Original Article

Mandibular Asymmetry in Cleft Lip and Palate Versus Class I Malocclusion: A Panoramic Radiographic Study in Mosul

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Abstract

Objective: This study aimed to evaluate the mandibular asymmetry between patients with Unilateral and Bilateral Cleft Lip and Palate in Mosul city by using panoramic radiographs and mandibular asymmetry index to compare with Class I malocclusion controls for selecting the type of treatment in future.

Methods: A retrospective cross-sectional study was performed on 150 orthodontic patients (75 with CLP and 75 controls with Class I anterior relationship) visiting a dental hospital in Mosul city. Patients between 12 and 18 years of age who had not been previously treated orthodontically were included in the study. Digital orthopantomograms were analyzed for vertical ramus and condylar heights using Habets' method. The mandibular asymmetry index for each patient was calculated as the percentage difference between right and left ramus or condylar heights. A $p \leq 0.05$ was considered significant.

Results: The CLP and Class I groups showed no statistically significant differences in mandibular asymmetry indices. The mean ramus asymmetry index was 2.61% in Class I vs 3.88% in CLP, and the mean condylar asymmetry index was 7.68% vs 8.99%, respectively (both comparisons, $p>0.05$). Within each group, the right and left ramus and condylar heights were symmetric (no significant side-to-side differences, $p>0.1$). Age was associated with increased asymmetry: older adolescents exhibited higher ramus asymmetry, significantly in the Class I group ($p<0.01$). Sex had no significant influence on asymmetry in either group ($p>0.05$).

Conclusions: Both groups had vertical mandibular asymmetry, with no difference in asymmetry between CLP subjects and Class I malocclusion controls. The average asymmetry indices for both groups were greater than 3%, implying that mild vertical mandibular asymmetry was present in both boys and girls.

Keywords: *Mandibular asymmetry, Cleft lip and palate, Class I malocclusion, Habets index.*

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Introduction

Facial symmetry and proportionality are key components of craniofacial esthetics, while mandibular asymmetry is defined as a discrepancy in form or size between the right and left sides of the mandible and is one of the most common asymmetrical features encountered in orthodontics[1]. Multiple factors, such as age, growth pattern, occlusion, parafunctional habits, trauma, and developmental defects, can influence the development of mandibular asymmetry. Indeed, epidemiological studies have reported that up to one-third of orthodontic patients may have noticeable facial or mandibular asymmetries 2.

Maxillary deficiencies are associated with Cleft lip and palate (CLP) and there is interest in whether CLP also contributes to mandibular growth disturbances or asymmetry[3]. The mandible of unilateral CLP patients has been observed to grow in a complex manner due to functional shifts and occlusal compensations[4]. Some longitudinal studies indicate that unilateral CLP patients manifest mandibular asymmetry that increases during growth and parallels the maxillary asymmetry, underscoring the intertwined development of the jaws. This has led to recommendations for early evaluation and intervention addressing both the nasomaxillary complex and the mandible in CLP patients[5]. The literature on mandibular asymmetry in CLP has reported inconsistent findings, which may be attributable to differences in sample characteristics, imaging techniques, and measurement methods across studies[6]. Non-syndromic CLP patients have a wide spectrum of growth outcomes, and while some studies have found significant differences in mandibular ramal or condylar heights between CLP patients and non-cleft controls, others have found no significant differences[7].

Clinically, panoramic radiography (orthopantomogram, OPG) is a common imaging modality used in the initial orthodontic assessment of CLP patients[8]. Prior studies have validated panoramic measurements of condylar and ramus height asymmetries as having acceptable reproducibility and accuracy for screening purposes[9,10,11]. We are looking for any significant relationship between mandibular asymmetry and cleft patients with class I malocclusion. We hypothesized that adolescents with CLP would demonstrate greater vertical mandibular asymmetry than Class I controls.

Materials and Methods

Study Design and Ethical Clearance

This was a retrospective, cross-sectional study in which available patient records were reviewed at the College of Dentistry, University of Mosul. The protocol was presented to the Institutional Research Ethics Committee of the University of Mosul, and approval was granted (Approval No. MOS-OD/2025/001).

