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# Investigation of Dental Missing Pattern in Craniofacial Morphology Variations

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**ABSTRACT**

**Introduction:** Previous research has demonstrated a correlation between certain dental anomalies, including hypodontia, and distinct craniofacial morphological patterns. The aim of the present study was to examine the patterns of dental missing across different craniofacial morphologies.

**Materials & Methods:** This cross-sectional study enrolled 50 patients aged above 8 years (mean age = 21.66 ± 8.01 years), all presenting with at least one missing tooth due to hypodontia. A matched control group comprising 50 Class I dentition patients with no evidence of hypodontia (mean age = 19.76 ± 7.67 years) was recruited for comparative analysis. Patients were categorized into three distinct groups according to the location of hypodontia within the dental arch, with further classification into three additional categories by jaw location. Diagnostic confirmation of hypodontia and precise localization were established through panoramic radiography, whereas lateral cephalometric analysis served as the primary modality for tracing and measurements.

**Results:** The lateral maxillary tooth and second mandibular premolars demonstrated the highest prevalence of missing teeth. Furthermore, maxilla length (P=0.04) and SNA (P=0.03) values were both significantly reduced in hypodontia patients relative to controls. No other intergroup differences reached statistical significance in the case and control groups. The findings revealed greater anterior cranial base length, mandibular body length, as well as anterior and posterior facial heights, in male participants compared to their female counterparts. Of particular interest, the angle and position of the mandibular incisors, along with ANB values, tended to be higher in females compared to males (P=0.004).

**Conclusion:** The present study demonstrated a significant reduction in specific craniofacial parameters, especially maxillary length (ANS-PNS) and SNA angle, in patients with permanent dental agenesis. Important clinical implications of these findings suggest that orthodontists should incorporate these morphological associations into diagnostic evaluations, therapeutic decision-making processes, and comprehensive treatment strategies.

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## Introduction

The congenital missing of teeth, known as hypodontia, represents one of the most prevalent dental anomalies in the maxillofacial region [1-3]. Epidemiological data demonstrate considerable variation in hypodontia prevalence across different ethnic groups, with reported rates generally falling between 3% and 10%. In a 2012 study across eight provinces in Iran, the prevalence of congenital missing teeth, including third molars, was 45.7%, while hypodontia (excluding third molars) was 10.9%. In this population, the most commonly affected teeth were the second mandibular premolars, followed by the second maxillary premolars, maxillary lateral incisors, and first maxillary premolars [4]. This pattern of agenesis diverges from the more commonly reported sequence of mandibular second premolars, maxillary lateral incisors, maxillary second premolars, and mandibular central incisors. [2, 3, 5-8]. In contrast, a study in Mazandaran, Iran, estimated the prevalence of hypodontia at 1.7% [9].

Given that dental development is under strict genetic control, mutations in genes like WNT, TGFB3, MMPs, BMP4, FGFR1, AXIN2, PAX9, and MSX1 have been strongly associated with dental agenesis [10-15]. Additionally, various environmental and anatomical factors may play etiological roles, such as dental trauma, medications, systemic diseases (e.g., polio and syphilis), and limited space in an abnormal jaw, which can also contribute [7, 16, 17].

Hypodontia frequently co-occurs with a spectrum of dental anomalies, ranging from enamel hypoplasia and delayed tooth eruption to distinct morphological changes such as taurodontism, peg-shaped incisors [17-20], and non-syndromic oral-facial clefts [14]. Numerous studies have explored the relationship between hypodontia and craniofacial morphology [1-3, 5, 6, 21-25]. Most findings suggest distinct growth patterns in individuals with hypodontia, such as a prognathic mandible, smaller maxilla, reduced mandibular plane angle, shorter ramus height, retrusive upper and lower incisors, and a tendency toward class III malocclusion [1, 2, 5, 26, 27].

