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Evaluation of Periodontal Biotype in Relation to Skeletal Malocclusions

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Abstract

Introduction: The periodontal biotype influences diagnosis, prognosis, and response to orthodontic and periodontal therapy; its distribution across skeletal classes remains debated [1] [2]. **Objective:** The main objective of this study is to determine whether there is a direct correlation between the periodontal biotype and skeletal malocclusion. As complementary objectives, the study aims to identify the association between each biotype and each skeletal class, as well as to establish the prevalence of biotypes and skeletal classes in men and women, in order to contextualize their distribution within the study population. **Materials and Methods:** Quantitative, descriptive, observational, cross-sectional study in 69 patients treated in an orthodontic clinic. Periodontal biotype (thin, thick, mixed) was determined by probe transparency on maxillary incisors. Skeletal class (I, II, III) was recorded using current clinical cephalometric criteria. A chi-square test of independence was applied and, to strengthen validity with low expected cell counts, Monte Carlo simulation was used (estimating the p-value and its confidence interval). **Results:** Biotype distribution: thin 24 (34.8%), thick 26 (37.7%), mixed 19 (27.5%); skeletal class: I 13 (18.8%), II 49 (71.0%), III 7 (10.1%). No significant association was observed between biotype and skeletal class ($\chi^2 = 1.52$; df = 4; $p = 0.823$). Symmetric association measures were near zero and non-significant, and Monte Carlo confidence intervals for the p-value supported independence. **Conclusions:** In this sample, the periodontal biotype behaved independently of the skeletal pattern. It is recommended to consider the biotype as an autonomous diagnostic factor in orthodontic–periodontal planning and to promote multicenter studies with larger sample sizes and imaging techniques (e.g., CBCT) to refine risk estimation.

Keywords

Periodontal Biotype, Skeletal Class, Periodontal Phenotype, Malocclusion,

Periodontal Probe

1. Introduction

The periodontal biotype refers to the anatomical and functional characteristics of the periodontium, which vary from one individual to another [1]. These differences may condition the predisposition to develop periodontal diseases, the way the body responds to treatment, and the esthetic outcome of dental procedures [2].

Various methods are available to identify the periodontal biotype. Among them are visual inspection, measurement of gingival thickness by means of probe transparency, and, at a more advanced level, the use of techniques such as Cone-Beam Computed Tomography (CBCT) or ultrasonography [3]-[6].

Based on this, it is clinically reasonable to define three categories to classify these periodontal characteristics. The thin periodontal biotype is characterized by the visibility of the probe through the gingival margin during probing, indicating thin tissue that is more susceptible to recession. In contrast, the thick biotype is defined by the absence of probe visibility, reflecting thicker and more resistant gingival tissue. This leads to the concept of the mixed periodontal biotype, defined as the condition in which areas with a thin phenotype and areas with a thick phenotype coexist within the same patient, identified by probe transparency, transgingival gingival thickness assessment, keratinized tissue width, and/or evaluation of the bone morphotype.

Moreover, when selecting the assessment method, the economic possibilities of each individual must also be considered. In this sense, exploration with a periodontal probe represents a considerably more accessible alternative compared with cone-beam tomography or ultrasonography [3]-[6].

2. Methodology

Type of research: This study is quantitative, descriptive, and observational, with a cross-sectional design.

2.1. Study Universe

The study universe consisted of all first-time orthodontic patients seen in a population in the city of Villahermosa, Tabasco, Mexico, during the period from August 2024 to June 2025. Patients of both sexes, between 13 and 60 years of age, with a clinically evaluable healthy periodontium were considered.

Patients with previous orthodontic treatment, active periodontal disease, loss of more than one permanent tooth (except third molars), systemic conditions affecting supporting tissues, or who did not authorize their participation by signing the informed consent form, were excluded.

2.2. Sample

The sample consisted of 69 patients selected by non-probabilistic convenience sampling, including only those who met the previously established inclusion and exclusion criteria.

