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The Relationship Between Pillowing as a Mechanical Pressure Habit on The Facial Skeleton and Unilateral Crossbite in Patients Aged 3 To 12 Years. A Cross-Sectional Study

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Abstract

Objective: Analyze the relationship between the pillowing effect (preferential facial support posture adopted during sleep) and unilateral crossbite as a sign of dentoalveolar compression in a pediatric sample, evaluating the laterality concordance between the habit and the malocclusion.

Material And Method: An observational, analytical, and cross-sectional concordance study. The sample consisted of 57 patients aged 3 to 12 years with crossbite. To strictly evaluate laterality concordance, an analytical subsample of 39 patients with a defined side of facial support during sleep and a unilateral crossbite was analyzed. Fisher's exact test, Odds Ratio (OR) with 95% CI, and Cohen's Kappa index were applied.

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Results: A direct concordance between the side of support during sleep and the side of the crossbite was identified in 87.2% of the evaluated cases, with a highly significant association ($p < 0.0001$). The obtained OR was 46.67 (95% CI: 6.87–316.77), indicating that lateral postural preference is associated with a higher probability of presenting an ipsilateral crossbite. The Kappa index (0.738) confirmed a substantial concordance between the studied variables.

Conclusions: There is a significant relationship and robust laterality concordance between the pillowing effect and crossbite. Prolonged mechanical pressure during sleep acts as a possible associated factor in the development of an ipsilateral crossbite, which requires longitudinal confirmation; its early detection is fundamental.

Keywords

Crossbite (CB); Pillowing; Malocclusion; Interceptive orthodontics; Sleep posture; Oral habits.

Introduction

The harmonious development of the craniomandibular complex during childhood is a dynamic process influenced by genetic, environmental, and functional factors. Among the most common abnormalities during the primary and mixed dentition stages is dentoalveolar compression, which can be clinically identified by the presence of a crossbite. If this condition is not detected and treated in a timely manner, it can lead to established facial asymmetries, functional masticatory abnormalities, temporomandibular dysfunction, and complications in the stability of the patient's permanent occlusion in adulthood [1,2]. Crossbite has a significant epidemiological impact, affecting between 8% and 20.8% of children in the primary and early mixed dentition stages [2,3]. It is notably that 91.9% of unilateral crossbites present with a functional mandibular deviation that, if not corrected in time, can lead to asymmetric growth [2-4].

This transverse maxillary deficiency has been closely linked to respiratory problems and upper airway obstruction, which exacerbate dental arch collapse [5,6] and the presence of multiple environmental and modifiable risk factors; although it has traditionally been associated with sucking habits [7]. Scientific evidence suggests that early intervention is effective in preventing malocclusion from persisting into the permanent dentition [2,8]. This highlights the need for research into other predisposing factors, such as mouth breathing and, notably, body posture and head position during sleep [9-12].

In this biomechanical context, the clinical phenomenon known as the "pillowing effect" takes on particular significance. This habit refers to the posture adopted when sleeping predominantly on one side, exerting external, asymmetrical, and constant pressure on one side of the face against the pillow or mattress, or with the patient's own upper limbs providing predominant support to a specific area of the craniofacial region during sleep [9]. From a biophysical perspective, it is estimated that the lateral pressure exerted by the child's head weight on the support surface during sleep ranges from 2 to 4 kg [13], a magnitude that far exceeds the 50–150 g used in orthodontics [1].

According to Proffit's Equilibrium Theory, a minimum threshold of approximately 6 hours per day of continuous stimulation is required to induce a change in tooth position and remodeling of the alveolar processes. Given that the sleep cycle in the pediatric population typically ranges from 8 to 10 hours per

day, the pillowing effect meets and exceeds the physiological requirements for generating permanent morphological changes, establishing itself clinically as a functional deforming matrix [1,14].

