ISSN 2706-6819 Vol.5, Issue 2: 42-47, DOI: 10.25236/IJFM.2023.050208

Research progress on asymmetry of mandibular ramus and condyle of different skeletal patterns

Xiaoyu Shi, Wanyu Zhu, Jing Nie*

Department of Orthodontics, the First Affiliated Hospital of Xinjiang Medical University (Affiliated Stomatological Hospital), Urumqi, Xinjiang, 830054, China
**Corresponding author: dentistnj@163.com*

Abstract: *Asymmetry of the face and dental arch is a natural phenomenon. Symmetry can be defined as an equal or corresponding distribution at two extremes, poles or on both sides of the body, in the form of a distribution around a center or an axis. Previous studies have shown that different skeletal patterns have a significant effect on mandibular condyle morphology, and that the jaws are asymmetrical in function and movement, indicating that the left and right sides of the mandible develop differently. Therefore, Symmetry assessment is important in aesthetic assessment of any craniofacial region as well as in assessment of malocclusion.*

Keywords: *Skeletal patterns; mandibular ramus; condyle; asymmetry*

Facial symmetry refers to the balance state corresponding to the size, shape, and arrangement of facial tissues and structures on both sides of the midsagittal plane. The left and right sides of the craniofacial complex containing the same structure need to grow and develop in a similar manner to achieve symmetry. Craniofacial growth does not have absolute transverse uniformity and even faces considered satisfactory may have some asymmetry [1]. Wang Xing [2] et al. concluded that the horizontal asymmetry rate between the two sides of the midsagittal plane of the face should be less than 2% in a beautiful population, and Farkas [3] et al. concluded that abnormal asymmetry should be considered when the mean difference between the left and right sides exceeds 3 mm or 3%. Some scholars [4] believe that subjective visual differences only occur when asymmetry on both sides of the face develops to a certain extent. According to the classification proposed by Wolford, normal facial asymmetry (non-pathological) may be due to genetic defects, differences in growth models and natural growth, and environmental factors [5]. The rate of asymmetry gradually increases from top to bottom in all parts of the face, especially in the lower jaw [6]. The mandible is the only movable bone in the craniofacial skeleton and is the main body that performs the function and plays an important role in determining the shape and symmetry of the face. Adaptive responses of the mandible to deviations during functioning, which may have implications for modeling of the condyle and glenoid fossa as well as remodeling and modeling of the mandible. This may result in dimensional differences in the size or shape of the left and right sides of the jaw, i. e. jaw asymmetry [7]. The condyle plays an important role as the growth center of the mandible, occlusal imbalance leads to abnormal stress distribution on the condylar joint surface, and mandibular asymmetry may lead to internal disturbances and functional impairment of the temporomandibular joint [8]. There is much less mention of the asymmetries that may occur normally in the mandible than the pathological reactions that arise from mandibular asymmetries.

1. Progress in facial symmetry research

For orthodontists, it is essential to identify the impact of asymmetric dental arches and bones on maxillofacial function and etiology in order to make a correct diagnosis and make a treatment plan. However, some degree of asymmetry in craniofacial bone, muscle, and soft tissue structures in humans is acceptable from a clinical point of view. Cho [9] et al investigated craniofacial asymmetry in 533 children aged 0 to 18 years without craniomaxillofacial developmental malformations and found head asymmetry of 1.5 plus and minus 0.5 mm (range, 0.46 to 4.78 mm) and facial asymmetry of 1.2 plus and minus 0.6 mm (range, 0.4 to 5.4 mm), 99.7% of healthy children, with head asymmetry less than 3.6.mm, facial asymmetry less than 3.2 mm. Therefore, they concluded that craniofacial asymmetry within this numerical range is “normal asymmetry”. Kim [10] et al concluded that facial asymmetry was manifested when the horizontal distance between the mandibular midpoint of soft tissue and the midline was more than 2 mm or between the mandibular midpoint of hard tissue and the midline was