The final distribution of the sample included 24 patients with a thin periodontal biotype, 26 with a thick biotype, and 19 with a mixed biotype, classified according to clinical parameters described in the literature. The skeletal class distribution was: Class I (13 patients), Class II (49 patients), and Class III (7 patients).

The number of subjects was considered sufficient to establish a descriptive and relational analysis between periodontal biotype and type of skeletal malocclusion, ensuring the pertinence and representativeness of the results within the population treated.

Inclusion Criteria

Patients with adequate periodontal health.

Presence of maxillary central incisors and canines.

Patients starting orthodontic treatment (for the first time).

Exclusion Criteria

Subjects with extensive restorations or crowns on the maxillary incisors.

History of previous orthodontic treatment.

Subjects under medication that could affect the periodontium.

Gingival inflammation.

Dental developmental disorders.

Pregnant women.

Loss of attachment or probing depth greater than 4 mm, or use of antibiotic premedication in the last 6 months.

Subjects who smoke.

2.3. Procedures

A data collection instrument was designed specifically for this study. It included general patient information and information obtained from periodontal probing performed manually using a periodontal probe.

The periodontal probe is an instrument used to evaluate periodontal status, including pocket depth, presence of biofilm, and other periodontal indices. There are different types of periodontal probes, such as the Marquis, Williams, Goldman Fox, WHO, and Florida probes. For this study, the North Carolina probe (Montana model, American Eagle brand) was chosen for practical reasons.

The periodontal biotype was measured using the probe transparency method.

2.4. Probe Transparency Method

The periodontal probe is inserted in the mid-buccal region of the maxillary left or right central incisor.

It is observed whether the markings of the probe can be seen through the gingiva.

If the markings are visible, the biotype is considered thin; if not, it is considered thick.

The mixed periodontal biotype is identified when not all teeth exhibit the same pattern, but rather there is an alternation between thin and thick biotype characteristics in different areas of the mouth.

This means that in some teeth you may observe:

- Probe transparency (thin).
- Absence of transparency (thick).

This method is simple, inexpensive, and reproducible. For general patient information, only age and sex were recorded [4].

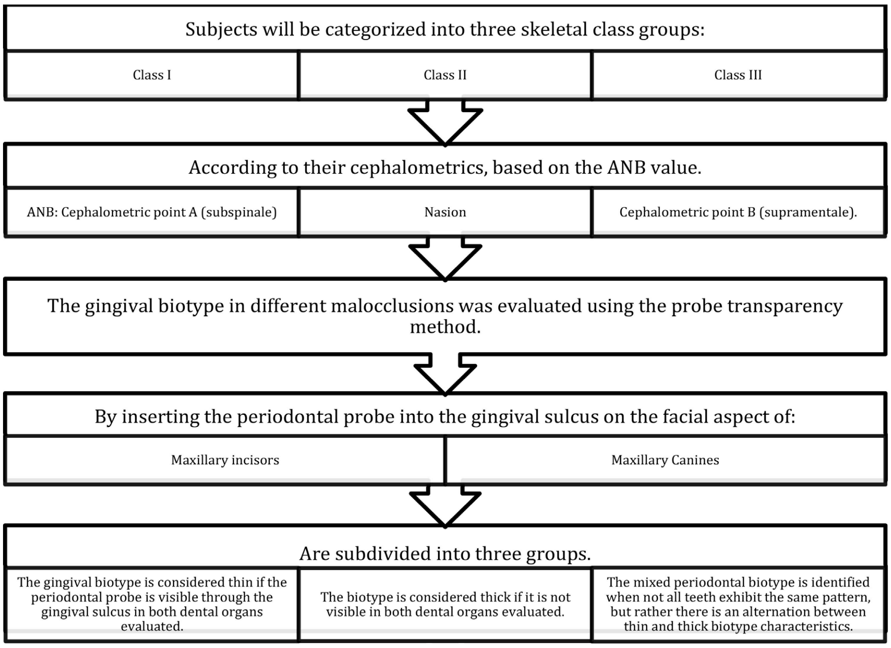


Figure 1. Statistical analysis protocol.