However, a study by Costa et al. reported that Class I malocclusion predominated in hypodontia patients, followed by Class II and III, with a smaller ANB angle compared to the control group [28]. These observations underscore the substantial impact of both hypodontia severity and the location of missing teeth on skeletal and dental patterns. Consistent with this, Endo et al. also noted morphological differences between individuals with anterior and posterior hypodontia [2]. Notably, despite the established relationship between hypodontia and craniofacial morphology, no investigation to date has specifically evaluated these associations within the Iranian population, prompting the present investigation's primary objective of elucidating these potential relationships.

## Materials & Methods

In this cross-sectional study, fifty patients aged over 8 years presenting with missing teeth were referred to a private oral and maxillofacial radiology center in Babol, Iran. This study received ethical approval from the Babol University of Medical Sciences Institutional Review Board (Approval #: IR.MUBABOL.REC.1399.073).



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Due to the study's cross-sectional design, all eligible cases that visited the center during the designated period were examined. Exclusion criteria comprised patients with systemic or syndromic diseases, cleft lip and palate, a history of trauma or tooth extraction, and any prior orthodontic treatment. Diagnostic confirmation of dental missing and its precise location was established through panoramic radiography combined with a comprehensive patient history review.

"The minimum sample size of 50 participants was calculated based on precedent studies and using the following formula:”

$N= (Z_{1-\alpha} + Z_{1-\beta})^2 (S_1^2 + S_2^2) / d^2 =50$

$\alpha=0.05$ $\beta=0.20$ S1=2.6 s2=3.7 d=2

The patients were divided into three main groups based on the location of dental missing:

Group 1: Missing in the anterior region (from the canine to the canine)

Group 2: Missing in the posterior region (from the first premolar to the second molar)

Group 3: Missing in both anterior and posterior regions

Additionally, the patients were categorized into three groups based on the affected jaw:

Group 1: Dental missing in the maxilla only

Group 2: Dental missing in the mandible only

Group 3: Dental missing in both maxilla and mandible

The control group (designated as Group 4) comprised Class I dental patients without dental missing who required lateral cephalometric radiography as part of their orthodontic diagnostic workup.

Lines and angles were traced for each lateral cephalometric radiograph, and 13 angular and 13 linear measurements were taken using a protractor and a ruler. All measurements were documented systematically. To calibrate the measurements, the magnification coefficient for each radiograph was calculated based on the markings on its stencil, and the measurements were adjusted accordingly. To evaluate measurement reliability, a random subset of 15 cephalograms was reanalyzed after a two-month interval. The resulting intraclass correlation coefficient (ICC) of >0.99 demonstrated exceptional measurement consistency, with clinically insignificant error variance.

**Statistical Analysis**

All statistical analyses were conducted using SPSS software (version 22). The analytical approach incorporated both descriptive and inferential statistics, including frequency distributions, percentages, mean, standard deviation, independent t-tests, multivariate linear regression, one-way analysis of variance, and Tukey’s post hoc test were used to examine differences in the measured values between the dental missing groups and the control group. A significance level of $p < 0.05$ was applied.

## Results

This study enrolled fifty patients aged ≥8 years presenting with ≥1 permanent tooth (third molars excluded) as the case cohort, and 50 Class I patients without dental missing served as the control group. Demographic characteristics revealed similar gender distributions across groups, with 72% (n=36) females and 28% (n=14) males in the case group versus 70% (n=35)



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females and 30% (n=15) males in controls (P=0.82). The mean age was 21.7±8.0 years (rang10-37) among cases compared to 19.8±7.7 years (range 10-37) in controls, demonstrating comparable age distributions between groups.

The case group exhibited a total of 83 missing teeth (excluding third molars), with a predilection for the maxilla (n=55, 66.3%) over the mandible (n=28, 33.7%). As detailed in Table 1, which present the frequency distribution according to the Fédération Dentaire Internationale (FDI) classification system, the maxillary lateral incisors demonstrated the highest prevalence of missing teeth (21.6%), followed sequentially by the mandibular second premolars (18%), maxillary canines (16.8%), mandibular lateral incisors (12.04%), and maxillary second premolars (10.82%).