Based on the biomechanical principles of Neuro-Occlusal Rehabilitation (NOR) developed by Dr. Pedro Planas, who posits that “function creates the organ” [14], it is established that the development of the stomatognathic system depends on functional stimuli. For Planas, crossbite is not a static malocclusion, but rather an alteration of mandibular dynamics that disrupts the functional balance of the system [14,15]. Under these principles, an incorrect unilateral pressure stimulus during growth interferes with the transverse development of the maxilla, leading to the establishment of an asymmetrical morphology. In this context, pillowing acts as a “reversed law of least resistance”: rather than promoting the natural expansion of the maxilla, it applies an extrinsic load that nullifies transverse growth stimuli, favoring ipsilateral collapse and the consequent establishment of crossbite [14]. The magnitude of this biomechanical impact on growing structures is grounded in Moss’s Functional Matrix Theory, which posits that constant pressure acts as a “deforming matrix,” altering the skeletal unit and nullifying natural expansion stimuli, thereby making pillowing an important biological signal [16].

In addition to this force factor, there is also the time factor. This mechanism is consistent with the principles of NOR. According to Planas, mastication and mandibular movement are responsible for expanding the maxillary sutures; however, the constant pressure of one side of the face against the pillow acts as a mechanical brake. This extrinsic load nullifies the natural expansion stimuli, forcing the maxilla to collapse on the side of support [14].

The clinical impact of this force is magnified when one considers that the facial skeleton of children between the ages of 3 and 12 is highly malleable, with sutures in an active growth phase. Added to this anatomical vulnerability is the fact that growth hormone is released during sleep, and its tissue distribution may be affected by uneven and/or inappropriate pressures, favoring possible ipsilateral dentoalveolar compression and the development of posterior crossbite on the preferred side of facial support during sleep [10,14].

Despite the seriousness of these biomechanical implications, current scientific evidence regarding this postural etiology remains limited. Therefore, it is essential to explore this association through an analysis of lateralization, which justifies the need for this study to verify the direct relationship between the preferred facial support position during sleep and the development of crossbite. Consequently, the objective of the study was to analyze the relationship between the pillowing effect (preferred facial support position during sleep) and crossbite as a sign of dentoalveolar compression in children aged 3 to 12 years at the European University of Madrid (UEM), evaluating the lateralization concordance between the habit and the malocclusion to provide useful clinical evidence in the field of preventive dentistry.

Materials And Methods

- **Study design:** An observational, analytical, cross-sectional, and concordance study was designed, and the manuscript was written in accordance with the STROBE guidelines for observational studies. The initial sample consisted of 68 children with crossbite aged between 3 and 12 years who visited

the dental clinics of the European University of Madrid during the years 2025 and 2026; these children were selected after applying the inclusion/exclusion criteria, resulting in a usable sample of 57 patients. Subjects with genomic abnormalities (2 patients), fractures (3 patients), or surgeries (1 patient) requiring postural changes were excluded, as were those with a history of prior orthodontic appliance use (1 patient), and those whose parents/guardians could not determine with certainty the predominant side of facial support while sleeping or for whom photographic evidence did not allow confirmation of the crossbite diagnosis (4 patients).

- **Ethical considerations:** This study was conducted in accordance with the ethical principles for medical research involving human subjects as set forth in the Declaration of Helsinki. It was also reviewed and approved by the Research Ethics Committee of the European University of Madrid (Code CI: 2025-220). The anonymity of the participants and the confidentiality of the data obtained were guaranteed at all times. Furthermore, prior to their inclusion in the sample, all parents or legal guardians were duly informed of the study's objectives and signed the corresponding informed consent form.
- **Variables and data collection:** The dependent variable (crossbite side) was determined through direct clinical examination and corroborated using intraoral photographs taken with a professional camera (Canon EOS 200D, 70mm lens, ring flash) and cheek retractors to obtain three occlusal views (right lateral, frontal, and left lateral) (see Figure 1), in order to document signs of dentoalveolar compression due to the present crossbite, performed by a single researcher.



Figure 1: Standardized set of intraoral photographs for the diagnosis of crossbite. A) Right lateral view. B) Frontal view at maximum intercuspation. C) Left lateral view.

Note: Images used with the informed consent of the legal guardians and ensuring patient anonymity in strict compliance with the protocol of the UEM Ethics Committee (CI: 2025-220)

Source: Author's clinical records.

The independent variable (preferred side on which the child rests their face while sleeping) was determined using a double-check protocol to minimize memory bias. First, a questionnaire was administered to parents/guardians regarding the child's preferred side on which to rest their face while sleeping, using targeted questions about the room layout and the child's waking habits to verify their response with certainty. Second, this was corroborated with the child through a simulation test of their preferred sleeping position in the dental chair, and by asking questions to assess spatial orientation, such as: what is the first thing they see when they open their eyes in the room; in order to confirm the preferred side on which the face rests. (see Figure 2).