Figure 1 describes the steps carried out after data collection. The results for skeletal malocclusion and periodontal biotype were recorded and organized. Skeletal malocclusion was classified as Class I, II, or III, while the periodontal biotype was categorized as thin, thick, or mixed. Subsequently, both variables were prepared for descriptive and correlational statistical analysis in order to evaluate the possible relationship between them.

2.5. Data Analysis

Qualitative data on the gingival biotype were recorded and subjected to statistical analysis using SPSS v25 for Windows. A chi-square test was implemented to evaluate the relationship between gingival biotype and the different skeletal malocclusions as well as sex.

In addition, a Monte Carlo approach was chosen to obtain robust p-values and confidence intervals when the asymptotic assumptions of classical tests (e.g., chi-square) might not be met because of cells with expected frequencies < 5 and a moderate sample size. The simulation approximates the null distribution through random sampling, reducing bias and controlling Monte Carlo error.

3. Results

Table 1. Periodontal Biotype vs. Skeletal Class.

Cross Table Biotype*Skeletal Class					
		Skeletal Class			
		Class I	Class II	Class III	Total
Biotype	Count	5	17	2	24
	Expected Count	4.5	4.5	2.4	24.0
	% of Total	7.2%	24.6%	2.9%	34.8%
Thick	Count	4	18	4	26
	Expected Count	4.9	18.5	26.1	37.7
	% of Total	5.8%	26.1%	20.3%	27.5%
Mixed	Count	4	14	1	19
	Expected Count	3.6	13.5	20.3	27.5
	% of Total	5.8	20.3	1.4	27.5
Total	Count	13	49	7	69
	Expected Count	13.0	49.0	7.0	100%
	% of Total	18.8%	71.0%	10.1%	100.0%

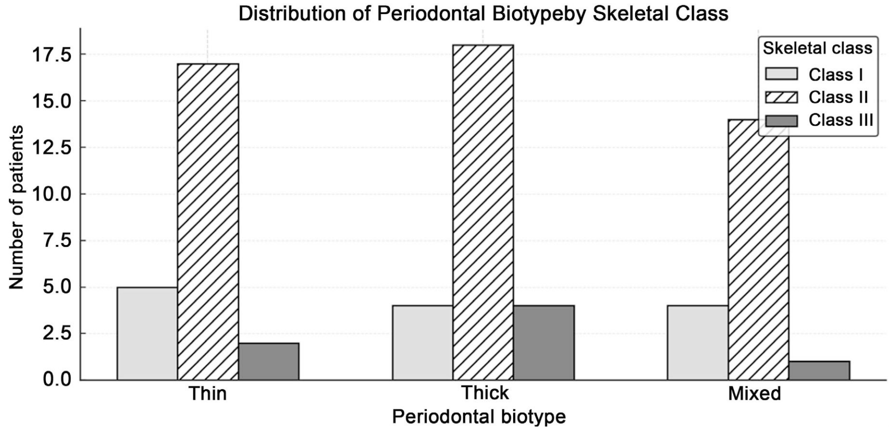
Table 1 presents the relationship between periodontal biotype (thin, thick, and mixed) and skeletal class (I, II, III). It includes three types of data: observed count (actual number of patients in each cell), expected count (theoretical number of cases if there were no relationship between variables), and percentage of the total sample (n = 69).

A marked predominance of Class II is observed in the sample (Graph 1). Comparison between observed and expected counts:

Across all combinations, observed and expected counts were very similar, indicating a homogeneous distribution. For example, for thin biotype/Class I, the observed value was 5 versus an expected 4.5; for thick biotype/Class II, the observed value was 18 versus an expected 18.5. This suggests no important differences between what was observed and what would be expected under independence.

Chi-Square Test and Interpretation

The p-value (0.823) was much higher than the conventional significance level ($\alpha = 0.05$). Therefore, there was no statistical evidence to reject the null hypothesis.