Sample Selection

The sample comprised 150 subjects (75 with cleft lip and/or palate and 75 with Class I malocclusion) treated in the Department of Orthodontics in Mosul. Inclusion criteria for the CLP group were non-syndromic unilateral or bilateral cleft lip and palate patients aged 12–18 years who had pre-treatment panoramic radiographs of diagnostic quality. The Class I malocclusion group consisted of

orthodontic patients ages 12–18 with skeletal and dental Class I relationships (ANB ≈ 2–4°) and no crossbites or significant asymmetries noted clinically. Mild dental crowding or spacing was permitted in the Class I group (as these are common and not expected to affect mandibular symmetry), but cases with any anterior or posterior crossbite were excluded. Additional exclusion criteria for both groups were: history of previous orthodontic treatment or jaw surgery, any systemic conditions or syndromes affecting growth, and trauma or pathologies of the jaw. From an initial pool of 180 eligible records (95 CLP, 85 Class I), we applied the above criteria and randomly selected 75 individuals per group for analysis. A power calculation was performed using G*Power 3.1 to determine the sample size: based on an effect size of 0.5 for asymmetry index difference, a total of ~138 subjects (69 per group) was required for 80% power at $\alpha = 0.05$. Our final sample of 150 exceeded this requirement, providing adequate power to detect moderate group differences.

Imaging and Measurements

All subjects had pre-treatment panoramic radiographs (orthopantomograms) taken as part of their orthodontic records. The radiographs were acquired using a digital panoramic X-ray unit (Planmeca ProMax, Helsinki, Finland) set at standard exposure parameters and 1.3× magnification.

Panoramic images were exported to digital imaging software (EzDent-i, Vatech, Korea) for measurement. Before analysis, each image was calibrated to account for the machine's known magnification factor. The technique described by Habets *was* used to measure the vertical height of the mandibular ramus and condyle on each side. Briefly, a horizontal reference line (line “A”) was drawn as a tangent to the inferior border of the mandible (at the gonial region). A perpendicular line was constructed from this tangent to the highest point of the condylar process, defining the condylar height (CH). The ramus height (RH) was defined as the distance from the most superior condylion point to the intersection

with the tangent at the mandibular angle (i.e., the distance between points O1 and O2 as per Habets' method). Each measurement was performed for the left and right sides of the mandible. Figure 1 illustrates the reference points and measurements on a sample panoramic radiograph (O1: lateral condylar point; O2: lateral ramus point; AC: condylar height; AR: ramus height). The condylar asymmetry index (CAI) and ramus asymmetry index (RAI) were then calculated for each subject using the formula:

$$Asymmetry\ Index\ (AI) = \frac{Right\ side - Left\ side}{Right\ side + Left\ side} \times 100\%$$

where the absolute difference in heights is normalized to the average of both sides. An asymmetry index of 0% indicates perfect symmetry, whereas higher values indicate greater asymmetry. We considered an index >3% as the threshold for clinically notable vertical asymmetry, based on the original validation by Habets[11], who reported that a 3% index corresponds to ~6% linear discrepancy due to minor head positioning differences.

All radiographic measurements were made by a single calibrated examiner (an orthodontist). To assess intra-observer reliability, 15 radiographs (10% of the sample) were randomly selected and re-measured by the same examiner after a 3-week interval. Furthermore, a second orthodontist measured 10 radiographs to assess inter-examiner reliability. Intraclass correlation coefficients for measurements of ramus and condyle height were 0.93 and 0.91, indicating excellent repeatability. Small differences (≤ 1 mm) in duplicate measurements were resolved by consensus, and the average was used.

Statistical analysis

SPSS 26.0 (IBM, Armonk, NY) was used to process the data. Age was presented as a continuous variable (years). Continuous variables were tested for normal distribution using the Shapiro–Wilk test. For each group (CLP and Class I), paired t-tests were applied to compare the means of right vs left ramus height and condylar height. Comparisons between CLP and Class I groups were assessed using independent samples t-tests for normally distributed variables (e.g., age). Comparison between groups of the nonnormally distributed asymmetry indices was made using the Mann–Whitney U test. Categorical data (percentage with >3% prevalence of asymmetry, gender) were compared using the chi-square test (or Fisher's exact test if expected counts were <5). Furthermore, we used Spearman's rank correlation analysis to examine the association between age and AsysCs within each group. The criterion for statistical significance was $p \leq 0.05$ in all analyses.

Results

Sample Characteristics

Table 1 presents the demographic distribution of the two groups. The mean age of the Class I group was slightly higher than that of the CLP group (15.8 ± 1.8 vs 14.9 ± 1.9 years, respectively), and this difference was statistically significant (p = 0.010). The CLP sample included 38 males (50.7%) and 37 females (49.3%), whereas the Class I sample had 27 males (36.0%) and 48 females (64.0%). Although the CLP group had a higher proportion of males than the Class I group, the difference in sex distribution did not reach statistical significance (chi-square, p = 0.073). Overall, the combined sample comprised 43.3% males and 56.7% females.

