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Description of length, height, and mandibular gonial angle of Kennedy classification class I, II, III, and IV patients

(Reviewed using panoramic radiograph at Ulin Regional Hospital and Gusti Hasan Aman Oral and Dental Hospital Banjarmasin)

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ABSTRACT

Objectives: This study aimed to describe the length, height, and mandibular gonial angle of Kennedy classification class I, II, III, and IV patients using panoramic radiographs at Ulin Regional Hospital and GHA Oral and Dental Hospital Banjarmasin.

Materials and Methods: This study was descriptive with a cross-sectional design. Sampling used the purposive sampling technique. The research sample was an archive of digital panoramic radiographs of Ulin Regional Hospital and GHA Oral and Dental Hospital Banjarmasin patients aged 30-70 with Kennedy classification, recorded in the Radiology Installation from January 2018 to January 2024.

Results: The results from 108 samples of Kennedy classification patients showed that the smallest length of the mandible on the left and right sides is in class I Kennedy. The measurement of mandibular height at points II-R is the smallest in class IV, and the smallest at III-L is in class II. At point II-R, the smallest mean is in class IV, and the smallest at II-L is in class I. The largest measurement of the gonial angle on the left and right sides is in class IV.

Conclusion: The mandibular length most likely to cause the temporomandibular disorder is Kennedy class I on the left side in 18 samples (17%). The height and gonial angle of the mandible that most likely causes temporomandibular disorder are on the right side for height and the left side for gonial angle in Kennedy class IV as many as 18 samples (17%).

Keywords: *Mandibular length, mandibular height, gonial angle, Kennedy classification, panoramic radiography*
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INTRODUCTION

Edentulous is the partial or complete loss of teeth in the jaw arch, which can be used as an indicator of the oral health of a population.[1] According to Riset Kesehatan Dasar (RISKESDAS), in 2018, partial tooth loss in Indonesia occurred at 19% of the total population, while partial tooth loss in South Kalimantan province was 17.84%.[2] Edentulous usually occurs due to tooth decay, periodontitis, or trauma that causes tooth loss.[3] Missing teeth can reduce the vertical dimension of the occlusion, cause unbalanced occlusion, and affect neuromuscular adaptation, as well as increase the likelihood of TMD (Temporomandibular Disorder).[4]

If the edentulous area is not replaced with a denture, over time it will experience resorption of the alveolar bone resulting in a decrease in the crest of the alveolar bone.[5] The research results of Nguyen et al., (2018) confirmed that edentulous subjects had substantial changes in the morphology of craniofacial structures, especially in the mandible.[4] The mandible is the largest and strongest bone in the human skull, which is a place to attach the teeth.[6] The alterations in the relationship between the structure and function of the mandible can be caused by the loss of many teeth in sufferers.[7] The alterations in the mandibular bone after tooth loss can lead to residual ridge resorption.[8]

Craniofacial structural changes were significantly associated with signs of TMD. The more zones of occlusal support are lost, the more significant the changes in craniofacial structure.[4] According to Nguyen et al., (2018), patients who experience TMJ pain have a shorter total mandibular length, which can be explained by the fact that TMJ pain can cause ankylosis and inhibit clockwise movement of the mandible. The study of Ahn et al. strengthens this finding, and Matsumoto et al., who wrote that TMD patients had relatively

shorter mandibles and progressive mandibular retrusion.[4] Okşayan et al., (2014) found significant differences in mandibular morphology in the toothed and toothless groups.[8,9] According to Basheer et al., (2019), the average Gonial Angle value was significantly higher in the group with partial edentulous than those with complete edentulous.[10]

Changes in mandibular morphology can be evaluated using panoramic radiographs.[11] Panoramic radiography is an extraoral radiography technique commonly used in dentistry as a supporting examination. This radiograph allows visualization of all the teeth, maxilla and mandible, temporomandibular joint, and other anatomical structures ~~are~~ shown in one film on a panoramic x-ray.[11] This advantage makes this radiograph often used for partially or completely edentulous patients.[10]

