Analysis of the Position and Density of Condyle Head, Gonial Angle, and Ramus Height in Terms of Panoramic Radiographs

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Abstract

Down Syndrome (DS) is a disorder with characteristic abnormalities of muscle hypotonia that might affect TMJ position, growth and development of facial bones and bone density. This can be measured using a panoramic radiograph. This study aimed to determine the differences in the position and density of condyle head, gonial angle and mandible ramus height in terms of panoramic radiographs between DS and normal patients.

It was a comparative analytic study. The population was all panoramic radiographs of DS patients in the Dental Radiology Installation of RSGM UNPAD during March 2016-April 2017. The 21 samples of panoramic radiograph were obtained using purposive sampling method. The measurement method using Image-J software,

The mean position of the right condyle head in DS patiens was 1.4mm (anterior), 2.52mm (superior), 2.44mm (posterior) and the left condyle was 1.45mm (anterior), 2.79mm (superior), 2.75mm (posterior) with $p > 0.05$. The mean density of the right condyle head (10.25%, p-value 0.040) and left (9.47%, p-value 0.004) in DS patients had a smaller mean value than in normals. The right gonial angle (124.49o) and left (123.89o) on DS showed smaller value than in normal group with $p>0.05$. The height of the right ramus (30.82mm, p-value 0.015) and left (30.29mm, p-value 0.002) in DS had an average smaller rate than in normal.

There was no difference in the position of the condyle head in terms of panoramic radiographs between DS and normal patients. There was a difference in the density of the condyle head between DS and normal patients. There was no difference in gonial angle between DS and normal patients. There was a difference in the ramus height of the mandible from the panoramic radiograph between DS and normal patients.

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Introduction

Down Syndrome (DS) was firstly found by John Langdown Down in 1866, a syndrome with multifactorial causes i.e. interaction of genetical and other factors. Genetical disorders caused by chromosomal aberation might result as chromosomal overload on Chromosome-21 which influence/affect 1-2 of 1000 live births.[1-3] DS is the most common genetical cause of developmental disability, marked by intellectual disorders and musculoskeletal disorders.[4-5] Clinically DS patients were described to have low tone muscles, or low stiffness muscles that might affect the muscle strength and motoric skills.[5] Several phenotyping features might be seen on DS such as morphologic disorder of the head and limbs, short stature, hypotonia (80%-100%)[6], and hyperlaxity of the ligaments (75%).[7] Broken organ function especially the heart (50% of newborns with DS), gastrointestinal obstruction (4%-5% newborns with DS), higher risk of leukemia, early neuropathological such as Alzheimer. Nearly all DS children have muscle hypotonia (MH), decreased muscle tone that usually related with the muscle of the frame.[8-9]

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Muscle hypotonia and joint hypermobility is routinely reported in describing the characteristics of DS.[8-9] According to the "functional muscle-bone unit" concept, the bone mass and geometrics are influenced by the muscle growth and development of children and adolescents. The muscle weakness on DS patients might result as decreasing bone mass and changes of bone matrix. Muscle contraction result the most physiological burden on the bone, and the bone strength should be adapted with the muscle strength. So it could be concluded that the weak muscle contraction is the main cause of bone weakness on DS patient.[4-10]

Combination of musculoskeletal disorders and the low bone mass might cause deletion of the body growth and development, motoric development and weakness of orofacial muscles : lips, tongue, and cheeks.[11] The weakness of orofacial muscles may interfere the balance of the ligaments and chewing muscles that furtherly influence the dentocraniofacial growth and muscle movements on the temporomandibular joints.[11-13] Hypotonia of the chewing muscles (such as masseter and temporalis muscles) will reduce the mechanical strength on mandibula that reduce the muscle stimulation on the bone and cause mandibular ramus deficiency (vertically growth of the face) and change of gonial angle (anteroposterior growth of the face). This change is caused by the movement of the masseter and temporalis muscles within/while opening and shutting the mouth; besides, the gonial angles has a direct correlation with the activity of the masseter muscles, and the masseter muscles have "insersi" on the angulus and mandibular ramus, and origin on "arcus zygomaticus".[11,14,15]

Dual-energy X-ray absorptiometry scanning (DXA) is a BMD standard measuring technique on the hip and lumbar, but for DS patients the evaluation on several body spots using other technique also need to be done.[16] Some difficulties using DXA technique are it need a high cost, high radiation and not available in every place/(clinic ?) so we can not use this technique in early examination of bone density on patients with a possibility of osteoporosis.[17]