ISSN 2706-6819 Vol.5, Issue 2: 42-47, DOI: 10.25236/IJFM.2023.050208

more than 2 mm, and for the first time, facial asymmetry was classified as TML according to the deviation of the submental point (horizontal distance between the submental point-midline more than 2 mm), transverse asymmetry of soft tissue (T, The horizontal distance from the point of the soft tissue mandibular angle to the midline is greater than 2 mm), maxillary inclination (M, the vertical distance between the point of bilateral molar to the point of lateral orbital wall and the septal bone is greater than 2 mm), lip inclination (L, through the line between the bilateral labial angle junction points that is, the difference between the labial plane and the vertical distance between the left and right pupillary centers is greater than 2 mm). Many scholars believe that when bone tissue deviates is Greater than or equal to 2 mm from the midline and/or soft tissue deviates is greater than 2 mm from the midline, it shows detectable significant facial asymmetry [11].

In the past, due to the lack of objective measurement, surgeons could only design the amount of surgical changes through personal experience and estimate the surgical outcome, which may lead to differences between the surgical outcome and patient expectations [12]. Therefore, careful and accurate preoperative characterization and quantitative analysis of the contour morphology of the face, comparison of bilateral facial asymmetry, and reliable prediction of facial changes are very important for preoperative surgical design of intraoperative surgical guidance as well as postoperative surgical effect evaluation, which can maximize the compliance with the patient's expectations. In order to compare facial asymmetry, a series of reliable, accurate and reproducible landmarks [13] need to be set, and the degree of facial asymmetry needs to be analyzed by measuring the distance from each landmark point to the midsagittal plane (MSP), so the selection of MSP is essential [14 – 16].

2. Research progress on mandibular symmetry

Good mandibular symmetry is a prerequisite for normal functioning of the stomatognathic system and a measure of coordinated aesthetic facies in patients undergoing orthodontic treatment. In the normal population, differences in bilateral mandibles may also be found by actual measurements. The diagnosis of mandibular asymmetry is mainly determined by the location of the central point of the mandible, such as Pogonion (Pog), Gnathion (Gn) and Menton (Me). Traditionally, the distance from these central landmarks to the facial MSP has been calculated to quantify and classify mandibular asymmetry, mild asymmetry (less than 2 mm), moderate asymmetry (range 2 to 4 mm), and severe asymmetry (more than 4 mm) [17–19]. Using cone beam computed tomography (CBCT) [20] or posteroanterior cephalography (PA cephalography). In 1988, Habets et al [21] introduced an asymmetry index and analyzed the vertical asymmetry of the mandible using digital orthopantomograms, and mandibular ramus and/or condylar height asymmetry index values of more than 3% were considered to have vertical asymmetry. This method has been well applied in three-dimensional examinations such as CBCT.

3. Relationship between different skeletal patterns and asymmetry of mandible

3.1 Relationship between sagittal skeletal pattern and mandibular asymmetry

Clinical studies of mandibular asymmetry in orthodontic and orthognathic surgical patients have found the prevalence of mandibular asymmetry to be 12% to 37% in different populations and in different sagittal skeletal pattern. Some scholars have shown [17-19] that the prevalence of mandibular asymmetry is higher in Class III malocclusion patients than in Class II or I. Then mandibular overgrowth in class III patients may be a risk factor for unbalanced development on both sides of the mandible. Sezgin et al [22] assessed mandibular asymmetry in young adults under different sagittal skeletal pattern and concluded that skeletal Class II division 1 and Class III malocclusion had a significant impact on the condylar asymmetry index (CAI) compared to other occlusal types. Kasimoglu et al [23] investigated the relationship between vertical asymmetry of the mandibular condyle and sagittal skeletal pattern in adolescent patients and found no significant differences in condylar asymmetry values among Class I, II, and III malocclusion. Sievers et al [24] assessed possible differences in mandibular asymmetry between patients with skeletal Class I and II relationships and concluded that although mandibular growth was inconsistent, skeletal Class II mandibular asymmetry did not occur at a higher rate than skeletal Class I. All groups studied by Monje F [25] et al. had higher condylar asymmetry index (CAI) values than the 3% threshold of Habets et al. In addition, patients with skeletal Class II division 1 and Class I malocclusion had significantly higher CAI values compared to the Class III group. Compared with Class I malocclusion, Class II Class I malocclusion showed significantly higher CAI values. Therefore, these two types of malocclusion may become a predisposing factor for condylar asymmetry if left untreated.

