# Condylar and ramal vertical asymmetry in patients with different vertical skeletal patterns

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*Objective:* The objective of the present study was to evaluate condylar, ramal and condylar+ramal mandibular vertical asymmetry in a group of patients with different vertical skeletal patterns.
*Methods:* Mandibular condylar and ramal measurements of 104 patients were performed on panoramic radiographic images and asymmetry indices were obtained according to the Habets' formula. The study groups consisted of 35 hypodivergent, 34 normodivergent and 35 hyperdivergent patients. Data were statistically analysed by means of two-way ANOVA, Kruskal–Wallis and Pearson chi square tests.
*Results:* Ramal height was significantly higher in the hypodivergent group ($p < 0.05$). No significant differences were found between the vertical skeletal pattern groups in relation to the asymmetry indices ($p > 0.05$).
*Conclusion:* Condylar asymmetry values were found to be higher than a 3% threshold value in all groups, but no significant differences were observed between the groups. The effect of the vertical skeletal pattern on vertical mandibular asymmetry was found to be insignificant.
(Aust Orthod J 2021; 37: 85 - 92. DOI: 10.21307/aoj-2021-009)

Received for publication: August 2020
Accepted: January 2021

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## Introduction

Facial asymmetry is considered to be a lack of balance in size and form between the right and left side facial structures.[1] Mandibular asymmetry, which can be regarded as a naturally occuring phenomenon in most subjects,[2] is a primary cause of facial asymmetry.[3] Although perfect symmetry does not exist in nature, there is no consensus in defining the boundary between normal and pathological states, particularly in reference to mandibular asymmetry.[4]

A number of genetic, enviromental and/or functional factors are reportedly involved in the aetiology of mandibular asymmetry.[5-9] It is important to determine the aetiological factor and to identify the site of the asymmetry in order to achieve a balanced and harmonious facial appearence following orthodontic or surgical treatment.

Apart from a thorough clinical examination, additional diagnostic tools have been applied in the diagnosis of mandibular asymmetry. These include photographs of frontal and side views, lateral and postero-anterior cephalometric radiographs, oblique radiographs of the mandible taken at 45°, panoromic radiographs, cone beam computed tomography and the other 3D techniques.[8-10]

However, Habets et al.[11] described a method, used in orthodontic diagnosis, to determine asymmetries between the condyles and mandibular rami using panoramic images. In later studies, it was concluded that vertical measurements of the height of the condyle or ramus could be reliably assessed on panoramic images with acceptable reproducibility.[10,12-14] The Habets method has been used to evaluate vertical mandibular asymmetry in temporomandibular disorders,[15,16] Class I, Class II and Class III malocclusions,[6,17,18] unilateral and bilateral posterior crossbites[19-21] and different sagittal skeletal patterns.[22] However, controversial findings have been reported

Table I. Age and gender distributions of the study groups.

| Groups | Gender | N | Age (y) Mean | SD |
|---|---|---|---|---|
| Hypodivergent (SNGoGN ≤ 28) | Male | 17 | 13.65 | 2.4 |
| | Female | 18 | 14.28 | 2.1 |
| | total | 35 (33.65%) | 13.97 | 2.2 |
| Normodivergent (28 ≤ SNGoGN ≤ 36) | Male | 9 | 15 | 2.2 |
| | Female | 25 | 13.36 | 1.8 |
| | total | 34 (32.7%) | 13.79 | 1.9 |
| Hyperdivergent (36 ≤ SNGoGN) | Male | 13 | 14.54 | 1.3 |
| | Female | 22 | 14.14 | 1.9 |
| | total | 35 (33.65%) | 14.29 | 1.7 |

y: year; N: number of patients; SD: standard deviation; SNGoGn: sella nasion gonion gnathion

regarding the relationship between mandibular vertical asymmetry and the type of malocclusion in the sagittal and transverse planes.[17,18,20-22] Posterior crossbites and Class II malocclusions were found to be associated with vertical mandibular asymmetry.[20,23]

According to current knowledge, no published study has evaluated mandibular condylar and ramal vertical asymmetry in patients with different vertical skeletal patterns using the method of Habets et al.[11] Therefore, the objective of the present study was to investigate the effects of a vertical skeletal pattern on condylar and ramal heights and vertical mandibular asymmetry.

## Materials and methods

This retrospective study was approved by the Ethics Committee of the Medical School of Akdeniz University and the study was conducted in accordance with the ethical rules of the Declaration of Helsinki (The ethics approval number was 70904504/89).