Panoramic radiograph can be used as a media/technique in assessing the quality of bone and temporomandibular joints because it is easy to use, non invasive, inexpensive/low cost and its expose on the patient is relatively low, so it can be used as a routine examination.[18,19] Panoramic radiograph is proven to become the first technique, simple and useful in assessing the disorders on head condyle, hyperplasia or hypoplasia, trauma and tumour on the head condyle.[20, 21]

Panoramic radiographs can be used to analyze the trabecular, cortical, and radius of the condyle head in postmenopausal women which can be used for early detection of osteoporosis.[22] The right/precise area choosed to assess the quality of the bone is the head condyle because it is a part of the mandibula in the location of muscle origo-incersio on the area of temporomandibular joints, unreached by the direct effect of occlusion, but get the largest load of stomatognatic.[23] Condyle has many trabecula load (98.4%) and metabolism grade of 5-8 times higher than the cortical.[23-25] Condyle is a relatively constant area, not influenced/effected by the local factors and becomes an important point of the growth because the process of condyle bone forming enchondrally is similar with the vertebra, lumbal and femur on DXA examination.[23]

Based on those phenomens, the author was interested to make/perform the study to find out the position and density of head condyle, gonial angle and height of the mandible on the panoramic radiographs of DS patients as an effort in the early identification of the changes on the condyle, in prevention of TMJ disorders and the decreasing bone quality on DS patients.

Materials and methods

This was a comparative analytic study. The study subject was all panoramic radiographs of DS and normal patients at the Radiologic Installation Faculty of Dentistry RSGM Universitas Padjadjaran during the period of March 2016 to April 2017 which fulfilled the inclusion and exclusion criterias as follows
Inclusion criteria :

1. Panoramic radiographs of patients aged 7-16 years.
2. Panoramic radiographs wirh clear images of condyle, angulus, ramus
3. Panoramic radiographs with good density, contrast and details.

Exclusion criteria:

1. Panoramic radiographs of patients with fracture TMJ.
2. Panoramic radiographs of patients with history of TMJ surgery.

The samples were divided into two groups, DS patient group as the test group, and normal patients as normal/control group. The sample were collected by purposive sampling. There were 21 radographs of DS patients and 21 of normal patients. The analytical study was the normality test using Shapiro Wilk test followed by the difference test. If the data were normally distributed, then we used t-independent test to find out the mean difference between both sample groups, and if the data were not normally distributed, the Mann-Whitney test was then used. The significancy level used was 5% ($p<0.05$).

The measurement of the position of head condyle in this study used the method by Ikeda et al.[25] The density of head condyle on the panoramic radiograph was taken from the bone density value, (which is) expressed by "nilai derajat kehitaman" from the radiograph. The bone density was taken in the form of ROI (Region Of Interest) with 4x4 mm size on one area that is head condyle. Mandibular gonial angle on the panoramic radiograpth was taken from the mandibular angle which is formed by the ramus line (RL) and mandibular line (ML); measured in degree. The height of mandible ramus on the panoramic radiograph was measured by the distance from the Gonion (Go), the most postero-interior point on the mandible angulus and condylion (Co), the most superior point on the head mandible condylus and is stated in mm.

Results

Age (years)	DS		Normal		∑
	n	%	n	%	
7	6	28.57	1	4.76	7
8	4	19.05	8	38.09	12
9	2	9.53	1	4.76	3
10	3	14.28	4	19.05	7
11	1	4.76	2	9.53	3
12	2	9.53	2	9.53	4
13	1	4.76	1	4.76	2
14	1	4.76	1	4.76	2
15	1	4.76	1	4.76	2
Total	21	100		100	42

Table 1. Characteristics of the patients based on age.

	DS		Normal		∑
	n	%	n	%	
Female	5	23.81	8	38.1	13
Male	16	76.19	13	61.9	23
Total	21	100	21	100	42

Table 2. Characteristics of the patients based on sex.

The subject of this study were files of panoramic radiographs of DS children aged 7-15 years who came to the Dental and Oral Hospital Universitas Padjadjaran during the period March 2016 - April 2017, consisted of 21 patients to be compared with 21 normal patients.

Table 1 shows the majority of the DS patients (28.57%) were 7 years old and the least were 11, 13, 14 and 15 years (4.76%). Table 2 reveals that the majority of DS and normal patients were males (76.19% DS and 61.9% normal patients) and the rest were females. The genetical type of the DS samples in this study were all trisomy-21.

