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Three-dimensional evaluation of mandibular asymmetry: a new classification and three-dimensional cephalometric analysis

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Abstract. Mandibular asymmetry is common among orthognathic patients and exhibits great variation. The aim of this study was to propose a new classification of mandibular asymmetry by anatomical regions; namely R (ramus), B (mandibular body) and C (chin), in conjunction with a corresponding 'RBC' three-dimensional (3D) cephalometric analysis. The cone beam computed tomography data of 65 patients with mandibular asymmetry was retrieved to perform the RBC 3D cephalometric analysis and to investigate the characteristics of mandibular asymmetry. It was found that the more posteriorly in mandible, the more pronounced was the vertical asymmetry. Significant transverse asymmetry was only noted in mandibular body. Both mandibular body and chin were significantly asymmetric in length. Seven significant morphologic predictors of menton deviation were identified, namely lower dental midline shift, difference in ramus height, difference in chin length, difference in body length, body height on contralateral side, coronoid height on deviated side and body width on contralateral side, confirming the complex nature of mandibular asymmetry. This simple and concise classification allows comprehensive assessment of mandible morphology by anatomical regions which also facilitates diagnosis, treatment planning and communication in both clinical and research settings.

Key words: orthognathic; classification of mandibular asymmetry; three-dimensional cephalometric analysis.

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Mandibular asymmetry is common among orthognathic patients, being diagnosed in up to almost 50% of skeletal class III patients[1–3]. Traditional plain radiographs such as posteroanterior cephalograms are largely inadequate for asymmetry assessment due to extensive superimposition of anatomical structures. Therefore, three-dimensional (3D) assessment is becoming common practice.

In orthognathic patients, mandible is commonly the most severely asymmetric

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facial structure[4] and is easily noticeable by both surgeons and patients. Correcting mandibular asymmetry is the cornerstone of achieving a symmetrical face, while maxilla is mainly a determinant for anteroposterior projection of the face. However, other than midpoint deviation, mandible asymmetry can arise from bilateral morphologic discrepancies. Simply aligning chin point to facial midline may not solve the problem completely and may leave behind residual asymmetry in other parts of mandible. Various classification systems of mandibular asymmetry categorized the condition based on aetiology, pattern of growth, cluster analysis or incorporating other anatomical structures, e.g. maxilla, lip[5–14]. However, mandibular asymmetry is a condition of great variation, reflected by different clustering outcomes and the inclusion of an atypical category in some classifications[8,10]. Therefore, instead of categorizing mandibular asymmetry into certain patterns, the aim of the study was to propose a comprehensive, region-based anatomical classification, along with a new corresponding 3D cephalometric analysis. The existing classification systems each have their strengths and weaknesses and will continue to be of help in making clinical decisions; however, the new classification aims at facilitating surgeons practically in achieving symmetrical surgical outcome. This study also investigated the characteristics of mandibular asymmetry based on the new classification scheme.

Materials and methods

This was a retrospective study utilizing existing cone-beam computed tomography (CBCT) scans in the database of Oral and Maxillofacial Department, Prince Philip Dental Hospital. The sample size calculation was based on previous 3D analysis of mandibular morphology in patients with facial asymmetry and mandibular prognathism (mean: 2.01 mm, standard deviation (SD): 2.15 mm[15]) and retrognathism (mean: −2.31 mm, SD: 1.60 mm[16]). Using G Power (version 3.1.9.2), a minimal sample size of 14 patients was required to achieve 95% statistical power at 5% confidence interval. In another research investigating mandible lateral displacement with CBCT[18], a minimal sample size of 40 was chosen based on statistical power and clinical significance.

Patients with clinically detectable mandibular asymmetry who underwent CBCT as a part of orthognathic surgery planning for correction of mandibular asymmetry were included, e.g. soft tissue menton deviation > 2 mm in transverse or vertical dimension, obvious mandibular canting or difference in mandibular body or gonial angle prominence. The CBCT scans with a wide field of view covering nasion to menton, and a slice thickness of 1 mm or less, were retrieved from the database. Patients presented with syndromal deformity (e.g. cleft lip and palate), history of maxillofacial trauma, previous orthognathic treatments or reconstruction were excluded. Each subject's demographic profile was recorded.

The CBCT data in digital imaging and communication in medicine (DICOM) format was imported to ProPlan CMF 2.1 (Materialise, Leuven, Belgium). A new 3D cephalometric analysis was designed, aiming to evaluate mandible morphology by anatomical regions. Thirty-eight landmarks were identified on the CT images; and verified on the volume-rendered bone model, coronal, sagittal and axial views (Tables 1, 2). Mandibular sagittal plane (Md-Sag) was designated as the plane through menton (Me) and midpoint between bilateral gonions (*Go|Go) and perpendicular to mandibular plane (Md-Pl) (Fig. 1). Ramal plane (R-Pl) was constructed as the plane through condyle (Co), gonion (Go) and perpendicular to mandibular sagittal plane (Md-Sag). Parallel to ramal plane (R-Pl) and perpendicular to mandibular sagittal plane (Md-Sag), coronal planes were designed at sigmoid notch (Sig-Pl), coronoid process (Crn-Pl), and mesial buccal cusp of lower first molar (B-Pl). The most inferior points and the most prominent points were marked on these planes for later measurements. For example, on the Sigmoid plane (Sig-Pl,) the most lateral point and the most inferior point at mandibular body were marked as *Sig-W and *Sig-H to assess the width and height of mandible in the sigmoid area. Similarly, *B-W, *B-H, *Crn-W and *Crn-H were marked on body plane (B-Pl) and coronoid plane (Crn-Pl) (Figs 2, 3). For assessment of the chin, the most inferior and the most anterior point of chin on the outline of mandibular symphysis at canine region were marked as *C-H and *C-L in a similar fashion to identifying menton (Me) and pogonion (Pog) at mandibular midline, respectively. The complete cephalometric analysis is depicted in Tables 2, 3 and 4.

After finishing the 3D cephalometric analysis, the data was exported as Microsoft Excel files and then imported to version 24: IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, USA) for statistical analysis. To assess intra-observer reliability, the 3D cephalometric analysis was performed again by the same investigator (M.Y.L.) on 10 samples, after a 1-week interval. Intraclass coefficient of correlation was performed. Primary outcomes were the linear measurements namely height, width and length of different anatomical regions of mandible. The mean and standard deviation of the linear measurements of mandibular asymmetry analysis were generated. The side to which menton deviated to was considered the deviated side of mandible. Level of significance was set at $P < 0.05$. Paired t-test was performed to compare the linear measurements of the deviated side and the contralateral side of mandible. Differences (Δ) were calculated by subtracting the linear measurements on the deviated side from the contralateral side of mandible. Stepwise multiple regression analysis was carried out to investigate the relationships between menton deviation and other measurements.

The RBC Classification of Mandibular Asymmetry

The new classification (see Table 5) used the letters R (Ramus), B (Body) and C (Chin) to delineate mandibular morphology by anatomical regions (Figs 2–4).

Table 1. Abbreviations in the RBC three-dimensional cephalometric analysis.

Abbreviation	Meaning
Rt	Right
Lt	Left
R	Ramus
B	Body
C	Chin
H	Height
W	Width
L	Length
*	Point
->	Shift
Dev	Deviated side, same side as menton deviation
Con	Contralateral side, opposite side to menton deviation
Δ	Difference, by subtracting linear measurements on the deviated side from the contralateral side