The study material was selected from the archives of the Akdeniz University, Faculty of Dentistry, Department of Orthodontics. Pretreatment orthopantomagrams (OPGs) of 104 patients who met the following inclusion criteria were examined:

1. Dental Class I molar relationships (pretreatment dental casts were used for the classification)
2. Skeletal Class I relationship, which was defined by the ANB angle (0 ≤ ANB ≤ 5)
3. No posterior crossbites or non-occlusions in the transverse plane
4. Presence of all tooth germs excluding the third molars
5. No history of previous orthodontic treatment
6. No developmental or acquired neuromuscular or craniofacial deformities
7. No systemic disease or trauma affecting bone structure
8. The presence of an apparent normal anatomic condyle and coronoid processes in the radiographic images.

OPGs in which temporomandibular joint pathology was suspected, poor image quality involving horizontal distortions and in which anatomical landmarks were not clearly visualised, were excluded from the study.

A total of 104 patients were divided into three study groups based on their vertical skeletal facial pattern. Pretreatment SNGoGN angle values were used for the classification.

Group 1 (N = 35): Hypodivergent group (SNGoGN ≤ 28)

Group 2 (N = 34): Normodivergent group (28 ≤ SNGoGN ≤ 36)

Group 3 (N = 35): Hyperdivergent group (36 ≤ SNGoGN)

The age and gender distributions of the study groups are shown in Table I.

OPGs were obtained using the same Planmeca ProMax panoramic device (Planmeca Oy, 00880 Helsinki, Finland), in accordance with the manufacturer's instructions (66 kVp, 7 mA, and 16 seconds), by the same X-ray technician in a standard manner. All OPGs were evaluated using the same LED monitor by a single investigator (H.A.) who had seven years

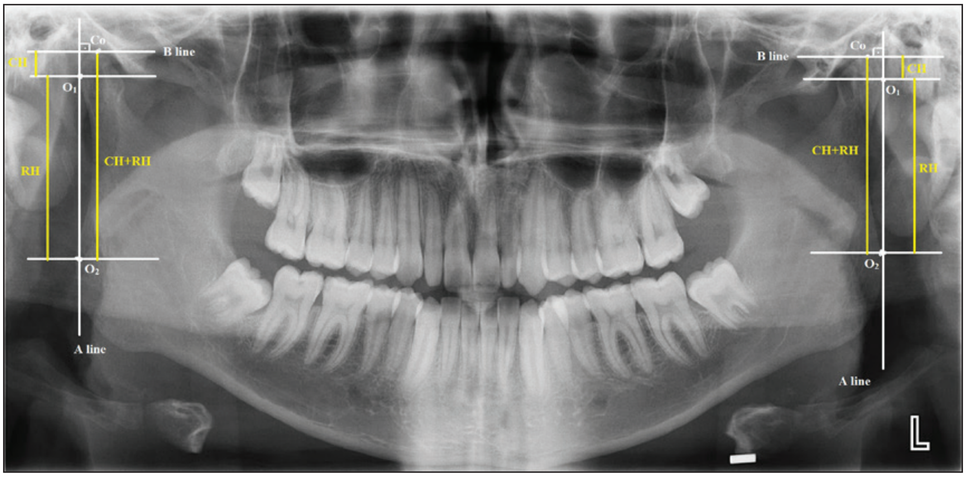


Figure 1. Linear measurements on panoramic radiographic image.

of experience in dental radiology. The evaluation was conducted in a dimly-lit room with tonal adjustments made on images to maximise the view, and approximately 30–40 cm away from the LED monitor. Only 10 OPGs were evaluated per day in order to prevent investigator fatigue.

$O_1$ point, $O_2$ point, A line and B line were determined according to Habets et al.[11] (Figure 1) and the following linear measurements were made on the OPGs for both the right and left sides:

*Co:* the most superior part of the condylar image

*$O_1$ and $O_2$:* the most lateral points of the condylar image

*A line:* a ramus tangent

*B line:* a perpendicular line from Co to A line

*Condylar height (CH):* the distance between Co and $O_1$ points

*Ramal height (RH):* the distance between $O_1$ and $O_2$ points

*Total height (CH+RH):* the distance between Co and $O_2$ points

The asymmetry indices were determined using the formula developed by Habets et al.[11]

*Asymmetry Index (AI)* = ((Right – Left)/(Right + Left)) × 100

Measurements were automatically calibrated by the Planmeca Romexis 4.0 software program, which was developed for the Planmeca ProMax machine (Planmeca Oy, 00880 Helsinki, Finland). After four weeks, CH, RH and CH+RH measurements of 50 randomly selected patients were repeated and inter-observer variability was assessed.