Kennedy classified partially edentulous areas into four classes of edentulous conditions, namely class I Kennedy Bilateral Posterior Edentulous Area (free end), class II Kennedy Unilateral Posterior Edentulous Area (free end), class III Kennedy Unilateral or Bilateral Edentulous (bounded), and class IV Kennedy Single Edentulous Area Anterior.[12,13] Kennedy's classification is widely used because it clearly and quickly shows the types of edentulous states, is simple, easy to communicate, logical, and is known worldwide.[13] The grouping is easy to interpret.[14]

Indications for digital imaging measurements (dental imaging software) can be carried out for screening or detection, classification and quantification of signs of disease on radiographs. Measurement of the mandible is one step in diagnosing TMD.[15,16] Mandible measurements are rarely researched in Indonesia, especially in South Kalimantan. This research can also be a reference for further research, so researchers are interested in researching the description of the length, height and gonial angle of the mandible in patients classified as Kennedy class I, II, III, and IV were reviewed using panoramic radiographs at Ulin Hospital and Gusti Hasan Aman Hospital Banjarmasin.

MATERIALS AND METHODS

This type of research is descriptive with a cross-sectional design. Sampling used purposive sampling technique. This research has received ethical approval from the ULM Banjarmasin Faculty of Dentistry Health Research Ethics Committee with No. 145/KEPKG-FKGULM/EC/XI/2023. The research sample is an archive of digital panoramic radiographs of patients at Ulin Hospital and Gusti Hasan Aman Hospital Banjarmasin with the Kennedy classification, which have been recorded in the Radiology Installation for January 2018 – January 2024. The following are the inclusion criteria in this study: partially edentulous panoramic radiograph of the upper and lower jaw with Kennedy classification class I, II, III, IV period January 2018–January 2024 with good quality evaluation, panoramic radiographs with patients aged 30-70 years, complete patient data in the form of name and age, anatomical landmarks such as the inferior and posterior borders of the mandible, as well as the condyle area are visible. Here are the exclusion criteria in this study: panoramic