Condyle head position	DS	Normal	p-value
	X ± SD	X ± SD	
Right anterior	1.40 ± 0.50	1.52 ± 0.36	0.059
Right superior	2.52 ± 0.64	3.13 ± 1.23	0.08
Right posterior	2.44 ± 0.68	2.97 ± 1.24	0.09
Left anterior	1.45 ± 0.52	1.57 ± 0.37	0.174
Left superior	2.79 ± 0.92	2.94 ± 1.05	0.753
Left posterior	2.75 ± 0.95	2.92 ± 1.09	0.597

Table 3. Comparative test of condyle head position.

Head condyle density	DS	Normal	p-value
	X ± SD	X ± SD	
Right density	10.25 ± 3.10	12.16 ± 2.99	0.040
Left density	9.47 ± 2.43	12.31 ± 3.47	0.004

Table 4. Comparative test of head condyle density.

Mandibular gonial angle	DS	Normal
Right gonial angle		
X ± SD	124.49 ± 8.14	124.69 ± 5.42
Median (Min-Max)	124.88 [104.68-136.00]	124.51 [116.82-134.69]
Left gonial angle		
X ± SD	123,89 ± 9.36	125.41 ± 5.13
Median (Min-Max)	125.23 [100.26-136.42]	124.63 [117.54-136.69]

Table 5. Mandibular gonial angle.

Mandible ramus height	DS	Normal
Right mandible height		
X ± SD	30.82 + 3.11	33.454 + 3.43
Median[Min-Max]	30.80 [25.85–37.57]	31.96 [29.34-41.45]
Left ramus height		
X ± SD	30.29 + 2.91	33.62 + 3.45
Median [Min-Max]	30.05 [25.74-35.56]	33.44 [28.52–41.49]

Table 6. Mandible ramus height (mm).

The main value of the anterior head condyle, superior and posterior of the right as well as left part on DS patients were lower than those in normal patients, with p-value >0.05 (Table 3). The main value of the right as well as left head condyle of DS patients were lower than those in normal patients with p-value <0.05 (Table 4). The main value of mandible gonial angle, left as well as right were lower than those in normal patients with p-value >0.05 (Table 5). The main value of the mandible ramus height, left as well as right in DS patients were lower than those in normal patients with p-value <0.05 (Table 6).

Discussion

The position of the mandible condyle of TMJ is directly conducted by the mouth structure including the involved muscles. The condyle as the main central of mandible growth get/receive the stimuli as long as the remodeling process, so the condyle has an important role on the final dimension of the adult mandible. The volume and size can be involved with the final mandible and the final relation between the upper and lower arch of the jaws. The parameter used in this study were measurement of the head condyle position, head condyle density, gonial angle and height of mandible ramus in terms of panoramic radiographs at RSGM Universitas Padjadjaran. Those four variables were examined as representation of head condyle position, vertical dimension, antero-posterior dimension and microstructural condition of head condyle of DS patients.

The movement of the condyle nearer to the fossa glenoidalis is known/detected when the distance is less than normal, i.e. 1.3 mm (interior), 2.55 mm (superior) and 2.1 mm (posterior) that is similarly with the opposite distance.[26] The result of this study showed that compared with the normal group, DS patients have lower/smaller main value of the head condyle, with the comparison of 1.44 mm (anterior), 2.52 mm (superior), and 2.44 mm [posterior] on the right condyle and 1.45 mm (anterior), 2.79 mm (superior), 2.75 mm (posterior) on the left condyle (Table 3). Descriptively, this calculation showed that there was no difference of head condyle position anteriorly, superiorly, and posteriorly on DS as well as normal patients. This result is similar with the study by Almeida et al[27] on the head condyle position of DS patients using transcranial radiographs that showed the right and left condyle position of DS patients were likely to be in anterior position, during occlusion as well as centric occlusion.

The author suspected that the DS patients in this study did not show symptoms of disorders of the TMJ. Asymptomatic patients might show the condyle position in normal and not normal situation/condition. The condyle position is said to be normal if it is in the position it should be, and is said to be not normal if there is less or more position than it should be in normal limits. Asymptomatic change of the condyle indicates that the patient had a light trauma, loss of tooth/teeth and imbalanced chewing habit of the right and left TMJ. Krisjane et al[28] used the Linear Tomography and MRI to detect the condyle position of 29 asymptomatic patients and found 39.9% condyles were in concentric position, 14.3% more to posterior, and 46.4% more to anterior position. Treatment is not required if asymptomatic, but a long term follow up is necessary. In symptomatic case, the treatment depends on presenting complaints of patient.[29]