### *Statistical analysis*

Intra-observer reliability was assessed using the interclass correlation coefficient. Data were statistically analysed by the SPSS software package (version 23.0, SPSS, IL, USA). The assumption of normality was evaluated using the Shapiro–Wilk test. The parametric two-way ANOVA test was conducted to compare the effect of the vertical skeletal pattern on the condylar and ramal height measurements. The non-parametric Kruskal–Wallis test was performed to evaluate the groups' differences. The gender distributions of the groups were evaluated using the Pearson chi-square test. The results with a $p$-value of $< 0.05$ were considered statistically significant.

## Results

The inter-class correlation coefficient was found to be greater than 0.95 for all parameters. The means and standard deviations of the chronological ages and the gender distributions of the subjects are shown in Table I. No statistically significant difference was found between the groups in regard to age and gender ($p = 0.166$, $p = 0.476$, respectively).

Table II shows the mean, standard deviation, minimum, maximum and $p$-values of the CH, RH and CH+RH measurements for the left and right sides, regardless of the vertical skeletal pattern. As presented in Table II, left CH measurements were significantly higher

Table II. The mean, standard deviation, minimum, maximum and p values of the condylar, ramal and condylar+ramal height measurement for the left and right sides.

| Parameter | Mean (mm) | SD | min | max | *p* value |
|---|---|---|---|---|---|
| right CH | 8.83 | 2.38 | 4.9 | 15.1 | 0.001* |
| left CH | 9.48 | 2.31 | 5 | 15.4 | |
| right RH | 61.82 | 7.37 | 48.3 | 89 | 0.763 |
| left RH | 61.97 | 7.38 | 48.6 | 82.9 | |
| right CH+RH | 70.66 | 8.18 | 55 | 98.3 | 0.065 |
| left CH+RH | 71.52 | 8.25 | 55.4 | 92.7 | |

CH: condylar height; RH: ramal height; CH+RH: total height; mm: millimeter; SD: standard deviation; min: minimum; max: maximum; * $p < 0.05$

Table III. The comparison of the right and left side measurements according to the vertical skeletal pattern.

| | | Group 1 (hypodivergent) | |
|---|---|---|---|
| | right mean (mm) ± SD | left mean (mm) ± SD | test |
| CH | 9.67 ± 2.77 | 10.17 ± 7.5 | NS |
| RH | 62.32 ± 6.74 | 63.95 ± 6.46 | 0.037* |
| CH+RH | 71.99 ± 7.31 | 74.32 ± 7.27 | NS |
| | | Group 2 (normodivergent) | |
| CH | 8.16 ± 1.96 | 9.05 ± 2.02 | NS |
| RH | 61.85 ± 8.77 | 60.75 ± 8.06 | NS |
| CH+RH | 70 ± 9.19 | 69.8 ± 8.67 | NS |
| | | Group 3 (hyperdivergent) | |
| CH | 8.64 ± 2.11 | 9.2 ± 2.26 | NS |
| RH | 61.3 ± 6.62 | 61.18 ± 7.34 | NS |
| CH+RH | 69.95 ± 8.02 | 70.39 ± 8.27 | NS |

CH: condylar height; RH: ramal height; CH+RH: total height; mm: millimeter; SD: standard deviation; NS: non significant; test: two way ANOVA; * $p < 0.05$

than the right CH measurements ($F(1,101) = 11.25$, $p < 0.001$, $\eta^2 = 0.1$) and the differences between the right and left side measurements of RH and CH+RH measurements were insignificant ($F(1,101) = 0.92$, $p = 0.763$, $\eta^2 = 0.001$ and $F(1,101) = 3.492$, $p = 0.065$, $\eta^2 = 0.033$, respectively).

When the vertical skeletal pattern was considered, RH measurements were significantly higher in the hypodivergent group compared to the other groups ($F(2,101) = 3.185$, $p = 0.046$, $\eta^2 = 0.059$). However, CH measurements and CH+RH measurements did not show a significant difference between the vertical skeletal pattern groups (($F(2,101) = 0.405$, $p = 0.668$, η2 = 0.008) and ($F(2,101) = 2.776$, $p = 0.067$, $\eta^2 = 0.052$), respectively).

Table III presents the comparison of the right and left side measurements for different vertical skeletal pattern groups. According to Table III, the left RH measurements were significantly higher than the right RH measurements in the hypodivergent group ($F(1,101) = 4.471$, $p = 0.037$, $\eta^2 = 0.042$).