Side-to-Side Comparisons of Mandibular Dimensions

Table 2 summarizes the vertical ramus and condylar height measurements on the right and left sides for each group. In the Class I group, the mean ramus height was 38.5 mm on the right and 39.0 mm on the left, a difference that was not statistically significant (paired t-test p = 0.68). The mean condylar process height in Class I patients was 5.7 mm (right) vs 5.9 mm (left), and the difference was not statistically significant (p = 0.21). Similarly, in the CLP group, the mean ramus heights were 40.6 mm (right) and 42.0 mm (left), with no significant side difference (p = 0.33). The mean condylar heights in CLP patients were 5.9 mm (right) and 5.5 mm (left); although the left condyle tended to be slightly shorter on average, this difference was not statistically significant (p = 0.17). Figure 2 illustrates an example panoramic radiograph from a CLP patient, demonstrating the measurement of right and left ramus and condylar heights using the reference lines (the left condylar height is marginally less than the right in this case, consistent with the trend in group means).

Asymmetry Indices and Group Comparison

Table 3 shows the condylar and ramus asymmetry indices of two groups. For ramus asymmetry, the median asymmetry index was 2.0% in Class I as well as CLP groups. The mean ramus asymmetry index tended to be greater in CLP (3.5% ± 3.8%) than in Class I subjects (2.9% ± 2.4%), but the difference was not significant (Mann–Whitney U = 2648, p = 0.538). Regarding condylar height asymmetry, the median of the CLP group was 9.0% for the asymmetry index (mean 9.5% ± 7.5%), and this value in the Class I group was 6.5% (mean = 7.2% ± 6.5%). The condylar asymmetry was statistically higher in the CLP patients, although the inter-group difference did not reach the usual level of significance (p = 0.067). Accordingly, the cleft sample trended towards greater condylar asymmetry, although

there remained significant overlap between samples. Significantly, both groups had mean values well above the 3% threshold for both ramus and condylar asymmetry indices, indicating that mild vertical asymmetries are frequently observed even in Class I individuals.

The mean condylar height differences were in the range of 5–10%, and the mean ramus height differences were smaller (~3%) for this group of adolescent patients. There was a large inter-individual variation: for example, in the CLP group, the condylar asymmetry indices ranged from nearly 0% (i.e., almost perfectly symmetrical condyles) to about 25%. In the Class I sample, the maximum observed condylar asymmetry index was approximately 21%. Despite CLP patients including some of the most asymmetric cases, the overall distribution did not differ significantly from that of the Class I group.

From a clinical standpoint, we also evaluated the prevalence of notable asymmetry in each group using the 3% cutoff. In the Class I group, 27 out of 75 patients (36%) had a ramus asymmetry index >3%, compared to 15 out of 75 (20%) in the CLP group; this difference was not significant ($\chi^2 = 0.41$, $p = 0.523$). For condylar asymmetry, 60 of 75 Class I patients (80%) and 62 of 75 CLP patients (82.7%) had an index >3% ($\chi^2 = 0.07$, $p = 0.799$). Figure 3 illustrates the prevalence of ramus asymmetry >3% in each group, and Figure 4 shows the prevalence of condylar asymmetry >3%; both figures demonstrate the similarity between groups (no significant group differences).

Association of Asymmetry with Age and Sex

We investigated whether mandibular asymmetry was related to patient age or sex within each group. Because age was treated as a continuous variable, a correlation approach was used. In those with Class I malocclusions, a significant positive correlation was observed between age and the ramus asymmetry index (Spearman $\rho = +0.28$, $p = 0.018$), indicating that older patients show greater vertical ramus asymmetry.

For instance, for Class I subjects, the average RAI was 1.8% in the youngest subset (12–14 years old) and 4.0% in the oldest subset (18 years old). This was also evident in the categorical analysis: 60% of Class I patients at age 18 had an "abnormal" asymmetry (>3% of the ramus, whereas ages 12–17 had only 20–40% (this age-group comparison was significant, $p = 0.037$). On the other hand, no significant age-dependence was found for ramus asymmetry in the CLP group ($\rho = +0.13$, $p = 0.24$); neither could the previously noted difference between those aged 18 (50% prevalence of ramus asymmetry >3%) and aged 12–17 (26%) be attributed to chance (not statistically significant).

