95 mm, whereas the overbite value was slightly lower (2.8 ± 1.89 mm). Gummy smiles were uncommon, with a mean score of 0.69 ± 1.11 (Table 1 and 2), and 68.4 % of teeth 11 and 21 were sound. The most common occlusion class was class I (68 %), followed by class II (19.6 %) and class III (12.4 %). Most participants had a low lip line (58.2 %) and normal lip tone (97 %), and only 16 % were mouth breathers. Only 23 participants (24.2 %) had undergone orthodontic treatment (Table 1).

Statistical analysis revealed significant associations between the occlusion class and certain frenum types. Simple frenum was significantly associated with class I occlusion (78.2 %) ($p = 0.018$). Similarly,

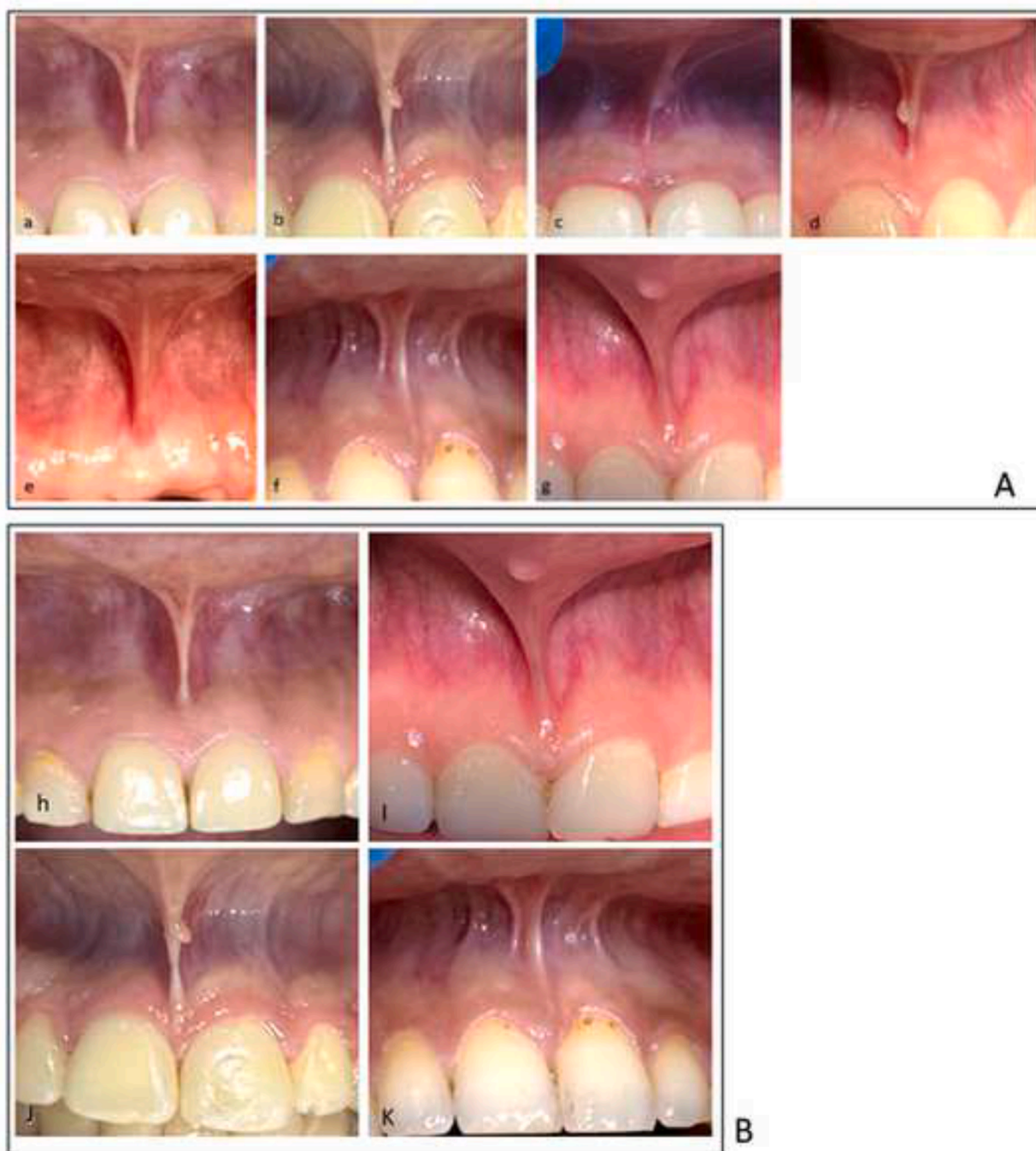


Fig. 1. Clinical intraoral photographs showing A-Different frenum types based on its morphology. (a) Simple frenum; (b) simple frenum with appendix; (c) simple frenum with nodule; (d) double frenum with appendix; (e) persistent tectolabial band; (f) trifid frenum; (g) trifid frenum with nodule B-Different frenum types based on attachment site. Mucosal frenal attachment; (I) Gingival frenal attachment; (J) Papillary frenal attachment; (K) Papillary penetrating frenal attachment.