**Table 1. Frequency Distribution of Dental Missing in Maxilla and Mandible**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Maxilla** | **Tooth No** | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| | **Frequency** | - | 1 | 0 | 4 | 7 | 8 | 10 | 1 | 0 | 8 | 6 | 3 | 5 | 1 | 1 | - |
| **Mandible** | **Tooth No** | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |
| | **Frequency** | - | 0 | 0 | 7 | 0 | 1 | 5 | 0 | 1 | 5 | 0 | 0 | 8 | 0 | 1 | - |

Table 2 presents the mean and standard deviation of linear variables (e.g., SN, ANS-PNS) and angular variables (e.g., N-S-Ar, SNA) for both the case and control groups.

**Table 2. Investigation of Mean and Standard Deviation of Linear and Angular Variables in Case and Control Groups**

| Group | Variables | Control Mean±SD | Case Mean±SD |
|---|---|---|---|
| Linear | SN | 67.90±4.46 | 67.11±4.61 |
| | ANS-PNS | 52.27±3.85 | 50.45±5.70 |
| | S-Ar | 32.99±3.45 | 32.66±4.47 |
| | Ar-Go | 43.96±4.49 | 44.02±7.73 |
| | Go-Me | 67.96±5.16 | 66.36±6.90 |
| | Ar-Me | 99.04±10.05 | 98.93±8.65 |
| | N-ANS | 50.88±4.35 | 52.61±12.98 |
| | ANS-Me | 64.26±7.00 | 64.38±7.27 |
| | S-Go | 73.59±6.38 | 72.42±7.56 |
| | N-Me | 113.49±9.79 | 112.89±11.16 |
| | U1-NA | 4.93±1.52 | 5.76±3.19 |
| | L1-NB | 5.45±1.72 | 5.16±3.09 |
| | JARABACK Index | 65.02±4.19 | 64.28±5.54 |
| Angular | N-S-Ar | 122.70±4.58 | 122.49±5.82 |
| | SNA | 80.24±3.15 | 78.74±3.75 |
| | SNB | 77.13±3.26 | 76.23±3.58 |
| | ANB | 3.11±1.11 | 2.49±3.91 |
| | S-N-Pog | 78.17±3.30 | 77.13±3.41 |
| | SN-FH | 7.59±2.54 | 8.52±3.21 |
| | SN-MP | 35.03±4.94 | 35.82±6.91 |
| | FH-MP | 28.78±6.18 | 27.62±6.02 |
| | PP-MP | 25.86±5.16 | 27.35±6.38 |
| | Yaxis-SN | 68.39±3.65 | 69.18±4.02 |
| | Yaxis-FH | 60.89±2.96 | 61.07±3.74 |
| | U1-NA | 22.89±5.36 | 22.65±9.09 |
| | L1-NB | 28.17±4.11 | 28.77±5.91 |



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Multivariate linear regression analyses examining the effects of group, gender, and age on linear variables revealed that only gender was significantly associated with SN, with males having a larger SN than females (β=3.61, P<0.001). In the case of ANS-PNS, only the group variable proved significant, with the case group exhibiting lower ANS-PNS values compared to the control group (β=-0.94, P=0.04). Regarding Ar-Go, only age emerged as a significant factor, with Ar-Go increasing by 0.18 units per year of age (β=0.18, P=0.02). In the context of Go-Me, both gender and age served as significant predictors: males demonstrated a larger Go-Me than females (β=4.74, P<0.001), and Go-Me increased with age (β=0.14, P=0.04). Similarly, for ANS-Me, both gender and age were significant, with males having higher ANS-Me values than females (β=4.95, P=0.001) and ANS-Me increasing with age (β=0.32, P<0.001).