Figure 2: Visual representation of the clinical validation test for preferred positioning in the dental chair.

Note: Illustrative model image used to demonstrate the positioning protocol applied to pediatric patients in this study.

Source: Adapted from Ferreiro, J [9]. Reproduced with permission.

To avoid pseudo replication bias and ensure the assumption of independence among observations in the data analysis, records were not duplicated for patients who had crossbites in more than one simultaneous location (for example, “right posterior crossbite + complete anterior crossbite”). In such cases, the methodological decision was to prioritize the crossbite with a strictly unilateral component, given that it is directly biomechanically associated with the side of facial support.

Statistical analysis

The analysis was performed using R software (version 4.3, R Core Team, 2024). Since the two variables of interest (preferred side for facial support during sleep and side of the crossbite) are nominal categorical variables, nonparametric methods were used. The association between the two variables was evaluated using Fisher’s exact test (two-tailed), the test of choice for 2×2 contingency tables when the sample size is small ($N < 40$) or when any cell has expected frequencies less than 5—a condition that applies in the present study—supplemented by Pearson’s chi-square test for the exact probability of obtaining the observed distribution (or a more extreme one) under the null hypothesis of independence, without relying on asymptotic approximations. The magnitude of the association was quantified using the odds ratio (OR) and its 95% confidence interval (95% CI), which indicates how many times more likely a patient who sleeps with their face resting on a specific side is to have ipsilateral crossbite compared to the side of the face free of pressure during sleep. The degree of agreement between the preferred side for resting the face during sleep and the side of the crossbite was quantified using Cohen’s kappa coefficient (κ).

Results

Sample description and clinical characteristics

After the screening process and application of exclusion criteria, the final sample consisted of 57 patients with crossbite, with a predominance of girls (61.4%) over boys (38.6%). The mean age was 9.3 years (standard deviation [SD] = 1.8; range: 4–12 years). Although the inclusion criteria encompassed children from 3 years of age, the final useful sample consisted of patients ranging from 4 to 12 years.

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Regarding the independent variable (preferred side for resting the face during sleep), the distribution was relatively balanced. No patient reported sleeping exclusively in the prone position. Regarding the dependent variable (unilateral crossbite), the right side predominated over the left. The complete descriptive characteristics are presented in (Table 1).

Variable	Total	Males	Females
Panel A: Baseline characteristics			
N	57	22	35
Age, mean (SD)	9.3 (1.8)	9.6 (2)	9.1 (1.7)
Panel B: Preferred sleeping side (Pillowing)			
Right, n (%)	30 (52.6%)	12 (54.5%)	18 (51.4%)
Left, n (%)	25 (43.9%)	9 (40.9%)	16 (45.7%)
Supine, n (%)	2 (3.5%)	1 (4.5%)	1 (2.9%)
Panel C: Crossbite classification			
Right, n (%)	23 (40.4%)	10 (45.5%)	13 (37.1%)
Left, n (%)	17 (29.8%)	6 (27.3%)	11 (31.4%)
Bilateral, n (%)	7 (12.3%)	1 (4.5%)	6 (17.1%)
Anterior, n (%)	7 (12.3%)	3 (13.6%)	4 (11.4%)
Anterior and bilateral, n (%)	3 (5.3%)	2 (9.1%)	1 (2.9%)
Panel D: Main analysis (defined laterality)			
Analysis N (Pillowing R/L and CB R/L)	39	—	—
Sleeping side – CB concordance, n (%)	87.2% (34/39)	—	—

Note. Descriptive statistics of the total sample of pediatric patients (N = 57) with crossbite. Mean (SD) for continuous variables; n (%) for categorical variables. Panel D: subsample with defined laterality (Pillowing Right/Left and CB Right/Left).

Association between the preferred side of facial support during sleep and the side of the crossbite

For the association analysis, both variables must exhibit clear lateralization. Of the 57 patients included, 39 met this criterion by presenting right or left facial support and a

unilateral right or left crossbite, constituting the analytical subsample (N = 39). The remaining 18 patients were excluded (16 because they had anterior crossbite, bilateral posterior crossbite, or a combination of both; and 2 because they slept in the supine position).