The likely “prognathi” position of the mandible in DS patients might also affect the head condyle position. A study by Aline et al[15] compared the craniofacial class III non syndrome and control of DS patients, revealed that DS patients had smaller anterior and posterior cranials, maxilla hypoplasia, short facial height and anterior open bite. The small maxilla and mandible in DS patients was suspected to cause the head condyle position more to anterior than glenoidalis fossa. Cohlmia et al[30] and Seren et al[31] found that class III patients had smaller distance of anterior head condyles and nearer vertical relation between the condyle and top of glenoidalis fossa, and showed lower/smaller superior aspect. In another study, class III malocclusion in children with ectodermal dysplasia showed similar condylar, ramal, condylar-plus-ramal measurements with healthy control subjects.[32]

In this study, the majority of male samples were suspected to influence the head condyle position. Cohlmia et al[30] stated that boys/males had bigger head condyle position with steeper articular slope, condyle position in boys were more to anterior than in girls/females.

The smaller combination of TMJ joint space in class III patients and the majority bigger head condyle in boys/males was suspected to result the head condyle position is likely to the anterior.

The DS patients in this study were still within growth and development age/period, so the change of condyle position might still occur as the mandibular growth and development of the patient. Similar with the opinion of Burke et al[33] the condyle dimension could be influenced by several factors such as normal development, seasonal growth, and pathological changes on remodelling that might result changes in the joint dimension.[34] One of the changes that might be found in DS patients is muscle mastication such as hypotonia masseter and temporalis that might cause the mandible easier to drop, caused by the gravitation or the push down of the supranoid muscle. The mouth will always/go on open and the posterior teeth erupt that cause anterior open bite. Bakke et al[35] had proven that the patient with interior open bite had weak masseter and temporal muscles.

Hypotonia of the masseter muscles will cause decrease of the bite force and shorter movement of the condyle translation while opening the mouth. If repeatedly occur, this condition might cause pain on the masseter muscle and TMJ. As this change is a long-time process, it might not be seen/revealed in DS patients of this study. Miyawaki et al[36] stated/found that the severity of the open bite on adult patients were more than in pre-puberties. This revealed that the low/weak occlusal strength might be a trigger factor in anterior open bite.

Many studies had been previously performed on the lumbar and femur bones of DS patients and revealed that the BMD of DS patients were lower. Camargo et al[19] stated that mandible BMD correlated with BMD of the lumbar back bone and femoral neck on osteopenies and osteoporosis cases. Accordingly, it was concluded that the bone condition on the condyle might represent the bone condition on other growth areas of a patient.

It was found in this study that DS patients had lower density of head condyle. It was similar with the studies by Foley et al[37] and Aguilero-Gonzales et al[38] that DS patients had lower BMD compared with normals. A study by Allam et al[39] on the comparison of bone density between two groups of DS patients (7-10 years and 14-18 years old) and normals using DXA revealed that DS patients had lower Bone Mineral Density Z-score than those without DS. In this study, the author suspected that sub-optimal GH and selective IGF-I deficiency effected/(had an effect on) the change in bone matrix and mass of DS children.

The author also suspected that the low density of head condyle in DS patients was caused by the low osteoblastic proliferation and bone accumulation, that caused lower percentage of “trabekula”, maybe lower than in normal patients. It was in accordance with the study by McKelvey et al[40] which showed PINP biochemical marker had a role/function in a marker of lower bone forming (17 ng/m) in DS patients compared with normal patients. A study by Parson et al[41] on presphemoid bone of mouse T565Dn, a trisomy-21 model, showed lower bone volume fraction, trabecular number and trabecular connection, and more trabecula in rod (batang) form compared with control group. The author suspected the head condyle of DS patients had lower/smaller amount of trabeculla and bone amount in trabecular space, as marked by (as found through) the lower percentage of the bone particle value of DS patients in this study.

Beside genetically, the quality of bone architecture is also influenced by the environment, mechanical burden and infections.[41] Hypotonia of the masseter muscle in DS was suspected to influence the bone quality; a low mechanical pressure will decrease the activation of the osteosit that will cause decrease of osteoblast proliferation.[42-44] Several/Many authors had proven the correlation between the muscle strength and bone mass. Gravis et al[4] revealed the correlation of muscle strength and bone mass on DS had found the bone ultrasound analysis 6% lower than normal. Angelopoulou et al[45] identified the correlation of the strength of the front thigh muscle and BMD on DS individuals. Children with DS had significant excessive hypermobilities and hypotonia, less control and muscle strength that cause disorder of motoric movement and negatively influence the BMD. Muscle contraction gave/ placed the most physiologic burden on the bone, so the bone strength must be adapted with the muscle strength. It could be stated that decreased muscle contraction is the main cause of bone weakness.