For condylar asymmetry, neither group showed a significant age correlation (Class I $\rho \approx -0.10$, $p = 0.40$; CLP $\rho \approx +0.08$, $p = 0.51$). An interesting pattern in Class I was that the oldest patients (18 years) actually had *lower* condylar asymmetry on average than mid-adolescents, but given the high overall prevalence of condylar asymmetry, this inverse trend was not significant (prior age- group analysis in Class I found 66.7% of 18-year-olds vs ~87–90% of younger teens had condylar asymmetry >3%, $p = 0.406$, not significant). In CLP patients, condylar asymmetry remained high (75–89% prevalence >3%) across all age subgroups with no significant age effect ($p = 0.547$).

Regarding sex, we found no significant differences in asymmetry indices between males and females in either group. In the Class I group, the mean RAI was 3.1% in males vs 2.8% in females ($p = 0.75$) and the mean CAI was 7.5% in males vs 7.0% in females ($p = 0.84$). In the CLP group, mean RAI was 2.6% in males vs 3.4% in females ($p = 0.50$), and mean CAI was 8.3% in males vs 10.1% in females ($p = 0.58$). Although female CLP patients showed a slight tendency toward greater asymmetry than males (35% of females vs 26% of males had ramus asymmetry >3%, and ~83% of females vs 81.5% of males had condylar asymmetry >3%), these differences were not significant (chi-square $p > 0.4$). Our findings of no sex-based disparities in mandibular asymmetry are consistent with recent studies on asymmetry in orthodontic patients.

Table 1: Demographic characteristics of the Class I malocclusion and cleft lip and palate (CLP) groups. Data are given as mean ± SD for age, and number (%) for sex.

Characteristic	Class I (n = 75)	CLP (n = 75)	Total (N = 150)	p-value
Age (years) (mean ± SD)	(12–18) 15.8 ± 1.8	(12–18) 14.9 ± 1.9	(12–18) 15.3 ± 1.9	0.010*
Sex				0.073**
Male	27 (36.0%)	38 (50.7%)	65 (43.3%)	
Female	48 (64.0%)	37 (49.3%)	85 (56.7%)	

[*]: p-value by independent t-test for age difference between Class I and CLP groups.
[**]: p-value by chi-square test for sex distribution between groups (comparison of proportion male vs female).

Table 2: Descriptive statistics for right and left mandibular ramus and condylar heights (in millimeters) in Class I and CLP groups. P values refer to comparisons between right and left sides within the same group (paired analysis).

Group	Ramus height (R)	Ramus height (L)	p-value	Condylar height (R)	Condylar height (L)	p-value
Class I (n = 75)	38.5 ± 5.3 mm	39.0 ± 5.4 mm	0.68*	5.7 ± 1.2 mm	5.9 ± 1.3 mm	0.21*
Median (IQR)	38.8 (34.5–42.7)	39.2 (34.8–42.9)		5.6 (5.0–6.4)	5.9 (5.0–6.8)	
Min, Max	28.0, 48.5	28.1, 49.0		3.5, 8.7	3.5, 8.5	
CLP (n = 75)	40.6 ± 6.0 mm	42.0 ± 6.1 mm	0.33*	5.9 ± 1.3 mm	5.5 ± 1.3 mm	0.17*
Median (IQR)	40.7 (35.8–45.1)	42.5 (36.0–47.0)		5.7 (5.0–6.8)	5.5 (4.7–6.3)	
Min, Max	22.0, 55.0	21.5, 54.5		3.4, 9.5	2.3, 9.2	

[*]: Paired t-test (within-group) comparing right vs left side measurements.

Table 3: Comparison of mandibular asymmetry indices (ramus and condyle) between Class I and CLP groups. Values are given as mean ± SD and median. The asymmetry index is the absolute percentage difference between right- and left-side measurements.

Asymmetry Index (%)	Class I (n = 75)	CLP (n = 75)	p-value
Ramus asymmetry	2.9 ± 2.4% (Median 2.0)	3.5 ± 3.8% (Median 2.0)	0.538*
Condylar asymmetry	7.2 ± 6.5% (Median 6.5)	9.5 ± 7.5% (Median 9.0)	0.067*

[*]: p-value by Mann–Whitney U test (comparison of asymmetry indices between Class I and CLP groups).