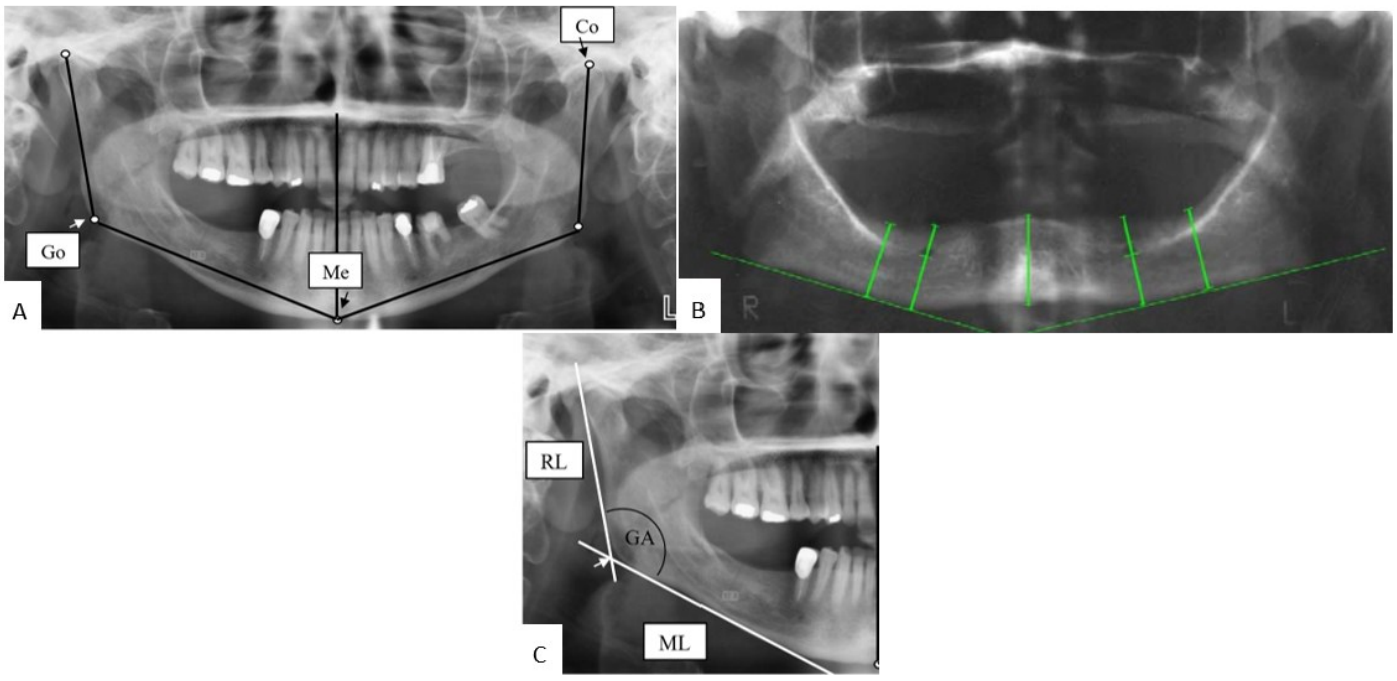

Figure 1. A) Measurement of mandibular length;[17] B) Measurement of mandibular height;[18] C) Measurement of the mandibular gonial angle.[11]

radiograph in the presence of a fracture of the lower jaw, panoramic radiograph in the presence of diseases affecting the mandible such as odontogenic cysts, odontogenic and non-odontogenic tumors, osteomyelitis, ankylosis/ hypoplasia/hyperplasia of the temporomandibular joint.

The sample size required in this study to anticipate dropout is 108 panoramic radiographs. The length, height, and gonial angle of the mandible were measured using ImageJ Software using the following measurements. Mandibular length is measured from the mandibular ramus height from the condyle point to the gonion point (Co-Go), and mandibular width is measured from the gonion point to the menton point (Go-Me).[17] The height of the mandible starting from the midline is determined by imaging the anterior nasal spine of the nasal septum and nasopalatine foramen. In the mandible, a line is drawn tangent to the most inferior point at the mandible's angle and the mandible's lower border. Measurements I (Midline), II (mental foramen/premolar area), III (molar area).[18] Gonial angle, the angle formed by the meeting of the mandibular line with the most inferior point at the gonial angle and the lower border of the body of the mandible and the meeting of the ramus line with the posterior border of the ramus and condyle.[19]

The data analysis used in this research is descriptive statistical analysis to describe variables in tabular form and then calculated using Microsoft Excel to determine the mean value and standard deviation of the measurement results.

RESULTS

The length, height, and gonial angle of the mandible on panoramic radiographs in this study were measured using ImageJ software, and the following results were obtained. The analysis results from table 1 show the highest average value of mandibular length in the Kennedy class III

Table 1. Average Value of Mandibular Length in the Kennedy Classification

Kennedy Classification		n	Mandible Length (mm)		Total
			Left side	Right side	
Upper Jaw Class	Lower Jaw Class		Mean ± SD	Mean ± SD	
I	I	9	152.36 ± 12.56	154.47 ± 10.15	146.77 ± 9.66
	II	9	144.37 ± 9.28	140.44 ± 9.07	
	III	9	141.35 ± 6.31	147.60 ± 10.56	
	IV	0	0	0	
Total		**27**	**146.03 ± 9.38**	**147.50 ± 9.93**	
II	I	9	150.76 ± 8.85	152.94 ± 12.37	151.31 ± 11.70
	II	9	153.44 ± 7.44	154.02 ± 10.78	
	III	9	148.50 ± 15.07	148.19 ± 15.68	
	IV	0	0	0	
Total		**27**	**150.90 ± 10.45**	**151 ± 12.94**	
III	I	9	146.90 ± 7.84	148.89 ± 9.07	154.54 ± 10.00
	II	9	156.44 ± 11.50	157.66 ± 14.27	
	III	9	157.06 ± 8.41	160.31 ± 8.90	
	IV	0	0	0	
Total		**27**	**152.47 ± 9.25**	**155.62 ± 10.75**	
IV	I	9	151.01 ± 12.74	147.54 ± 10.00	148.65 ± 14.43
	II	9	145.86 ± 9.92	145.27 ± 10.434	
	III	9	151.83 ± 21.22	150.41 ± 21.70	
	IV	0	0	0	
Total		**27**	**149.57 ± 14.63**	**147.74 ± 14.04**	