3.2 Relationship between vertical skeletal pattern and mandibular asymmetry

Facial features with differences in ramus height and mandibular plane angle in individuals with different vertical facial patterns, mandibular condyle morphology and position can be significantly affected by mandibular retrorotation [26, 27]. Riddle PC [26] et al investigated the relationship between the size, position, shape, ramus height, and vertical bone pattern of the mandible and concluded that individuals with high angles had lower ramus height than those with mean and low angles. Mendoza LV [28] et al found that in addition to the vertical facial pattern, gender and sagittal relationship of maxilla and mandible may also influence ramus height, condylar morphology and mandibular asymmetry. Saccucci [29] et al found that patients with low angles had larger condylar surface area and volume, patients with low angles had thicker condyles, while patients with high angles had smaller condyles. Alhammadi MS [30] concluded that the condyle was found more laterally in high-angle patients relative to the glenoid fossa. Monje F [31] notes, based on evidence from experimental animal models, that during craniofacial development, the medial and lateral pterygoid muscles determine an advantageous effect in terms of reduced movement of the medial ramus and therefore reduced intercondylar distance. To further investigate the causes of the effects of different skeletal pattern on mandibular asymmetry, Chen Jie et al. [32] found that the medial joint space was larger in low-angle patients with various sagittal skeletal patterns, the masticatory muscle strength was greater in low-angle patients, the stress on the medial pole of the condyle was greater, and stimulation of the medial wall of the glenoid fossa resulted in a larger intra-articular space; and the condyle was larger and the glenoid fossa was narrower in low-angle patients which indicate that the condyle was located laterally to the glenoid fossa in low-angle patients. The glenoid fossa was shallower and the posterior slope angle of the articular tubercle was smaller in the high-angle group, while the opposite was true in the low-angle group. Li Chen et al [33] concluded that patients with high angles need to open less occlusion when opening, so the posterior slope angle of the articular tubercle is small, and patients with high angles have weak masticatory muscle strength, making the glenoid fossa develop shallowly, and flat articular tubercle and shallow glenoid fossa make the condyle more likely to grow forward, so that the mandible rotates clockwise and the mandibular plane angle increases. Li Fang, Ye Yanyan and other scholars [34, 35] studied that the growth pattern of condyles with short surface morphology was mainly vertical growth, which contributed greatly to the growth of the ascending ramus and made the mandible turn counterclockwise, that is, the anterior mandible turned anteriorly and superiorly, which was more likely to form a low-angle vertical skeletal facial type and sagittal skeletal facial type Class III; while the growth pattern of the slender condyle was mainly sagittal growth, although the overall condyle was longer, it contributed less to the growth of the ascending ramus, and such a growth pattern made the mandible rotate clockwise, that is, the anterior mandible turned posteriorly and inferiorly, which was more likely to form a high-angle vertical skeletal facial type and sagittal skeletal facial type Class II.