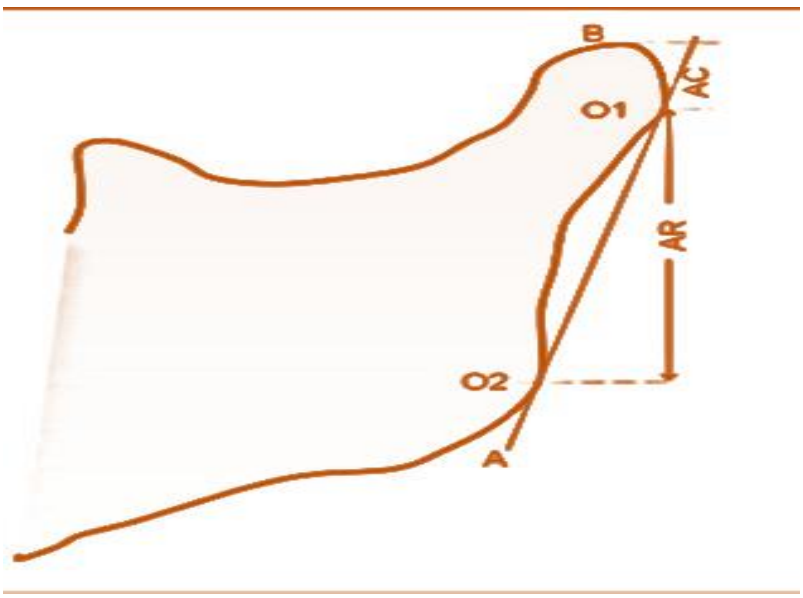

Figure 1: Schematic illustration of the Habets method showing reference points (O1, O2) and linear measurements used to determine condylar height (AC) and ramus height (AR). These measurements are taken along a tangent to the posterior ramal border to calculate the mandibular asymmetry index.

Figure 2: Digital panoramic radiograph (orthopantomogram) obtained with a Vatech PaX-i3D showing the Habets measurement technique for assessing mandibular vertical asymmetry. Red reference lines indicate ramus and condylar height measurements used to calculate the asymmetry index $(R - L)/(R + L) \times 100$.

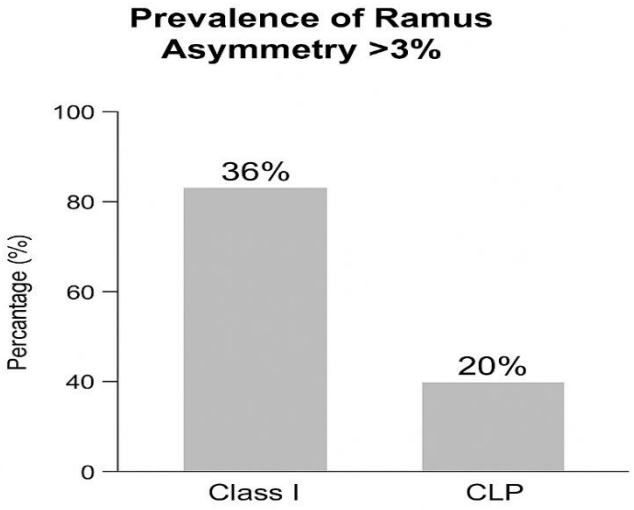

Figure 3: Prevalence of ramus asymmetry greater than 3% in Class I and CLP groups.

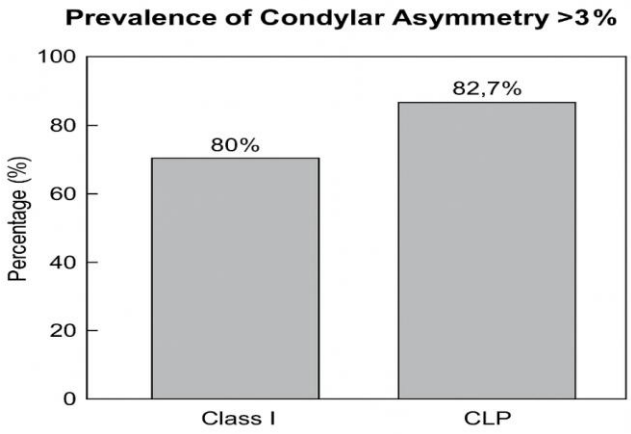

Figure 4: Prevalence of condylar asymmetry greater than 3% in Class I and CLP groups.