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Table 2. Average Value of Mandibular Height in the Kennedy Classification

Kennedy Classification		n	Mandible Height (mm)					Total
			III-R	II-R	I	II-L	III-L	
Upper Jaw	Lower Jaw		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Class	Class							
I	I	9	26.35 ± 4.62	31.76 ± 4.66	30.03 ± 3.67	30.58 ± 5.72	26.40 ± 5.39	28.65 ± 3.65
	II	9	24.20 ± 2.57	30.04 ± 3.23	29.82 ± 3.38	29.65 ± 3.1	25.92 ± 3.68	
	III	9	27.06 ± 3.70	31.23 ± 2.99	30.46 ± 3.09	30.34 ± 2.80	25.86 ± 2.19	
	IV	0	0	0	0	0	0	
Total		**27**	**25.87 ± 3.63**	**31.01 ± 3.63**	**30.10 ± 3.38**	**30.19 ± 3.87**	**26.06 ± 3.75**	
II	I	9	26.35 ± 1.67	31.43 ± 2.61	32.21 ± 3.67	30.71 ± 1.99	25.49 ± 2.41	29.41 ± 3.22
	II	9	26.98 ± 3.95	31.46 ± 2.82	31.53 ± 3.07	30.39 ± 3.20	26.21 ± 3.21	
	III	9	26.54 ± 4.25	31.36 ± 3.48	32.62 ± 3.65	31.38 ± 4.57	26.45 ± 3.73	
	IV	0	0	0	0	0	0	
Total		**27**	**26.62 ± 3.29**	**31.42 ± 2.97**	**32.12 ± 3.46**	**30.83 ± 3.25**	**26.05 ± 3.12**	
III	I	9	25.60 ± 1.86	31.35 ± 4.20	31.26 ± 3.42	32.04 ± 3.30	26.30 ± 1.88	30.61 ± 2.81
	II	9	27.63 ± 4.11	32.93 ± 3.3	33.12 ± 3.14	33.23 ± 3.68	27.86 ± 3.17	
	III	9	29.13 ± 3.20	33.86 ± 4.46	32.85 ± 3.72	33.47 ± 3.80	28.52 ± 3.26	
	IV	0	0	0	0	0	0	
Total		**27**	**27.45 ± 3.06**	**31.71 ± 3.99**	**32.41 ± 3.43**	**32.91 ± 3.59**	**27.56 ± 2.77**	
IV	I	9	25.00 ± 4.83	25.00 ± 4.83	31.42 ± 4.93	31.26 ± 4.40	25.41 ± 4.67	28.26 ± 4.88
	II	9	23.95 ± 2.55	30.75 ± 2.86	30.96 ± 3.19	30.46 ± 4.57	24.23 ± 3.14	
	III	9	24.88 ± 6.70	32.12 ± 6.26	31.44 ± 5.52	31.17 ± 7.67	25.84 ± 7.06	
	IV	0	0	0	0	0	0	
Total		**27**	**24.61 ± 4.69**	**29.29 ± 4.65**	**31.27 ± 4.55**	**30.96 ± 5.55**	**25.16 ± 4.96**	

classification of 154.54 ± 10.00, while the lowest average value is class I of 146.77 ± 9.66. The largest mean value on the left side of the mandibular length is in class III, namely 152.47 ± 9.25, and the smallest value is in class I, 146.03 ± 9.38. The largest mean on the right side is class III, with a value of 155.62 ± 10.75, and the smallest is class I, 147.50 ± 9.93.