Table IV presents the relationships between the vertical skeletal pattern and AI values. The statistical analysis showed that asymmetry index measurements of the condyle, rami and condyle+rami were not statistically affected by the vertical skeletal pattern.

## Discussion

The right and left sides of the craniofacial complex should grow and develop equally to ensure symmetry of facial morphology.[24] Mandibular asymmetry, which has a direct effect on facial appearance, is defined as asymmetry in the lower facial third.[23] Although it is considered that the presence of asymmetry is normal at some ages, especially in the young growing population, a size difference greater than 2–3 mm between

Table IV. The relationships between the AI values and the vertical skeletal pattern.

| Parameter | Groups | Mean(%) | SD | min | max | *p* value |
|---|---|---|---|---|---|---|
| Condylar AI | Hypodivergent | 10.23 | 8.36 | 0.46 | 31.65 | |
| | Normodivergent | 10.13 | 6.67 | 0 | 23.16 | 0.078 |
| | Hyperdivergent | 6.89 | 5.7 | 0 | 19.7 | |
| Ramal AI | Hypodivergent | 2.82 | 2.88 | 0 | 9.92 | |
| | Normodivergent | 2.58 | 2.33 | 0 | 9.88 | 0.802 |
| | Hyperdivergent | 2.74 | 2.35 | 0.18 | 11.39 | |
| Total AI | Hypodivergent | 2.8 | 2.59 | 0 | 10.28 | |
| | Normodivergent | 2.45 | 1.94 | 0 | 7.81 | 0.76 |
| | Hyperdivergent | 2.31 | 2.15 | 0 | 8.87 | |

AI: asymmetry index; SD: standard deviation; min: minimum; max: maximum

right and left sides of the mandible is considered as 'mandibular asymmetry' and of aesthetic concern.[24]

An accurate diagnosis of the presence of asymmetry in the mandibular facial third is important for clinicians to achieve a harmonious and balanced facial appearance following orthodontic, surgical or combined treatment options. In past studies, mandibular asymmetry has been detected by applying an asymmetry index formula introduced by Habets et al.[6,11,17-20,22] Mandibular vertical asymmetry was evaluated using this formula in patients who presented with temporomandibular disorders,[15] Class I, Class II and Class III malocclusions[6,17,18] and unilateral and bilateral posterior crossbites.[19-21] Although the formula uses vertical dimensional measurements of the condyle and the rami and determines mandibular vertical asymmetry, the present study is the first to investigate mandibular vertical asymmetry on panoramic radiographs, in patients of different vertical skeletal patterns.

Mandibular asymmetry was previously associated with malocclusions in the sagittal and transverse planes.[18,20,23,25] In order to eliminate the effects of the malocclusions in those planes, the test groups of the present study consisted of patients with dental and skeletal Class I relationships. The SNGoGN angle, which has been recommended as a reliable indicator of the vertical skeletal pattern,[26] especially in patients without sagittal discrepancies,[27] was used for the classification of the study groups.

Panoramic radiographs, which had been routinely taken before and after orthodontic treatment, were used in this study for the evaluation of mandibular vertical asymmetry. The use of panoramic radiographs to evaluate side-to-side differences is equivocal as it has been shown that there is magnification in both horizontal and vertical planes.[28] To prevent magnification in the vertical direction, the distance between the focal point of the X-ray tube and the film must always be the same.[29] Habets et al.[30] concluded that the patient's head must be centered in the head holder when a clinical OPG is to be evaluated and also reported that a 6% vertical size difference would occur as a result of a 10 mm change in head position. According to Habets, asymmetry index values greater than 3% should be considered as mandibular posterior vertical asymmetry.[11] In the horizontal plane, distortion between the left and right sides depends on the position of the patient's head. To determine horizontal distortions in OPGs, it was suggested that the mesiodistal widths of the mandibular first molars be bilaterally compared.[21] Although computed tomography scans are believed to be the gold standard of craniofacial imaging, many studies that have investigated the reliability and validity of OPGs for evaluating mandibular vertical asymmetry have suggested that good-quality OPGs yield acceptable results, are non-invasive and have a favourable cost-benefit relationship.[10,12-14] In the present study, all OPGs were taken by the same experienced technician in appropriate conditions and OPGs with mesiodistal size differences greater than 1 mm between right and left mandibular first molars were excluded from the study.[31]

When hemimandibular dimensions have been compared, previous studies have shown right and left dominance inconsistencies.[1,24,32-37] Regardless of the skeletal facial pattern, in the present study, the mean values of the left side were greater than those of the right side in all parameters, but the main effect was significant only in regards to measurements of condylar height ($F(1,101) = 11.25$, $p < 0.001$, $\eta^2 = 0.1$). Cohlmia et al.[38] showed that the left condyle was positioned more anteriorly than the right condyle and Yale[39] indicated that the shape, angular and positional differences between the right and left condyles without pathology or related malocclusion, could exist.