The distribution of the subsample revealed a nearly symmetrical pattern of ipsilateral concordance (Table 2). Of the 23 patients with right-sided pillow use, 20 (87.0%) had a right crossbite; among the 16 patients with left-sided pillow use, 14 (87.5%) had a left crossbite (Figure 3).

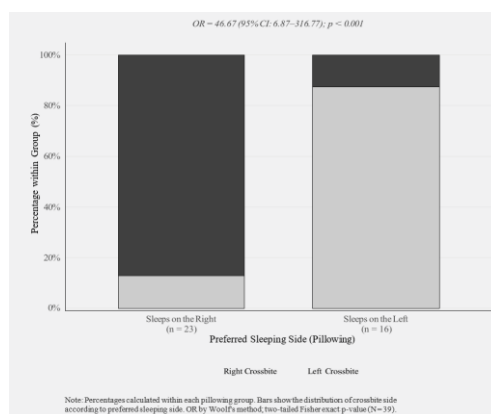


Figure 3: Distribution of patients.

Fisher's exact test revealed a statistically significant association between the preferred side for resting the face during sleep and the side of the crossbite ($p < 0.0001$), a result supported by Pearson's chi-square test ($p < 0.0001$). The odds ratio was 46.67 (95% CI: 6.87–316.77), indicating that the preferred side for resting the face increases the probability of having an ipsilateral crossbite by nearly 47 times.

Variable	Right CB	Left CB	Total
Panel A: Contingency table (N = 39)			
Right Pillowing	20 (87%)	3 (13%)	23
Left Pillowing	2 (12.5%)	14 (87.5%)	16
Total	22	17	39
Panel B: Measures of association			
Odds Ratio (IC 95%)	46.67 (6.87 - 316.77)		
Fisher's exact p-value	< 0.0001***		
Chi-squared (Yates)	18.354		
Chi-squared p-value	< 0.0001***		

*Note. Association analysis between preferred sleeping posture (pillowing) and the side of crossbite (N = 39). 2x2 table with frequencies and row percentages. Odds Ratio calculated by Woolf's method: CI 95% by logarithmic method. Fisher's exact test (two-tailed) used due to reduced sample size (N = 39). Pearson's chi-squared test with Yates's correction used as an additional contrast test. Analytical subsample: patients with defined laterality in both variables. *p < 0.05; **p < 0.01; ***p < 0.001. OR = 46.67 indicates that the probability of presenting an ipsilateral crossbite relative to the sleeping side is 46.67 times high than presenting it contralaterally. The wide CI 95% (6.87–316.77) is expected given the sample size and does not invalidate the effect magnitude.*

Correlation between the preferred side of facial resting position during sleep and the side of the crossbite

In terms of overall correlation, in 87.2% of cases (34/39 patients), the side of the facial resting position strictly coincided with the side of the malocclusion, with only 5 discordant cases recorded. The statistical reliability of this relationship was confirmed using Cohen's Kappa coefficient ($\kappa = 0.738$; 95% CI: 0.523–0.952), corresponding to substantial agreement according to the Landis and Koch scale [17]. The observed concordance ($P_o = 0.872$) far exceeded that expected by chance ($P_e = 0.512$) (Table 3).

Variable / Statistic	Value
Panel A: Observed agreement (N = 39)	
Concordant pairs, n (%)	34 (87.2%)
Discordant pairs, n (%)	5 (12.8%)
Total pairs analyzed	39
Panel B: Cohen's Kappa	
Kappa (κ)	0.738
95% CI (Fleiss method)	0.523 – 0.952
Interpretation (Landis & Koch, 1977)	Substantial
P_o (Observed agreement)	0.8718
P_e (Expected agreement by chance)	0.5115

Note. Agreement between preferred sleeping posture (pillowing) and the side of crossbite (N = 39). Cohen's Kappa calculated from the 2x2 laterality table. 95% CI calculated using the standard formula for kappa standard error. Landis & Koch (1977): < 0.20 slight; 0.21–0.40 fair; 0.41–0.60 moderate; 0.61–0.80 substantial; > 0.80 almost perfect. $\kappa = 0.738$ indicates substantial agreement, greatly exceeding what would be expected by chance ($P_o = 0.872$ vs $P_e = 0.512$). The 87.2% observed agreement confirms that the laterality coincidence is not random. Reference: Landis JR, Koch GG. Biometrics. 1977;33(1):159–174.