Table 2 shows that the Kennedy class III classification has the largest mean value for mandibular height, 30.61 ± 2.81, while the smallest mean is in class IV, 28.26 ± 4.88. The average height at point III-R (right side molar) was greatest in class III, namely 27.45 ± 3.06, while the smallest value was in class IV with a value of 24.61 ± 4.69, and the largest at III-L (left side molar) was at class III is 27.56 ± 2.77 while the smallest is class II with a value of 26.05 ± 3.12. At point II-R (right side premolar), the largest mean was 31.71 ± 3.99 in class III, while the smallest value was 29.29 ± 4.65 in class IV, and the largest at II-L (left side premolar) was 32.91 ± 3.59 in class III while the smallest value is 30.19 ± 3.87 in class I. The point I (midline), the largest mean is class III, with a value of 32.41 ± 3.43, while the smallest value is 30.10 ± 3.38 in class I.

Table 3 shows that the Kennedy class IV classification has the largest mean, 126.11 ± 5.36, and the smallest mean in class II, 123.12 ± 8.29. The largest mean on the left side was in class IV, 125.96 ± 5.11, and the smallest was in class II, with a value of 123.60 ± 8.30. The largest value on the right side is class IV, 126.26 ± 5.62, while the smallest is class III, 122.40 ± 6.95.

DISCUSSION

The results of measuring mandibular length in Kennedy classification patients show that the largest average value on the left and right sides is in class III, and the smallest is in class I. Changes in the

Table 3. Average value of Mandibular Gonial Angle in the Kennedy Classification

Kennedy Classification		n	Mandibular Gonial Angle (°)		Total
			Left side	Right side	
Upper Jaw Class	Lower Jaw Class		Mean ± SD	Mean ± SD	
I	I	9	122.73 ± 8.13	120.34 ± 5.95	124.32 ± 6.99
	II	9	124.04 ± 3.87	125.53 ± 7.31	
	III	9	125.14 ± 8.31	128.15 ± 8.38	
	IV	0	0	0	
Total		**27**	**123.97 ± 6.77**	**124.67 ± 7.21**	
II	I	9	126.77 ± 7.62	124.56 ± 8.10	123.12 ± 8.29
	II	9	119.56 ± 9.93	119.89 ± 9.18	
	III	9	124.47 ± 7.36	123.47 ± 7.52	
	IV	0	0	0	
Total		**27**	**123.60 ± 8.30**	**122.64 ± 8.27**	
III	I	9	130.99 ± 8.92	126.84 ± 6.81	123.28 ± 6.86
	II	9	121.07 ± 4.18	120.17 ± 6.22	
	III	9	120.43 ± 7.20	120.19 ± 7.82	
	IV	0	0	0	
Total		**27**	**124.16 ± 6.77**	**122.40 ± 6.95**	
IV	I	9	121.5 ± 4.63	120.73 ± 5.43	126.11 ± 5.36
	II	9	128.96 ± 5.28	128.18 ± 5.28	
	III	9	127.41 ± 5.41	129.87 ± 6.15	
	IV	0	0	0	
Total		**27**	**125.96 ± 5.11**	**126.26 ± 5.62**	

anatomical structure of the mandible can be caused by an imbalance in occlusion originating from edentulous. At the same time, class III is an edentulous area between the natural teeth that are still present in the anterior and posterior parts so that it is still possible for the patient to chew using the remaining posterior teeth so that the distribution of the load received is also relatively balanced. This condition helps maintain the function of the TMJ and reduces the risk of degenerative disorders, such as changes in the function or structure of the jawbone.[12,20]