The severity of mandibular asymmetry has been compared between different types of malocclusions in the sagittal and transverse planes.[17,21,23] Uysal et al.[21] found no statistically significant difference in the left and right side measurements of CH, RH, and total height in cases of unilateral posterior crossbite, bilateral posterior crossbite and normal occlusion groups. Similarly, Kurt et al.[17] also found no statistically significant difference in the left and right measurements of CH, RH, and total height in Class II subdivision and normal occlusion groups. However, Sezgin et al.[23] concluded that malocclusions in the sagittal plane had a remarkable effect on condylar height in comparison with ramal height. To the best of current knowledge, the present study is the first to investigate the relationship between mandibular asymmetry and vertical skeletal pattern. While RH was found to be significantly higher in the hypodivergent group compared to the hyperdivergent and normodivergent groups, CH and total height parameters were statistically similar between the different vertical skeletal pattern groups. The higher values of RH measurements in the hypodivergent group may be a result of an anterior rotation tendency of the mandible associated with this growth pattern.[40]

Previous authors have found craniofacial asymmetry to be independent of the occlusion and the severity of asymmetry has also been found to be independent of the severity of a malocclusion.[41,42] Studies evaluating condylar AI values using Habets' formula in different malocclusion types and in TMD patients also found asymmetry values greater than 3%, which is reported as the condylar asymmetry threshold[11] both in malocclusion and normal occlusion groups.[17,18,21,23,25,43]

In the present study, the mean condylar AI values were 10.23 ± 8.36, 10.13 ± 6.67 and 6.89 ± 5.7 for the hypodivergent, normodivergent and hyperdivergent groups, respectively. These values were higher than 3% but no statistically significant difference was identified between the skeletal pattern groups. These findings were consistent with previous studies.[17,18,21,23,25,43]

It is noteworthy that the condylar AI values were significantly greater than the 3% thereshold yet the ramal and total AI values were less than 3% in different malocclusion types. These high values for condylar AI, which indicate asymmetry according to Habets et al.[11] both in malocclusion and normal occlusion groups, could be related to the angular, positional and shape differences between the right and left condyles regardless of pathology or the malocclusion.[39] However, Kambylafkas et al.[14] reported that condylar height could be unreliable when evaluating asymmetry from panoromic radiographs because of the small dimension of the measurement or possible operator errors. According to these findings and/or comments, it could be concluded that the thereshold 3% is not an appropriate value for an assesment of condylar height asymmetry using OPGs. It could be concluded that a 3% condylar AI value on OPGs is an expected finding regardless of the malocclusion and therefore is unlikely to be clinically significant.

Miller et al.[44] stated that condylar asymmetry was related to the strong forces that affect the skeletal and soft tissue components of the temporomandibular joint. Karic et al.[45] reported a significant association between condylar asymmetry, temporomandibular disorders and a mouth-opening index. Similarly, Maglione et al.[46] also found that articular disc displacement was a significantly frequent symptom in patients presenting with condylar asymmetry. As a result, panoramic radiographs of patients with clinical signs or symptoms of temporamandibular disorders were not included in this study.

In summary, mandibular asymmetry was found to be related to posterior crossbites in the transverse plane[18,20] and Class II malocclusions were found to be more related to condylar asymmetry compared with the Class I malocclusions[23,25] in the sagittal plane. In the present study, the relationship between mandibular asymmetry and differences in the vertical plane were investigated but there were no statistically significant differences between the hypodivergent, normodivergent and hyperdivergent groups in relation to condylar, ramal and total vertical mandibular asymmetry. The effect of vertical skeletal pattern on vertical mandibular asymmetry was found to be insignificant.

## Conclusion

- The mean ramal height measurements were significantly higher in the hypodivergent group.
- Condylar asymmetry index values were found to be higher than a 3% threshold value in all study groups.
- The condylar, ramal and total asymmetry index values were not statistically different between the vertical skeletal pattern groups.

## Conflict of interest

The author reports no professional or financial conflict of interest in relation to this article.

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## Acknowledgement

Statistical analysis of this study was carried out by the Akdeniz University Statistical Consulting, Application and Research Centre.

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