frenum with nichum was significantly associated with class II occlusion (66.7 %) ($p = 0.019$) (Fig. 2A). However, we did not find any significant associations between occlusion class and frenum attachment site (Fig. 2B). When comparing gender and frenum type, we observed a significant association between simple frenum with nodule and female (85.7 %, $p = 0.042$) (Fig. 2C), but no significant associations were observed between gender and frenum attachment site (Table 3).

No significant differences were observed between the history of previous orthodontic treatment and the frenum type. By contrast, the absence of previous orthodontic treatment was significantly associated with the mucosal frenum attachment site ($p = 0.042$) (Table 4).

4. Discussion

In this study, 100 Saudi Arabian adults were clinically examined to identify associations between MLF morphology/attachment and patient-related clinical factors. The findings indicated that the simple frenum type was most prevalent, followed by simple with appendix and simple with nodule, and gingival attachment was the most common attachment type.

These results align with those of previous studies (Jonathan et al., 2018, Christabel, 2017, Taran et al., 2023), which also reported a high prevalence of simple frenal types and gingival attachment in children.

Table 1
Demographic data of the study sample.

Variable	Frequency	Percentage %
Gender		
Male	38	38.0
Female	62	62.0
Frenum Type		
Simple	57	57.0
Simple with appendix	15	15.0
Simple with nodule	14	14.0
Frenum with nichum	7	7.0
Double with appendix	3	3.0
Persistent techolabial bond	1	1.0
Trifid	1	1.0
Trifid with dodule	1	1.0
Frenum attachment Site		
Mucosal	39	39.0
Gingival	54	54.0
Papillary	7	7.0
Maxillary right central incisor #11 condition		
Sound	67	68.4
Missing	6	6.1
Crown	3	3.1
Abutment for FPD	13	13.1
Composite	1	1.0
Veneer	7	7.1
Caries	1	1.0
Maxillary left central incisor #21 condition		
Sound	67	68.4
Missing	6	6.1
Crown	5	5.1
Abutment for FPD	11	11.2
Composite	1	1.0
Veneer	7	7.1
Caries	1	1.0
Dental Occlusion Class		
Class I	66	68.0
Class II	19	19.6
Class III	12	12.4
Lip line		
Low	57	58.2
High	41	41.8
Lip tone		
Normal	96	97.0
Hyper	3	3.0
Mouth breather		
No	84	84.0
Habitual	4	4.0
Pathological	10	10.0
Previous orthodontic treatment		
Yes	23	24.2
No	72	75.8

Table 2
Clinical findings in the examined sample.

Variables	Minimum	Maximum	Mean	SD
Age	20.00	45.00	32.6	5.09
Diastema width	0.00	3.00	0.23	0.58
Attached gingiva width #11	1.00	9.00	4.88	1.53
Attached gingiva width #21	1.00	8.33	4.8	1.55
PPD #11	1.00	9.00	2.5	1.48
PPD #21	1.00	9.00	2.5	1.45
Overjet	0.00	12.00	3.0	1.95
Overbite	-2.00	9.00	2.8	1.89
Gummy smile	0.00	5.00	0.69	1.11

However, our observation of gender-specific differences in frenum types, especially the higher prevalence of the simple with nodule type in females, contrasts with previous findings (Christabel, 2017) reporting no significant differences in frenal attachment between genders. This could be attributed to variability across demographics and age groups.

In the current study, gingival attachment was the most prevalent attachment type, followed by mucosal and papillary attachment. These

findings align with those of several other studies (Zakirulla et al., 2021, Boutis and Tatakis, 2011, Deepa, 2016, Christabel, 2017), indicating a common pattern in different populations and age groups. Additionally, we did not observe papillary penetrating frenal attachment, which also aligns with previous research (Lindsey, 1977, Popovich et al., 1977) and suggests that this attachment type decreases with age. A study by Díaz-Pizán et al. (Díaz-Pizán et al., 2006) supports this, indicating a change in frenal types with age and craniofacial growth; thus, it is advised to defer the decision of early frenum interventions in children until the eruption of permanent teeth.

We observed an average diastema width of 0.23 mm, which was correlated with the limited presence of papillary frenal attachment. This finding supports the results of Sękowska and Chałas (Sękowska and Chałas, 2017), who reported a lower incidence of diastema in cases with gingival frenum. In the context of orthodontics, Abu-Hussein and Watted (Abu-Hussein and Watted, 2016) and Hasan et al. (Hasan et al., 2020) highlighted the role of frenal morphology in the development and recurrence of midline diastema, indicating the importance of considering frenal type in treatment planning.