4. Significance of Mandibular Asymmetry research

Although controversial, linear and volumetric mandibular asymmetry seems to be more prevalent in males. However, this condition seems to be closely related to the sagittal skeletal facial type, and asymmetric growth of the mandible may increase the risk of facial asymmetry [36]. Although questionable, asymmetry of specific components of the mandible such as mandibular ramus height may only serve as morphological predictors of risk and no causal relationship can be established [37]. From a clinical point of view, mandibular ramus height and condylar features are both common causes of facial asymmetry and may be associated with the vertical facial type [38]. For example, it has been suggested that individuals with high angles have lower mandibular ramus heights, however, data on the prevalence of Mandibular ramus height asymmetry differ between facial types and asymmetry may not differ significantly between the left and right sides. The condyle plays an important role as the growth center of the mandible, and abnormal stress distribution on the articular surface due to occlusal imbalance may lead to internal disturbances and functional impairment of the temporomandibular joint (TMJ) in patients with mandibular asymmetry. There are far fewer references to normal asymmetry that may arise in the TMJ than to other asymmetries in the craniomandibular region, however, differences in vertical skeletal facial type can affect the position of the condyle and may affect the positional asymmetry between the condyle and midsagittal plane. To date, no studies have assessed the impact of intercondylar distance on the severity of facial asymmetry [40].

Morphometric aspects such as mandibular ramus and intercondylar distance may be associated with mandibular asymmetry and may be considered as etiological or predisposing factors for the development of temporomandibular disorders syndrome [41]. Therefore, determining morphological differences between different mandibular components can help understand whether morphometric differences such as the mandibular ramus and condyle may be related to mandibular asymmetry and can be regarded as etiological or predisposing factors for the development of temporomandibular disorders syndrome. Thus, identification of morphological differences in different skeletal facial types could help to understand the etiology and associated pathology of asymmetry in the lower third of the face. It has some clinical implications that establish an asymmetric clinical pattern that is considered normal.

5. Conclusion

Mandibular symmetry is one of the important reference criteria for assessing facial aesthetics. Different skeletal facial types have an effect on the morphological development of the mandible, and asymmetry in the function and movement of the mandible is an indication of different development of the left and right sides of the mandible. Evaluating the differences in mandibular morphology between different osteofacial types allows for an understanding of the etiology and associated pathology of the lower third of facial asymmetry.

References

[1] Bishara S E, Burkey PS, Kharouf JG. Dental and facial asymmetries: a review [J]. Angle Orthodontist.1994, 64 (2): 89-98.

[2] Wang Xing, Zhang Zhenkang, Gao Kernan, Song Hui. Anteroposterior cephalometric study of Chinese beauty population [J]. Stomatological Horizontal and Horizontal, 1988 (4): 195-200.

[3] Farkas LG, Cheung G. Facial asymmetry in healthy North American Caucasians. An anthropometrical study [J]. Angle Orthodontist.1981, 51 (1): 70-74.

[4] Donaldson A, Mcdonald F, Coboume MT. Assessing the influence of Assessing the influence of asymtneftry affecting he mandible and chin point on perceived attractiveness in the orthognathic patient, clinician, and layperson [J]. Oral Maxillofac Surg. 2012, 70 (1): 192-206.

[5] Wolford LM. Facial asymmetry: diagnosis and treatment considerations [M].2nd edn.Turvey TA (ed) Oral and maxillofacial surgery.2009:272-315.

[6] Primozic J, Perinetti G, Richmond S, Ovsenik M. Three-dimensional evaluation of facialasymmetry in association with unilateral functional crossbite in the primary, early, and late mixed dentition [J]. Angle Orthodontist. 2013, 83 (2): 253-256.

[7] Wang MF, Otsuka T, Akimoto S, Sato S. Vertical facial height and its correlation with facial width and depth: threeimensional cone computed tomography evaluation based on dry beam skulls [J]. Int J Stomatol Occlusion Med. 2013, 6:120-129.

[8] Zhao C, Kurita H, Kurashina K, Hosoya A, Arai Y, NakamuraH. Temporomandi -detected joint response to mandibular deviation in rabbits detected by 3D micro-CT imaging [J]. Arch Oral Biol.2010, 55 (12): 929 – 937.

[9] Cho MJ, Hallac RR, Ramesh J, et al. quantifying normalofacial form and baseline craniofacial metryin the pediatric population [J]. Plast Recasymfacial Surg, 2018, 141 (3): 380e-387e.