Graph 1. General distribution.

Null hypothesis (H_0): Periodontal biotype and skeletal class are independent.

Alternative hypothesis (H_1): There is an association between the two variables.

Based on the results, independence is accepted: in this sample, periodontal biotype does not depend on skeletal class.

The distribution of biotypes (thin, thick, and mixed) within the different skeletal classes (I, II, III) did not show significant differences ($\chi^2 = 1.52$; df = 4; p = 0.823). This indicates that the presence of a specific biotype is not significantly related to the type of skeletal malocclusion.

Table 2. Correlation between variables.

		Value	Asymptotic Std. Error (a)	Approx. T (b)	Approx. Sig. (c)	Sig. Monte Carlo		
						Sig. (d)	95% Confidence Interval	
							Lower bound	Upper bound
Interval by interval	Pearson's R	0.015	0.115	0.124	0.902	1000	0.958	1000
Ordinal by ordinal	Spearman Correlation	0.010	0.117	0.081	0.936	0.942	0.887	0.997
	N of valid cases	69						

a) The null hypothesis is not assumed. b) Using the asymptotic standard error, assuming the null hypothesis. c) Based on the normal approximation. d) Based on 69 sampled tables with a starting seed of 2,000,000.

Table 2 shows the correlation results between two variables (for example, periodontal biotype and skeletal class). Two measures are presented:

- **Pearson's R (interval by interval),** which measures the linear association between continuous or interval variables.
- **Spearman's correlation (ordinal by ordinal),** which measures the association between ordinal variables.
- Both are presented with standard error, approximate T, significance (p-value),

and a 95% confidence interval based on Monte Carlo simulation.

The number of analyzed cases was **69.**

In the analysis of the distribution of periodontal biotype (thin, thick, and mixed) in relation to skeletal class (I, II, III), the chi-square test showed minimal differences between observed and expected counts, with no statistically significant evidence of association ($\chi^2 = 1.52$; df = 4; p = 0.823). This indicates that the distribution of biotypes behaves independently of skeletal class.

Symmetric correlation measures confirmed these findings. Pearson's coefficient yielded r = −0.015 (p = 0.902), while Spearman's correlation was rs = −0.010 (p = 0.936), both near zero and non-significant. The 95% confidence interval obtained using the Monte Carlo method included values close to independence, reinforcing the absence of a relationship between variables.

Main results:

- **Pearson's R =** −0.015 (practically null correlation; p = 0.902, not significant).
- **Spearman's correlation =** −0.010 (also practically null; p = 0.936, not significant).
- **Monte Carlo 95%** confidence intervals confirmed these results, including values compatible with independence.

Interpretation:

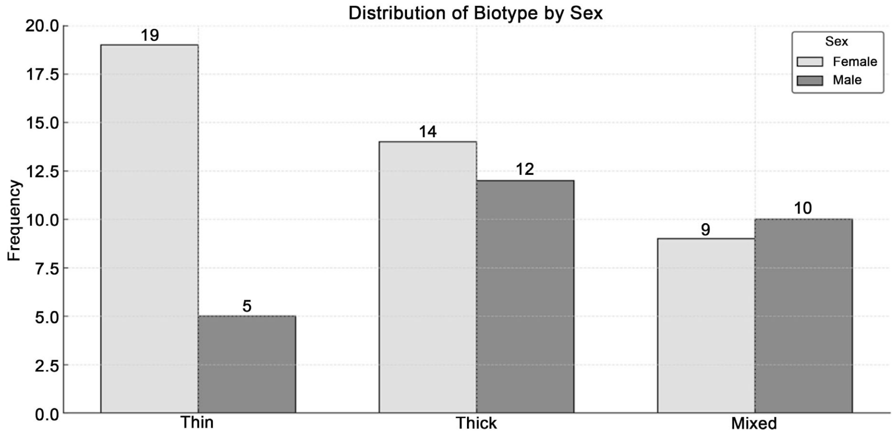
There is no evidence of linear or ordinal correlation between the evaluated variables. The values of Pearson's R and Spearman's rs, both close to zero, indicate that the relationship between variables is practically nonexistent.