Multivariate linear regression analysis of the S-Go variable revealed that both gender and age were significant predictors. Male patients exhibited higher S-Go values than female patients (β=5.90, P<0.001), and S-Go values increased with age (β=0.27, P=0.001). Similarly, for the N-Me variable, gender and age were significant, with male patients showing higher N-Me values than female patients (β=7.53, P=0.001) and N-Me values increasing with age (β=0.37, P=0.003). For the U1-NA variable, only gender was significant; male patients had larger U1-NA values than female patients (β=1.65, P=0.002). In contrast, for the L1-NB variable, only gender was significant, with male patients having smaller L1-NB values than female patients (β=-1.10, P=0.04).

Analysis of angular variables showed that for the SNA variable, only the group variable was significant, with the case group exhibiting a smaller SNA than the control group (β=-1.51, P=0.03). For the ANB variable, only gender was significant, with male patients having a smaller ANB than female patients (β=-1.80, P=0.004). Similarly, for the L1-NB angular variable, only gender was significant, with male patients showing smaller L1-NB values than female patients (β=-3.37, P=0.002). No significant relationships were observed for other angular variables (P>0.05).

Table 3 summarizes the cephalometric analysis of linear and angular variables based on the location of dental missing in the jaw. For the S-Go variable, a significant difference was found based on the location of dental missing (P=0.03), with Tukey’s post hoc test indicating that this difference was driven by Groups 1 and 3 (P=0.02). For the SNA variable, a significant difference was also observed based on the location of dental missing (P=0.01), with Tukey’s post hoc test attributing this to differences between Groups 1 and 4 (P=0.02). Additionally, the Y-axis-SN variable showed a significant difference based on the location of dental missing (P=0.02), with Tukey’s post hoc test identifying the difference between Groups 2 and 3 (P=0.04). No significant relationships were observed for other variables (P>0.05).



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**Table 3. Cephalometric Examination of Groups Based on the Location of Dental Missing in the Jaw**

| Variables \ Groups | Group 1 Mean±SD | Group 2 Mean±SD | Group 3 Mean±SD | Group 4 Mean±SD | p* | Significance** 3-2-4 2-3 1-4 1-3 1-2 4 |
|---|---|---|---|---|---|---|
| SN | 66.58±4.27 | 68.00±5.94 | 67.66±2.58 | 67.90±4.46 | 0.62 | |
| ANS-PNS | 50.20±5.39 | 50.78±6.93 | 50.91±4.98 | 52.27±3.85 | 0.31 | |
| S-Ar | 32.55±3.86 | 31.82±5.79 | 35.16±3.48 | 32.99±3.45 | 0.36 | |
| Ar-Go | 44.01±7.64 | 42.07±8.46 | 48.58±5.08 | 43.96±4.49 | 0.21 | |
| Go-Me | 65.60±7.35 | 67.42±6.98 | 67.66±4.32 | 67.96±5.16 | 0.41 | |
| Ar-Me | 99.11±8.91 | 98.14±9.89 | 99.83±3.97 | 99.04±10.5 | 0.98 | |
| N-ANS | 54.63±16.1 | 48.57±4.73 | 51.91±2.72 | 50.88±4.35 | 0.20 | |
| ANS-Me | 63.76±7.81 | 63.78±5.59 | 68.83±7.49 | 64.26±7.00 | 0.44 | |
| S-Go | 70.94±6.34 | 72.42±8.98 | 79.83±6.24 | 73.59±6.38 | 0.03 | * |
| N-Me | 112.2±11.9 | 111.8±10.6 | 118.5±7.52 | 113.4±9.79 | 0.56 | |
| U1-NA(mm) | 6.17±3.03 | 4.81±3.52 | 5.93±3.23 | 4.93±1.52 | 0.13 | |
| L1-NB(mm) | 5.34±2.99 | 4.40±3.40 | 6.03±2.92 | 5.45±1.72 | 0.47 | |
| JARABACK Index | 63.13±5.58 | 65.21±5.54 | 67.83±3.81 | 65.02±4.19 | 0.11 | |
| N-S-Ar | 122.1±5.46 | 122.6±7.14 | 123.8±4.79 | 122.7±4.58 | 0.90 | |
| SNA | 77.98±3.80 | 80.60±3.35 | 78.16±3.31 | 80.24±3.15 | 0.01 | * |
| SNB | 76.15±3.70 | 77.10±3.71 | 74.58±2.10 | 77.13±3.26 | 0.26 | |
| ANB | 1.80±3.00 | 3.50±5.27 | 3.58±4.27 | 3.11±1.11 | 0.14 | |
| S-N-Pog | 77.10±3.43 | 77.96±3.62 | 75.33±2.40 | 78.17±3.30 | 0.17 | |
| SN-FH | 8.85±3.23 | 8.07±3.13 | 7.91±3.72 | 7.59±2.54 | 0.32 | |
| SN-MP | 37.46±6.95 | 33.39±6.96 | 33.25±4.70 | 35.03±4.94 | 0.10 | |
| FH-MP | 28.68±6.14 | 26.14±5.72 | 25.75±5.86 | 28.78±6.18 | 0.36 | |
| PP-MP | 28.31±6.55 | 26.53±5.82 | 24.41±6.62 | 25.86±5.16 | 0.23 | |
| Yaxis-SN | 69.63±3.71 | 67.03±4.18 | 71.91±3.16 | 68.39±3.65 | 0.02 | * |
| Yaxis-FH | 61.08±3.64 | 59.75±2.70 | 64.08±5.08 | 60.89±2.96 | 0.06 | * |
| U1-NA(D) | 23.90±6.92 | 20.57±12.8 | 21.25±9.03 | 22.89±5.36 | 0.54 | |
| L1-NB(D) | 29.71±5.79 | 27.89±6.89 | 27.00±3.68 | 28.17±4.11 | 0.45 | |