[10] Kim JY, Jung HD, Jung YS, et al. A simple classification offacial asymmetry by TML system [J].J Craniomaxillofac Surg, 2014, 42 (4): 313-320.

[11] Thiesen G, Kim KB.Criteria for determining facial asymmetries [J]. Am J Orthod Dentofacial Orthop, 2016, 150 (6): 910.

[12] ZengH, Yuan-Liang S, Xie G, et al. Three-dimensional offacial contour based on preoperative computer simulation and its clinical application [J]. Medicine (Baltimore), 2019, 98 (2): e12919.

[13] MaasB, Pluijmers BI, Knoops PGM, et al. Using principal component analysis to describe the midfacial deformities in patients with craniofacial microsomia [J]. JCraniomaxilloSurg, 2018, 46 (12): 2032-2041.

[14] Schreiber JE, Stern CS, Garfein ES, et al. A novel approach to surgical markings based on a topographic map and a projected three-dimensional image [J]. Plast Recon -str Surg, 2016, 137 (5): 855e-859e.

[15] An S, Lee JY, Chung CJ, et al. Comparison of different sagittal midplane configurations evaluating craniofacial asymmetry by preference expert [J].Am J Orthod Dentofacial Orthop, 2017, 152 (6): 788-797.

[16] Shin SM, Kim YM, Kim NR, et al. Statistical shape based analysis of optimal midsagittal reference

ISSN 2706-6819 Vol.5, Issue 2: 42-47, DOI: 10.25236/IJFM.2023.050208

plane for evaluation of facial asymmetry [J].Am JOrthod Dentofacial Orthop, 2016, 150 (2): 252-260.

[17] Thiesen G, Gribel BF, Kim KB, Pereira KCR, Freitas MPM. Prevalence and associated factors of mandibular asymmetry in an adult population [J]. J Craniofac Surg. 2017; 28: e199- e203.

[18] Masuoka N, Momoi Y, Ariji Y, et al Can cephalometric indices and subjective evaluation be consistent for facial asymmetry? [J]. Angle Orthod. 2005; 75:651-655.

[19] Good S, Edler R, Wertheim D, Greenhill D. A computerized photographic assessment of the relationship between skeletal asymmetry and mandibular outline [J].Eur J Orthod. 2006; 28:97-102.

[20] Yousefi F, Rafiei E, Mahdian M, Mollabashi V, Saboonchi SS, Hosseini SM. Comparison efficiency of posteroanterior cephalometry and cone-beam computed tomography in detecting systematic craniofacial asymmetry: a review [J].Contemp Clin Dent. 2019; 10:358 – 371.

[21] Habets L, Bezuur J, Naeiji M, Hansson T. The orthopantomogram, an aid in diagnosis of temporomandibular joint problems. II The symmetry [J]. J Oral Rehabil. 1998 (15): 465 – 71.

[22] Sezgin OS, Celenk P, Arici S. Mandibular occlusion in different asymmetry patterns [J]. Angle Orthod.2007 (77): 803-7.

[23] Kasimoglu Y, Tuna EB, Rahimi B, Marsan G, Gencay K. Condylar asymmetry in different occlusion types [J]. Cranio 2015; 33:10-4.

[24] Sievers MM, Larson BE, Gaillard PR, Wey A. Asymmetry assessment using cone beam CT. A Class I and Class II patient comparison. Angle Orthod 2012; 82:410-7.

[25] Al Taki A, Ahmed M H, Ghani H A, et al. Impact of different maltypes on the mandibular vertical asymmetry in young adult samples [J]. European journal of dentistry, 2015, 9 (03): 373-377.

[26] Riddle PC, Nickel JC, Liu Y, Gonzalez YM, Gallo LM, et al. Mechanobehavior and mandibular ramus length in different facial phenotypes [J].Angle Ortho - d.2020; 90:86 6 – 72.