Table 3. Periodontal biotype according to sex.

Sex		Biotype	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Female	VALID	Thin	19	45.2	45.2	45.2
		Thick	14	33.3	33.3	78.6
		Mixed	9	21.4	21.4	100.0
		Total	42	100.0	100.0	
Male	VALID	Thin	5	18.5	18.5	18.5
		Thick	12	44.4	44.4	63.0
		Mixed	10	37.0	37.0	100.0
		Total	27	100.0	100.0	

Table 3 shows the distribution of periodontal biotypes (thin, thick, and mixed) according to sex. In the female group, the most frequent biotype was thin, with 19 cases (45.2%), followed by thick with 14 cases (33.3%), and mixed with 9 cases (21.4%).

Graph 2, in contrast, in the male group, the most common periodontal biotype was thick, with 12 cases (44.4%), followed by mixed with 10 cases (37.0%), and, in a lower proportion, thin with only 5 cases (18.5%). This indicates that, unlike women, the thick biotype predominates among men.



Graph 2. Distribution of biotype by sex.

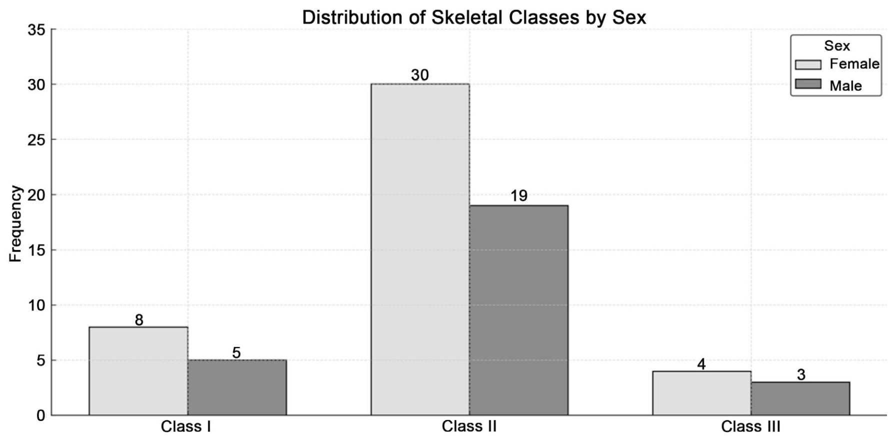
Overall, there is a difference in the distribution of biotypes between sexes: women tend to present a thin biotype more frequently, whereas men are more often associated with a thick biotype. This trend suggests possible anatomical or dimorphic differences related to periodontal tissue thickness between sexes, which may have clinical implications for the choice of surgical techniques, orthodontic management, and the assessment of the risk of gingival recession.

Table 4. Skeletal class according to sex.

Sex		SKELETAL CLASS	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Female	**VALID**	Class I	8	19	19.0	19.0
		Class II	30	71.4	71.4	90.5
		Class III	4	9.5	9.5	100.0
		Total	42	100.0	100.0	
Male	**VALID**	Class I	5	18.5	18.5	18.5
		Class II	19	70.4	70.4	88.0
		Class III	3	11.1	11.1	100.0
		Total	27	100.0	100.0	

Table 4 shows the distribution of skeletal classes (I, II, and III) according to sex. In the female group, Class II was the most frequent with 30 cases (71.4%), followed by Class I with 8 cases (19.0%) and Class III with 4 cases (9.5%).

Among men, Class II was also the most frequent, with 19 cases (70.4%), followed by Class I with 5 cases (18.5%) and Class III with 3 cases (11.1%). Although the distribution is similar to that of the female group, the proportions in men show a slightly more homogeneous trend between Class I and Class III (Graph 3).