*: One-way analysis of variance **: Tukey post hoc test

Table 4 presents the cephalometric analysis of linear and angular variables based on the location of dental missing in the dental arch. No significant associations were found in any of the variables (P > 0.05).

**Table 4. Cephalometric Examination of Groups Based on the Location of Dental Missing in the Dental Arch**

| Variables \ Groups | Group 1 Mean±SD | Group 2 Mean±SD | Group 3 Mean±SD | Group 4 Mean±SD | p* | Significance** 3-2-4 2-3 1-4 1-3 1-2 4 |
|---|---|---|---|---|---|---|
| SN | 67.84±4.95 | 66.25±4.39 | 67.33±3.05 | 67.90±4.46 | 0.53 | |
| ANS-PNS | 50.52±5.32 | 50.63±6.24 | 48.50±6.50 | 52.27±3.85 | 0.27 | |
| S-Ar | 32.64±4.99 | 32.54±4.21 | 33.66±1.52 | 32.99±3.45 | 0.94 | |
| Ar-Go | 43.98±8.09 | 43.72±7.88 | 46.50±3.90 | 43.96±4.49 | 0.91 | |
| Go-Me | 66.26±6.13 | 66.15±8.05 | 68.66±5.13 | 67.96±5.16 | 0.54 | |
| Ar-Me | 98.48±7.42 | 99.2±10.43 | 100.6±4.93 | 99.0±10.05 | 0.98 | |
| N-ANS | 51.6±12.04 | 53.86±14.9 | 51.83±2.56 | 50.88±4.35 | 0.69 | |