Exploratory analysis by sex and age group

The concordance of laterality between variables was analyzed according to the patients' sex and age group, on an exploratory basis (Table 4). When categorized by sex, girls showed a higher proportion of ipsilateral agreement (91.7%; $n=22/24$) compared to boys (80.0%; $n=12/15$).

When the sample was stratified by age, using 9 years as the cutoff (≤ 9 years; $n = 20$) and (> 9 years; $n = 19$), concordance was higher in the younger group (94.7%; $n=19/20$) compared to the older group (78.9%; $n=15/19$). However, the small size of the subgroups prevents drawing inferential conclusions.

Table N.4

Variable	n	Concordant pairs, n (%)	Discordant pairs, n (%)
Panel A: Agreement by sex (N = 39)			
Males	15	12 (80%)	3 (20%)
Females	24	22 (91.7%)	2 (8.3%)
Total	39	34 (87.2%)	5 (12.8%)
Panel B: Agreement by age group (N = 39)			
≤ 9 years	20	19 (95%)	1 (5%)
> 9 years	19	15 (78.9%)	4 (21.1%)
Total	39	34 (87.2%)	5 (12.8%)

Note. Agreement between preferred sleeping posture and crossbite side by sex and age group (N = 39).

Descriptive analysis. The sample size per subgroup is insufficient for valid statistical inference. Age groups: ≤ 9 years; > 9 years. Agreement was high in both sexes (80.0% in males; 91.7% in females) and in both age groups (95.0% in ≤ 9 years; 78.9% in > 9 years). These results are exploratory and should be interpreted with caution.

Sensitivity analysis and statistical power

To assess the robustness of the primary result, a sensitivity analysis was conducted by reclassifying one or two patients as discordant, which still yielded a significantly high OR (minimum OR = 20.58) ($p < 0.0001$) (Table 5). Additionally, the retrospective analysis yielded a large effect size ($h = 1.68$) and estimated a statistical power of 99.9%, confirming that the sample size of the subsample was fully sufficient to detect the observed association.

Table N.5

Scenario	Change	OR	95% CI	Fisher's p value	Agreement
Original (observed)	None	46.67	6.87 – 316.77	< 0.001 ***	87.2%
-1 concordant R to discordant	a-1, b+1	33.25	5.32 – 207.78	< 0.001 ***	84.6%
-1 concordant L to discordant	c+1, d-1	28.89	5.04 – 165.59	< 0.001 ***	84.6%
+1 discordant to concordant R	a+1, b-1	73.5	9.24 – 584.45	< 0.001 ***	89.7%
+1 discordant to concordant L	c-1, d+1	100	9.44 – 1059.26	< 0.001 ***	89.7%
Worst case scenario (2 simul. changes)	a-1,b+1,c+1,d-1	20.58	3.93 – 107.70	< 0.001 ***	82.1%
Panel B: Retrospective statistical power					
Parameter		Value			
P (Right CB Right Pillowing)		0.870 (20/23)			
P (Right CB Left Pillowing)		0.125 (2/16)			
Right pillowing N		23			
Left pillowing N		16			
Total analysis N		39			
Effect size (Cohen's h)		1.680 (large effect)			
Significance level (α)		0.05 (two-tailed)			
Retrospective power		99.9%			
Minimum N for 80% power		~6 per group (total ~12)			

Note. Robustness of the primary result (OR = 46.67; $p < 0.0001$) against changes in the classification of 1-2 patients, and retrospective statistical power calculation (N = 39). Panel A: each scenario modifies 1-2 cells of the 2x2 table. OR by Woolf's method; 95% CI by logarithmic method; two-tailed Fisher's exact p-value. The result remains significant ($p < 0.001$) across all scenarios. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Panel B: power calculated using $pwr: pwr.2p2n.test()$ for observed proportions. Cohen's $h > 0.80 =$ large effect. Warning: retrospective power should not be used to justify a priori design.