Our findings emphasize the relationship between MLF attachment and periodontal health. As suggested by Glickman (1, 1972), certain frenal attachments can contribute to periodontal disease by retracting the free gingiva away from the tooth, which is conducive to plaque accumulation, pocket formation, and gingival recession. This observation highlights the need for an interdisciplinary approach to managing distinct frenum characteristics. The study also showed a significant association between mucosal attachment and the absence of previous orthodontic treatment as well as between frenal attachment type and dental occlusion. Simple frenum was significantly associated with class I occlusion (78 %), whereas frenum with nichum was significantly associated with class II occlusion (67 %). Understanding this relationship is essential, especially when planning orthodontic or prosthodontic treatments. Rajani et al. (Rajani et al., 2018) reported that the presence of papillary and papillary penetrating frenum types was significantly associated with the class III skeletal pattern.

Conversely, a persistent tectolabial frenum was almost always associated with diastema, which was evident in nearly all patients.

Interestingly, our study observed a significant relationship between the mucosal attachment site and the absence of previous orthodontic treatment. The forces exerted on the teeth and the surrounding soft tissues during orthodontic treatments may affect the frenum’s position and attachment type. Alternatively, patients with certain frenal attachment types might display tooth positions or malocclusions that warrant orthodontic interventions more frequently than others. This finding is crucial for orthodontists, as it may influence treatment planning and the post-treatment retention phase.

The study’s findings on frenum types and their correlations with dental occlusal and previous orthodontic treatment are crucial for developing personalized treatment plans. The results of this study will support customized dental treatment planning, specifically in the fields of orthodontics and periodontics, based on individual patient characteristics and needs.

Despite these insights, our study has several limitations, such as a relatively small sample size and geographic area, which impact the generalizability of findings. Another limitation was our inability to verify the patients’ complete histories of orthodontic treatments. Specifically, we could not ascertain whether orthodontic treatment included premolar extraction for all participants. Consequently, previous orthodontic treatment was categorized dichotomously (i.e., yes or no) without the ability to provide more detailed information. Thus, future studies with access to more comprehensive orthodontic histories and larger, more diverse samples are warranted to enhance our understanding of the effects of treatment modalities on oral structures. In addition, longitudinal studies are required to assess changes and potential causal relationships over time, and further research should investigate the clinical implications of these associations in detail.