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| | | | | | |
|---|---|---|---|---|---|
| ANS-Me | 64.44±9.00 | 64.45±5.27 | 63.33±5.68 | 64.26±7.00 | 0.99 |
| S-Go | 72.71±7.66 | 71.61±7.81 | 76.00±5.29 | 73.59±6.38 | 0.61 |
| N-Me | 113.2±11.2 | 112.4±11.8 | 113.3±7.23 | 113.4±9.79 | 0.98 |
| U1-NA(mm) | 6.03±3.50 | 5.52±3.05 | 5.33±1.42 | 4.93±1.52 | 0.34 |
| L1-NB(mm) | 5.49±2.15 | 4.79±4.06 | 5.10±1.41 | 5.45±1.72 | 0.74 |
| JARABACK Index | 65.20±5.75 | 62.77±5.37 | 76.66±0.57 | 65.02±4.19 | 0.17 |
| N-S-Ar | 122.5±5.58 | 121.9±6.28 | 126.0±4.35 | 122.7±4.58 | 0.65 |
| SNA | 78.12±3.90 | 79.63±3.64 | 77.33±2.51 | 80.24±3.15 | 0.06 |
| SNB | 75.75±4.15 | 76.79±3.04 | 76.16±1.60 | 77.13±3.26 | 0.42 |
| ANB | 2.38±2.91 | 2.79±4.91 | 1.16±4.01 | 3.11±1.11 | 0.56 |
| S-N-Pog | 77.16±3.86 | 77.09±3.13 | 77.16±1.60 | 78.17±3.30 | 0.50 |
| SN-FH | 7.92±3.08 | 9.00±3.24 | 10.00±4.35 | 7.59±2.54 | 0.17 |
| SN-MP | 34.68±8.15 | 37.38±5.49 | 33.83±2.84 | 35.03±4.94 | 0.37 |
| FH-MP | 27.30±6.69 | 28.04±5.48 | 24.50±3.77 | 28.78±6.18 | 0.55 |
| PP-MP | 27.12±7.47 | 28.36±5.01 | 21.83±2.36 | 25.86±5.16 | 0.16 |
| Yaxis-SN | 68.66±4.82 | 69.75±3.16 | 69.33±2.08 | 68.39±3.65 | 0.57 |
| Yaxis-FH | 61.18±3.90 | 61.11±3.83 | 59.83±2.02 | 60.89±2.96 | 0.92 |
| U1-NA(D) | 23.36±8.99 | 21.93±9.66 | 22.00±8.00 | 22.89±5.36 | 0.92 |
| L1-NB(D) | 28.08±4.47 | 30.31±7.32 | 25.00±1.00 | 28.17±4.11 | 0.20 |

*: One-way analysis of variance **: Tukey post hoc test

## Discussion

This study investigated the relationship between dental missing patterns and variations in craniofacial morphology. Previous research indicates that the most frequently absent tooth type varies across racial groups [29-31]. Specifically, our results identified the maxillary lateral incisors as the predominant site of agenesis, followed by mandibular second premolars, corroborating findings by Haghanifar et al. [9], Razeghinejad et al. [32], and Hedayati et al. [33]. This distribution pattern contrasts with other studies reporting the mandibular second premolars as the most frequently absent [6, 29, 31]. These discrepancies may stem from racial differences, variations in sample size, or differences in evaluation methods, such as manual versus digital tracing.

The ANB angle, a key cephalometric measurement for assessing the sagittal relationship between the maxilla and mandible, showed no significant difference between the case and control groups in this study. This observation concurs with results reported by Tavajohi-Kermani H. et al. [6], Velásquez et al. [34], Jakhar et al. [35], and Zhou et al. [36]. However, this contrasts with several studies documenting reduced ANB values in hypodontia patients relative to controls [1, 27, 28]. Potential explanatory factors for these divergent findings include the developmental stage of adulthood, the broad age range of participants, or racial variations.

Furthermore, cephalometric comparisons based on the location of dental missing in the dental arch and jaw revealed no differences in ANB values, consistent with Herrera-Atoche et al. [37] and Gungor A. Y. et al. [1]. This stands in contrast to Endo T. et al. [2], who documented significantly reduced ANB values in patients with dental missing in both anterior and posterior regions (Group 3). The conflicting findings related to ANB values may be due to differences in sample characteristics, including the number and distribution of missing teeth, along with the varying classification criteria used in different studies. In this study, the SNA angle was significantly reduced in the case group compared to the control group ($P < 0.05$), a result corroborated by Amanda Silva Rodrigues et al. [27] and Celie et al. [38]. Notably, cephalometric comparisons based on the location of dental missing in the dental arch showed no differences in SNA values across the anterior, posterior, and combined anterior-posterior groups. Additionally, the case group exhibited significantly lower ANS-PNS values, indicating a shorter maxillary length than the control group, consistent with findings from two studies by Endo et al. [2, 5].