Graph 3. Distribution of skeletal classes by sex.

Overall, the results show that skeletal Class II is the most frequent in both sexes, representing around 70% of cases in women and men alike. Classes I and III appear with lower percentages and without marked differences between sexes, suggesting that, in the population studied, there is a predominance of the skeletal Class II pattern regardless of sex.

4. Discussion

In this study, no significant association was found between the periodontal biotype and skeletal malocclusions, suggesting that thin, thick, or mixed biotypes do not depend on the patient's skeletal pattern. This result is consistent with the findings of Al-Thomali *et al.* [3], who reported that the available evidence on this relationship is inconsistent.

Although Sharma and Singh [2] identified possible associations between biotype and skeletal malocclusion in specific populations, these tendencies were not observed in our sample. Differences may be related to ethnic variation, methodological discrepancies, or sample size, and therefore the hypothesis cannot be completely dismissed.

Similarly, Zhao *et al.* [4] demonstrated that the gingival phenotype is more strongly influenced by tissue thickness and localized anatomical characteristics than by skeletal factors, reinforcing the concept that the periodontal biotype should be considered an independent clinical parameter.

Regarding periodontal response during treatment, Jian *et al.* [7] and Yun *et al.* [8] reported that certain skeletal patterns may present a higher risk of gingival recession or bone loss during intensive dental movements. However, these studies analyze treatment-induced changes rather than the baseline relationship between biotype and skeletal class, and therefore do not contradict our findings.

Limitations: This study was conducted using the probe transparency method due to its practicality, low cost, and ease of application, making it particularly suitable for the population in which the samples were collected. Although this method presents a certain margin of error associated with the operator's experience and the variability of visual assessment, it remains the most accessible and feasible option in clinical settings with limited resources. In contrast, more precise techniques such as Cone-Beam Computed Tomography (CBCT) provide more accurate measurements of gingival thickness and periodontal structures; however, their significantly higher cost and limited availability hinder their routine use, especially in population-based studies. For these reasons, the probe transparency method was selected as the most appropriate diagnostic tool for the purposes of this research.

Taken together, these results suggest that the periodontal biotype should be evaluated as an independent diagnostic factor, essential for preventing periodontal complications. Nevertheless, due to the sample size, further research is recommended to confirm or refine these findings; therefore, the hypothesis cannot be ruled out.

5. Conclusions

The evaluation of the frequency distribution of categories involving bone within each specific functional pattern and its severity was verified using the chi-square test. No differences were found between expected and observed values ($\chi^2 = 1.52$; df = 4; $p = 0.823$), demonstrating independence between variables.

To provide greater support for this finding, symmetric correlation measures were used and complemented with the Monte Carlo method, which is capable of estimating robust confidence intervals in cases with limited data distribution.

Spearman's correlation values (rs = −0.010; $p = 0.936$) were close to zero, supporting the absence of both linear and ordinal association. More importantly, the 95% confidence intervals obtained through the Monte Carlo method included values indistinguishable from statistical independence. This implies that, considering sample variability via simulation, the finding of no strong association between the variables is further strengthened.

The practical significance of applying the Monte Carlo procedure is that it increases confidence in the results without restricting the analysis to normality or chi-square distribution assumptions, particularly given the moderate sample size ($n = 69$). Therefore, we are confident that there is no association between periodontal biotype and skeletal class.

Clinically, the present findings highlight that periodontal biotype may deserve its status as an independent diagnostic factor, not dependent on skeletal malocclusion. Consequently, complementary interdisciplinary treatment planning by the orthodontist and periodontist should simultaneously include both considerations without assuming dependence between them.

Finally, the complementary use of the Monte Carlo method not only confirmed that there was no visible statistical difference using the chi-square test, but also provided a more robust platform to support the conclusion that periodontal biotype and skeletal class are independent variables in this sample.

Ethical Considerations

An official informed consent document was required, in which each patient authorized, by signature, the collection of data through clinical probing.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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