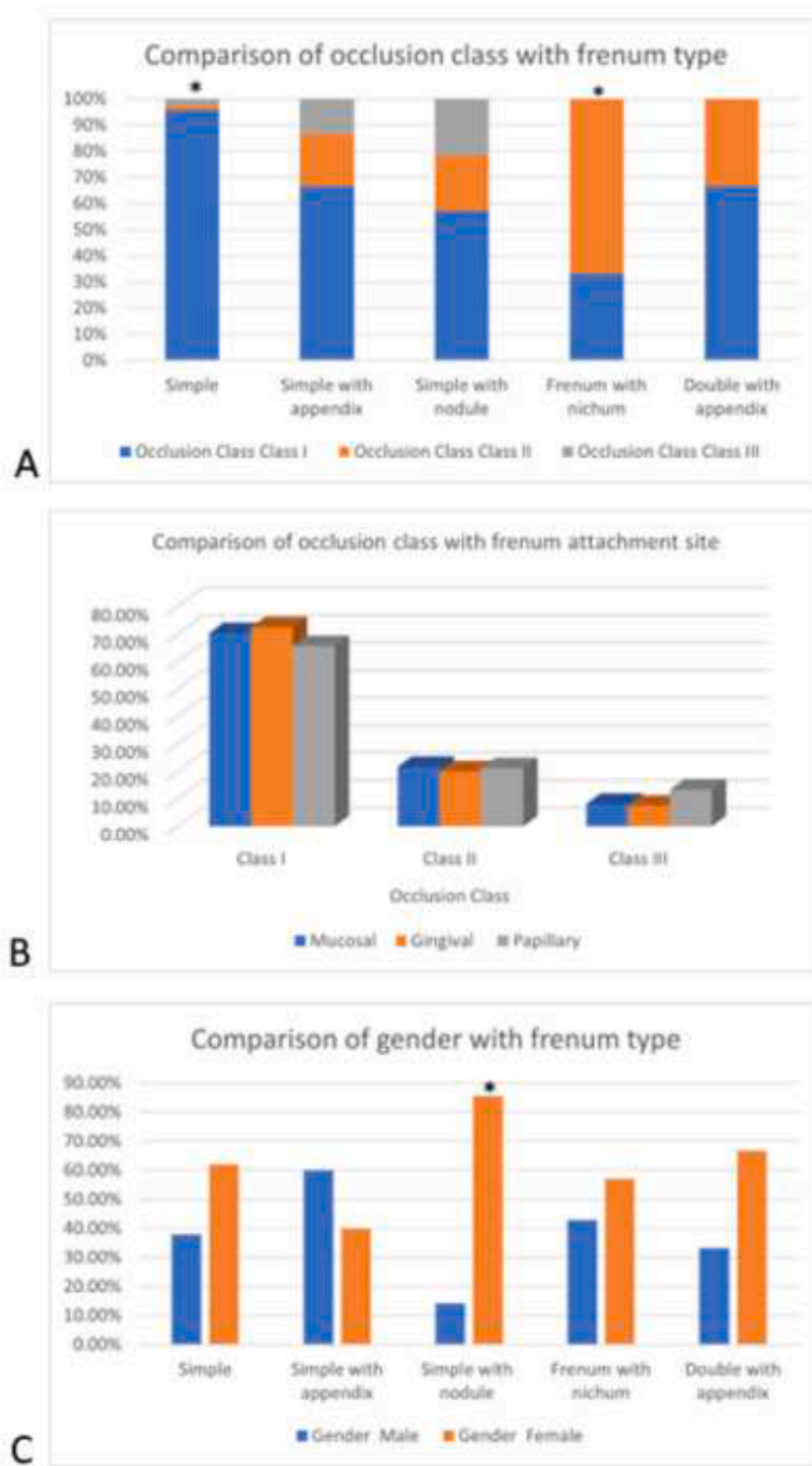


Fig. 2. Graphical representation showing the relation between A) Frenum types and dental occlusion, B) Frenum attachment sites and dental occlusion, and C) Gender differences and frenum types. *Statistically significant at 0.05 level of significance.

5. Conclusion

This study identified significant associations between MLF morphologies/attachment types and dental occlusion, gender, and previous orthodontic treatment. These findings will facilitate the planning of

surgical interventions, such as frenectomies and gingival recessions, thus enhancing treatment efficacy and patient satisfaction.

Clinical significance:

The study’s findings suggest that frenum characteristics can help predict orthodontic outcomes and affect treatment and retention

Table 3
Comparison of gender with frenum attachment site.

Frenum attachment site	Gender		P-value
	Male	Female	
Mucosal	17(43.6 %)	22(56.4 %)	0.259
Gingival	21(35.6 %)	38(64.4 %)	0.536
Papillary	1(14.3 %)	6(85.7 %)	0.246

Table 4
Comparison of previous orthodontic treatment with frenum type and frenum attachment site.

Frenum type and attachment site	Previous Orthodontic treatment		P-value
	No	Yes	
Simple frenum	42(77.8 %)	12(22.2 %)	0.631
Simple with appendix	11(73.3 %)	4(26.7 %)	1.0
Simple with nodule	9(69.2 %)	4(30.8 %)	0.729
Frenum with nichum	5(83.3 %)	1(16.7 %)	1.0
Mucosal attachment	5(13.5 %)	32(86.5 %)	0.042*
Gingival attachment	7(17.5 %)	33(82.5 %)	0.144
Papillary attachment	21(23.6 %)	68(76.4 %)	0.45

* Statistically significant at $p < 0.05$ level of significance.

strategies. Additionally, gender-specific variations in frenum types necessitate customized approaches in dental assessments and treatments. These insights are also valuable in planning frenectomies, especially for conditions such as diastema and gingival recession, as they may enhance treatment efficacy and patient satisfaction.

Source of funding.

This research did not receive any specific grant from funding agencies in the public, commercial, or nonprofit-profit sectors.

Ethical statement.

The study approval was obtained from Institutional Review board of Imam Abdulrahman Bin Faisal University, Dammam, KSA (IRB: 2020–02-282). The study was conducted according to the guidelines of the Helsinki Declaration.

Consent: Written informed consent was obtained from all participants.

Author’s contribution statement

The author has critically reviewed and approved the final draft and is responsible for the content and similarity index of the manuscript. **Marwa Madi:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Methodology. **Abdulaziz Alamri:** Data curation, Validation, Formal analysis, Writing – review & editing. **Deamah Aleisa:** Investigation, Data curation, Writing – original draft. **Mayysah Omar Almusallam:** Investigation, Data curation, Writing – original draft. **Sarah Saeed AlQahtani:** Investigation, Data curation, Writing – original draft. **Zainab S. Al-Aql:** Writing – review & editing, Investigation, Formal analysis, Resources. **Adel S. Alagl:** Writing – review & editing, Visualization, Validation, Supervision, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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