Class I is a bilateral edentulous area located posterior to the existing natural teeth (free end), where the back teeth are the teeth used for chewing. The possibility of temporomandibular joint disorders increases if there are small changes in the occlusion contact relationship that prevent normal occlusion from being achieved. Functional disorders can occur when there are abnormalities in activities such as abnormalities in position, function of the teeth or masticatory muscles.[21] Changes in the occlusion's stability and the occlusion's vertical dimension will occur in patients, which may affect the shape of the condylar process. The condylar process is part of the anatomical structure of the mandible, which can undergo morphological changes throughout life through functional adaptation, which usually occurs after the age of 30 years.[20]

According to research by Uma et al., (2013), the mandible is significantly shorter in edentulous subjects. Ramus and corpus length were also significantly reduced in edentulous subjects.[22] This statement is based on research by Nawira et al., (2015), who stated that there are differences in the mean values of ramus and condyle heights in toothless and toothed jaws. This difference is caused by the loss of teeth in the jaws, which reduces the mechanical stimulation of occlusion. Lack of mechanical stimulation to the bone can disrupt the balance of bone resorption and bone formation activities. Suppose the mandibular ramus receives less stimulation or load. In that case, the bone resorption process can increase, resulting in thinning of the trabecular bone and a

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decrease in the height of the ramus and condyle bones in the mandible. This decrease can result in a change in muscle position towards the posterior. Changes in muscle morphology due to decreased contraction strength and reduced muscle surface area will cause impaired masticatory muscle function.[7]

A decrease follows a decrease in the height of the mandibular ramus in the height of the mandibular condyle. Reducing the height of the mandibular condyle can increase the frequency of TMD. This condition is caused by disruption of the remodeling process in the mandibular condyles of edentulous patients so that they cannot adapt and support the normal structure and function of the TMJ. This is in line with previous research, which found that patients with temporomandibular joint disorders experienced greater changes in condyle height than healthy patients, and the frequency increased with age.[7]

The average value of mandibular length shows differences between the left and right sides in each class. According to research by Siagian (2016), tooth loss, especially in the posterior part, will cause a decrease in chewing efficiency, resulting in impaired masticatory muscle function so that the patient experiences an asymmetrical face.[23] There is literature reporting that disharmony between the left and right mandible can be caused by unbalanced occlusion and asymmetric masticatory function.[24] Al-Zubair and Agrawal et al., reported that the dimensions of the mandible are considered asymmetric when the difference between the two sides is more than 2-3 mm, while Gribel et al., also reported that the difference between the left and right mandible of 4-5 mm is still considered asymmetry normal facial dimensions.[25–28] According to research by Azhari et al., (2019), a large standard deviation indicates individual variation.[28]

The measurement results show that each region's highest mandibular height value is the same in class III, while the lowest value varies. The molar and premolar area on the right side shows class IV, which has the smallest value, whereas, in this study, several class IV samples were found to have lost teeth from the anterior until only one or two posterior teeth remained so that the risk of alveolar bone resorption was greater which could be the cause of the loss of the vertical dimension of occlusion which can cause changes in the shape of the condylar process.[20] Alveolar bone undergoes resorption when there is inadequate support from the remaining tissue, affecting masticatory function. Forces generated during mastication and excessive occlusal contact can also cause persistent alveolar bone resorption in edentulous patients.[29] Alveolar bone resorption can occur after tooth extraction, and bone remodeling occurs, which results in a decrease in jaw height, especially in the first year after extraction.[30]

Class II is the unilateral loss of some teeth in the posterior region so that masticatory function can be impaired by chewing on one side, and the loss of teeth in the posterior region causes a decrease in height in the left side molar area.[12,22] The premolar area on the left side and the median line obtained the lowest score in class I, where the edentulous area was in the posterior region on both sides of the jaw (bilateral) so the patient used the anterior teeth for chewing.[12] Loss of posterior teeth increases stress on the TMJ due to biting using anterior teeth and changes the vertical dimension and distal position of the mandible.[21]

Differences in the average value of mandibular height on the right and left side can be caused by bad habits and different developmental processes for each patient. These habits include supporting the chin on one side, chewing only on one side, and sleeping on one particular side which can result in excessive pressure on only one side of the joint. Improper chewing patterns can also cause abnormalities in the TMJ structure.[20,21]