The findings of this study, specifically the lower SNA and ANS-PNS values, suggest that patients with dental missing exhibit maxillary deficiency and a tendency toward a Class III skeletal pattern. These results are consistent with findings by Amanda Silva Rodrigues et al. [26] and Clarissa et al. [39]. Consequently, orthodontists should consider these morphological characteristics during consultation, treatment planning, and decision-making.

Regarding the influence of gender on craniofacial morphology, some studies have focused exclusively on one gender to eliminate its effect [2, 5]. While others have noted a higher prevalence of hypodontia in females without exploring its impact on craniofacial morphology [9, 32, 40]. Additionally, certain studies found no association between cephalometric variables and gender in individuals with dental missing [4, 28, 33]. In contrast, this study identified gender-related differences in several variables. Male patients exhibited greater anterior cranial base length (SN), mandibular body length (Go-Me), anterior and posterior facial height (N-Me, S-Go), and maxillary incisor position (U1-NA) compared to female patients. Conversely, female patients had higher values for the mandibular incisor angle and position (L1-NB) and ANB angle compared to male patients. These gender variations can be explained through differences in the timing of skeletal development and craniofacial growth patterns. Males, with their larger growth periods, have larger facial sizes, while females are inclined to develop earlier skeletal maturity. This could affect the position of the incisors and sagittal skeletal relationships, like the ANB angle.

As the first study in Iran to examine the relationship between dental missing patterns and craniofacial morphology, the variations in findings across studies may be attributed to factors such as race, geographical environment, biological diversity, sample size, evaluation methods, and age group selection. Although the cephalometric method used in this study is reliable, future research with larger sample sizes is recommended to enhance the accuracy and reliability of results. A significant challenge faced in this research was the restricted variation in the number of people across various age groups channeled to the imaging center. Consequently, we could not classify individuals based on detailed age brackets and were forced to use a general age bracket. Furthermore, the comparatively small sample size could restrict the applicability of the results.

## Conclusion

This study highlights the significant relationship between the absence of permanent teeth and craniofacial morphological changes, namely a reduction in maxillary length (ANS-PNS) and SNA angle, which is a potential influence on maxillary development. These skeletal aberrations emphasize the need for orthodontists to assess not only tooth position but also the



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underlying skeletal configurations in diagnosing and formulating treatment plans for patients with missing teeth. Furthermore, gender-specific differences in craniofacial measurements, namely increased anterior cranial base length (SN), mandibular body length (Go-Me), anterior and posterior facial height (N-Me, S-Go), and maxillary incisor position (U1-NA) in males, and a greater ANB angle and different angle and position of the mandibular incisors (L1-NB) in females, emphasize the need to include gender-specific growth factors in the clinical evaluation. No significant cephalometric differences were found depending on the site of the missing teeth (anterior versus posterior), highlighting that the general presence of agenesis may have a greater influence than the exact location. Overall, these findings support a detailed and individualized approach to the orthodontic diagnosis and treatment of individuals with dental agenesis.

## Conflicts of Interest

All authors declare no conflict of interest.

## Author's Contribution

Razieh Masruri: Designed the study, Data curation, Writing – original draft. Maryam Johari: Designed the study, writing, review & editing, Data curation. Samaneh Ghareh Khani: Methodology, Investigation, Conceptualization. Hemmat Gholinia Ahangar: data analysis. All the authors have read and approved the final version of the manuscript. The study was supervised by Meysam Mirzaei and Sepideh Sorur Homayun.

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