[27] Monje F, Delgado E, Navarro MJ, Miralles C, Jose R, del Hoyo A. Changes in the temporomandibular joint caused by the vertical facial pattern. Study on an experimen - tal model [J].Cranio-Maxillofacial Surg.1994; 22 (6): 361 – 70.

[28] Qu G L , Xu J , Zhou Q . Evaluation of the Spatial Position and Correlation of Mandibular Ramus in Skeletal Class III Patients With Mandibular Asymmetry[J]. Journal of Craniofacial Surgery, 2019, 30.

[29] Mendoza LV, Bellot-Arcís C, Montiel-Company JM, García-Sanz V, Almerich- Silla JM, Paredes-Gallardo V. Linear and volumetric mandibular metries in adult patients with different skeletal beam classes and vertical tomography: a cone-computed tomography study [J]. Sci Rep. 2018, 17 (8): 12319.

[30] Saccucci M, Polimeni A, Festa F, et al. Do cephalometric characteristics associated with condylar skeletal volume, surface and shape? A analysis [J].3D Head Face Med. 2012, 8:15.

[31] Alhammadi MS, Fayed MMS, Labib A. Comprehensive cone beam computed tomography analysis of the temporomandibular joint in different vertical skeletal facial patterns [J]. J World Fed Orthod. 2016, 5 (1): 9-17.

[32] Monje F, Delgado E, Navarro MJ, Miralles C, Alonso del Hoyo JR. Changes in the temporomandibular joint caused by the vertical facial pattern. Study on an experimental model [J]. J Craniomaxillofac Surg. 1994, 22 (6): 361-370.

[33] Chen Jie, Duan Yufeng, Tu Jingqiu, et al. Comparison of three-dimensional morphologic structure of temporomandibular joint in patients with different vertical facial skeletal types of skeletal Class III [J]. Journal of Central South University (Medical Edition), 2018, 43 (6): 625-630.

[34] Li Chen, Li Yonggang, Feng Xue. Three-dimensional study of the bony structure of the temporomandibular joint in adult women with skeletal class II high angle [J]. Journal of Practical Stomatology, 2016, 32 (2): 239-243.

[35] Li Fang, Wang Jianguo. Cone beam computed tomography study of the morphological characteristics of the temporomandibular joint in Angle Class I adult patients with different vertical facial patterns [J]. International Journal of Stomatology, 2015, 42 (5): 538-541.

[36] Ye Yanyan. Discriminant analysis of craniomaxillofacial features and surgical indications in adult patients with skeletal Class II [D]. Fourth Military Medical University, 2013.

[37] Good S, Edler R, Wertheim D, Greenhill DA.computerized photographic assessment of the relationship between skeletal asymmetry and mandibular outline [J]. Eur J Orthod.2006, 28 (2): 97 – 102.

[38] Leung MY, Leung YY.Three-dimensional evaluation of mandibular asymmetry: a new classification and threedimensional cephalometric analysis [J]. Int J Oral Maxillofac Surg.2018, 47 (8): 1043 – 1051.

[39] Wang MF, Otsuka T, Akimoto S, Sato S.Vertical facial height and its correlation with facial width and depth: threedimensional cone beam computed tomography evaluation based on dry skulls [J]. Int J Stomatol Occlusion Med.2013, 6:120 – 129.

[40] Lim YS, Chung DH, Lee JW, Lee SM. Reliability and validity of posterior mandibular asymmetry

ISSN 2706-6819 Vol.5, Issue 2: 42-47, DOI: 10.25236/IJFM.2023.050208

index in panoramic radiography compared with cone-beam computed tomography [J]. Am J Orthod Dentofacial Orthop.2018, 153 (4): 558 – 567.

[41] D'Ippolito S, Ursini R, Giuliante L, Deli R. Correlations between mandibular asymmetries and temporomandibular disorders (TMD) [J]. Int Orthod.2014, 12 (2): 222 – 238.