The largest average value of the gonial angle on the left and right sides is in class IV, while the smallest on the left is class II and on the right is class III. Uma et al., (2013) found that edentulous subjects had significantly larger gonial angles than dentulous subjects.[22] Since masticatory muscle function decreases with tooth loss in edentulous subjects, the gonial angle becomes wider compared to toothed subjects, as noted in previous studies.[22]

The results of mandibular gonial angle measurements have the largest average in Kennedy class IV on the left and right sides, where anterior tooth loss causes changes in the vertical dimension of occlusion, will result in increased biomechanical stress on the temporomandibular joint and can even cause changes in the shape of the condylar process. The anterior teeth and the anatomical structure of the temporomandibular joint determine mandibular movement, so the loss of anterior teeth will cause changes in mandibular movement patterns.[21] The force of masticatory muscle contraction influences the gonial angle. Masticatory muscle function decreases after partial or complete tooth loss, which can ultimately affect the gonial angle and other morphological features.[11,31] Any change in gonial angle is largely influenced by remodeling of the ramus and condyle because changes in mandibular basal bone morphology are generally associated with decreased masticatory muscle function due to tooth loss.[32] The basic shape of the mandible, especially the gonial angle, correlates with the function and shape of the masticatory muscles.[33]

Remodeling the edentulous mandible has deposited on the tooth surface of the basal bone on the medial and lateral sides of the body. Bone undergoes resorption on the buccal and lingual sides of the overlying alveolar region. The ramus's lateral and posterior half undergo resorption. When the posterior border of the ramus undergoes resorption, the posteroanterior dimension of the ramus becomes reduced. It narrows along with resorption along the anterior border so that the edge of the gonial angle moves anteriorly and superiorly due to the resorptive planes on its posterior and inferior sides.[22]

Nguyen et al., (2018) reported progressive tooth loss resulting in a larger gonial angle and a

smaller mandibular ramus.[4] Progressive tooth loss results in altered functional and structural relationships of the mandible, which include changes in occlusal relationships, rotation of the mandible, realignment and remodeling of the body of the mandible, changes in muscle to bone alignment, changes in location of muscle attachments and morphology of the mandible in response to some or all of the altered functional relationships. Thus increasing the likelihood of temporomandibular joint disorders.[4,22] Miwa et al., (2017) reported that a smaller gonial angle was associated with increased maximum occlusion pressure.[34] The masseter and medial pterygoid muscles, which are inserted near the molars, influence the occlusion force and masticatory pressure. [19,34,35] In patients with small gonial angles, the mandibular plane lies more parallel to the zygomatic arch, allowing occlusal forces to be applied more efficiently.[34] The stronger the muscle pull or occlusion pressure, the smaller the gonial angle.[22]

Differences in the average left and right gonial angles can be triggered by an imbalance in chewing habits, such as chewing dominantly on one side. The habit of chewing on one side can thicken and strengthen the masticatory muscles, resulting in facial asymmetry and affecting jaw growth. This imbalance in chewing habits can be caused by local factors in the oral cavity, one of which is tooth loss.[32] Tiwari et al., (2017) stated that unilateral chewing can potentially have high traumatic effects on the temporomandibular joint.[36]

CONCLUSION

The mandibular length most likely to cause temporomandibular joint disorders is Kennedy class I on the left side in 18 samples (17%). The height and gonial angle of the mandible that most likely causes temporomandibular joint disorders are on the right side for height and the left side for gonial angle in Kennedy class IV as many as 18 samples (17%).

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FOOTNOTES

All authors have no potential conflict of interest to declare for this article. . This research has received ethical approval from the ULM Banjarmasin Faculty of Dentistry Health Research Ethics Committee with No. 145/KEPKG-FKGULM/EC/XI/2023. All procedures conducted were in accordance with the ethical standards.

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