Discussion

This study evaluated mandibular vertical asymmetry in patients with cleft lip and palate compared to Class I malocclusion controls, using panoramic radiographic measurements. To our knowledge, it is one of the largest cross-sectional comparisons of mandibular asymmetry between CLP and non-CLP orthodontic populations in the Middle East. The key finding was that the non-syndromic CLP group did not exhibit significantly greater mandibular asymmetry than the Class I control group. Both groups demonstrated mild asymmetry in condylar and ramal heights (mean asymmetry indices above 3%), consistent with the notion that slight asymmetry is a normal finding in the general population. In fact, the prevalence of vertical condylar asymmetry (>3% difference) was around 80% in both groups, underscoring how common subtle mandibular asymmetry is, even among Class I individuals. Our results are consistent with prior observations that clinically acceptable asymmetry is frequently present and may not indicate pathology. In practical terms, a 5-10% asymmetry in condylar or ramus height (often translating to only 1-3 mm absolute difference) might be considered within normal variation and may not manifest as noticeable facial asymmetry or malocclusion.

Importantly, we found no statistically significant differences between the CLP and control groups in either ramus or condylar asymmetry indices. This suggests that having a repaired cleft lip and palate did not predispose patients in our sample to greater vertical mandibular asymmetry. This finding supports the work of [12], who also reported that unilateral CLP patients had mandibular asymmetry measurements comparable to those of non-cleft controls, while[13] noted no significant correlation between mandibular asymmetry and overall lower facial asymmetry in CLP individuals, proposing that the cleft-related facial asymmetry observed is likely due to other factors (such as cranial base or maxillary discrepancies) rather than the mandible itself. Our study reinforces this perspective: despite the maxillary deformity inherent in CLP, the mandible can often adapt or grow in ways that do not produce large unilateral deficiencies or excesses in vertical height.

Previous studies have found differences in mandibular symmetry between cleft and non-cleft groups, particularly with more advanced 3D imaging. For example, a study[14] observed greater mandibular asymmetry in unilateral CLP subjects with severe maxillary hypoplasia, while the mandible's growth direction may become asymmetric as a compensatory mechanism[15]. It has been reported that unilateral CLP patients with Class III relationships had significantly lower facial asymmetry[16]. In our CLP sample (which included both unilateral and bilateral clefts, mostly with Class I skeletal relations after treatment of the maxilla), any inherent asymmetry might have been mitigated by orthopedic and orthodontic interventions or simply not large enough to differentiate from the baseline asymmetry seen in controls.

In Class I malocclusion (with essentially symmetric craniofacial structure), any random differences in growth velocity between sides could lead to small asymmetries by the end of growth. The fact that we did not see a similar significant age trend in the CLP group might be due to the cleft patients receiving early interventions (such as maxillary expansions, alveolar bone grafts, etc.)[17]. Another interesting pattern was the slight reduction in condylar asymmetry in the oldest Class I patients; though not significant, this could imply that some condylar remodeling or normalization occurs in late adolescence, or it could be a chance finding. Overall, the age-related increase in ramus asymmetry for Class I aligns with general growth phenomena and has been reported in other contexts[18]. Regarding sex differences, our results showed no significant difference in asymmetry between males and females. This is held true for both ramus and condylar asymmetry indices and in both cleft and non-cleft groups. These findings concur with several reports in the literature that failed to find sex as a determinant of mandibular asymmetry severity. For instance, a study[19] found no consistent gender differences in ramus or total mandibular asymmetry in a sample of children with various malocclusions[20].

Both cleft and non-cleft patients can have asymmetry indices of 5–10% without visible facial asymmetry. However, indices well above 6% are beyond the typical magnification error range.

Future research could complement these findings by assessing transverse asymmetry using PA cephalograms or 3D imaging to obtain a more complete picture of mandibular asymmetry in CLP[15].

Conclusion

- In this Mosul sample, adolescents with repaired cleft lip and palate (CLP) did not exhibit greater vertical mandibular asymmetry than those with Class I malocclusion.
- There were no significant differences between CLP and non-cleft groups in right–left ramus height or condylar height asymmetry indices.
- Mild mandibular asymmetry was a common finding in both groups. The majority of patients in each group

showed a condylar asymmetry index above 3%, indicating slight vertical condyle height discrepancies within normal variation.

- Within the Class I malocclusion group, older patients tended to have slightly greater ramus asymmetry.
- No significant sex differences in mandibular asymmetry were observed. Both males and females in CLP and Class I groups had comparable asymmetry indices.
- Panoramic screening does not replace 3D evaluation when clinical asymmetry is suspected, but it is a simple method for diagnosis.

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