Discussion

The most significant finding of this study is the 87.2% concordance between the preferred sleeping side and the side of the crossbite. The statistical calculation yielded an odds ratio of 46.67 ($p < 0.0001$), indicating that the probability of developing ipsilateral crossbite is high when the pillow- sleeping habit is present. To gauge the clinical significance of this finding, recent studies such as that by Guinot Jimeno et al. [12] have shown that prolonged non-nutritive sucking (such as pacifier use) is considered one of the main etiological factors for posterior crossbite, with an odds ratio of 3.56 [12], demonstrating that the asymmetric pressure from sleeping posture is associated with a substantially greater likelihood of developing crossbite than that

reported for non-nutritive sucking habits, although future studies with larger sample sizes could narrow the confidence interval.

This vulnerability to asymmetric loads is strongly influenced by the patient's stage of development. When stratified by age, patients ≤ 9 years old showed a concordance rate of 94.7%, a figure that dropped to 78.9% in the group > 9 years old. This decreasing trend can be explained by the morphological evolution of the midpalatal suture. In early childhood, this suture is smooth and highly plastic, making it extremely susceptible to deformation by external and gravitational forces [18,19]. As the child approaches puberty (around age 10), the suture begins a process of synostosis and interdigitation that increases the maxilla's resistance to transverse forces [19,20].

By incorporating biomechanical concepts, it is understood that pillow positioning acts as a constant, silent gravitational force [18,21]. The pressure applied to the face is approximately 2 to 4kg, estimated based on a percentage of the child's total body weight [13], and its application for 8 to 10 hours daily exceeds the 6-hour threshold proposed by Proffit [1] to achieve bone remodeling. According to the principles of Planas' Neuro-Occlusal Rehabilitation [14], this interference alters the posture that guides growth [22,23]. Furthermore, the impact of this deforming matrix is magnified at night, as it coincides with the peak secretion of growth hormone [6,9,24]. Consequently, the unsupported jaw is able to expand naturally, while the supported side of the face undergoes ipsilateral collapse, nullifying this potential [6,24].

Despite the high correlation found, the 12.8% of discordant cases ($n=5$) in which the preferred side of facial support during sleep did not match the lateralization of the crossbite confirms the multifactorial etiology of maxillary compression. In these specific subjects, confounding factors not controlled for in this study—such as genetic inheritance, severe mouth breathing, or non-nutritive sucking habits—may have exerted a greater etiological influence than the mechanical load of pillow use [10,11,25,26]. As noted by some authors, such as Grippaudo [27], the influence of a postural habit may be masked by the presence of other highly dominant skeletal or functional factors.

From a clinical perspective, these results suggest an immediate need to update preventive diagnostic protocols. Given the high strength of association (OR: 46.67) and the substantial concordance found, it is essential to include questions about the preferred facial support position during sleep. Eliminating this “deforming functional matrix” would not only facilitate the success of orthodontic treatment but would also be essential for ensuring its long-term stability and preventing post-treatment relapse [9].

Among the limitations of this study are its cross-sectional design, which prevents the establishment of definitive linear causality, as well as the fact that the sample was recruited from a single clinical setting, requiring caution when extrapolating data to the general population [6]. However, these limitations are offset by key methodological strengths, such as the reduction of parental recall bias and the likelihood of historical variations in postural habits resulting from changes in environment. Additionally, the application

of a strict exclusion protocol and double verification: a survey of parents or guardians and postural simulation in the chair with spatial inquiry. This methodological rigor supports the statistical association found (OR = 46.67).

Conclusions

1. There are a highly significant statistical association and substantial lateral consistency (87.2%) between the preferred facial resting position during sleep (pillowing effect) and the development of ipsilateral crossbite in the sample of children aged 3 to 12 years analyzed.
2. Most of the patients evaluated adopt sleep patterns that generate unilateral loading, indicating that this prolonged asymmetric mechanical pressure during sleep has a strong clinical association with the development of ipsilateral crossbites.
3. The exploratory analysis suggests a tendency toward greater morphogenetic susceptibility to these loads in earlier stages of development (showing a 94,7% concordance in patients ≤ 9 years of age) and in females (91.7%), although larger-sample studies are required to confirm this statistically.
4. Although the presence of discordant cases confirms the multifactorial etiology of malocclusions, the extreme magnitude of the estimated risk (OR=46.67) underscores the need to confirm these findings longitudinally and highlights the importance of early detection of sleep posture to ensure treatment success and stability.

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