Table 4 shows the main density of the right condyle is higher (10.25%) than the left condyle (9.47%). It is suspected as a cause of chewing on one side because of different level of bone modeling and was considered to be involved with the amount of mechanical burden fron the chewing muscles. Van Eijden et al[46] stated that the bone with heavier burden was estimated to have higher level of remodeling and cause the bone to have/get more mineralization. Therefore, if the right condyle had a higher density, this right side will be more oftenly used during chewing.

On the other hand, the secondary cause of low BMD in relation to DS might also affect this study, such as dietary insufficiency (vitamin D and calcium intake) and endocrine (hypothyroidism, hyperparathyroidism, hypogonadism) and autoimmune disorders (celiac disease) may cause malnutrition. Low sunray exposure and the use of anticonvulsants are also involved in decreasing the bone mass.[47] Guijarro et al[48] reported that several/some general condition will appear in DS, such as thyroid dysfunction, disorders of sexual development, and musculoskeletal disorders (strength of peripheral muscle and respiratory) that might have a contribution in the development of osteoporosis.

Hypotonia of the chewing muscles in DS may decrease the mechanical strength in pressing the mandible and cause changes of gonial angles and ramus height.[49] The author suspected that it was affected by the decrease of the function and contraction of the mastication, i.e. masseter and medial pterygoid that have “insersio” on the gonial angle. This study showed insignificant difference of the mandible gonial angle value of DS compared to normal patients (Table 5). This was similar/in accordance with the studies by Suri et al[14] and Aline et al[15] that found no significant difference of gonial angles in DS and normal patients.

In the opposite with the study by Suharsini et al[11] on children aged 14-18 years, it was stated that mastication muscle had a significant effect on the growth of antero-posterior facial of DS patients (p-value 0.012<0.05). The author thought this was caused by the difference in the patients’ age; the majority of patients in this study were below 11 years old, so there was no significant change on the gonial angle area. Fischer-Brondis et al[50] studied the mandible growth on DS patients aged 0-14 years and found that the gonial angle in DS babies were 5.6 points (derajat) smaller than in normals, and up to the age 14 years the gonial angle grow normally while/even smaller than in normal. Allareddy et al[51] stated that the gonial angle and mandible angle on DS patients were likely to increase as the age increases. These patients might show the occlusion of anterior open bite as the growth and development of the jaws.

The calculation of ramus height on DS patients showed significantly lower result (p-value 0.002) than in normals (Table 6). This was similar with the study by Suri et al[14] and Aline et al.[15] In this study, the result was 30.82 mm on the right ramus and 30.29 mm on the left ramus. Suharsini et al[11] found that the chewing muscles also had significant result on the facial vertical growth (p=0.020).[11] The author suspected this was caused by the muscle hypotonia in DS patients decreased the muscle stimulation on the bone and caused a decrease of the vertically growth of the face. The masseter and medial pterigoid muscles had an insersio towards the gonial angle area and ramus mandible; the contractilic strength of these muscles also influence the basic form of the mandible. Huumonen et al[52] stated the strong massetter and the activity of the anterior temporal muscles were involved with the larger of posterior face height, flat mandible area and small gonial angle, the same with the opposites. Saini et al[53] stated that the mandible ramus was the object that received the strongest pressure compared with the other bones caused by the mastication process. The burden given at the time of mastication process will influence the cartilage on the condyle and other mastication muscles.

So was the soft food diet as often given to DS patients, it might decrease the muscle strength, hypotonia in DS and mostly had direct impact on the upper and lower jaw dimension. A study by Enomoto et al[54] reported an animal that was given consistently hard food had bigger condyle, longer mandible length and higher ramus height compared with other animal with consistently soft food. According to a term by Wolff, the form and structure of the bone depend on the stress from the functional muscles.

The limitation of this study were too small amount of sample in each age group and too far comparison of the total of female and male samples (5 : 16) so it was less representative in determining the change in the position and density of head condyle, gonial angle and height of the ramus mandible as the age and gender. On the other hand, the data used was a secondary data, so the author had no clinical data or patient's history that might be a barrier in this study such as bruxism, malocclusion, dietary food, systemic condition and endocrine of the patients, changes of the neck, shoulder and head postural, and pain on the TMJ or mastication muscles.

Conclusions

Based on the result of the study, it was concluded that

1. There was no difference of the condyle head position based on the panoramic radiograph between Down Syndrome and normal patients.
2. There was a difference of condyle head density based on the panoramic radiograph between Down Syndrome and normal patients.
3. There was no difference of the mandible gonial angle based on the panoramic radiograph between Down Syndrome and normal patients.
4. There was a difference of the height of the mandible ramus based on the panoramic radiograph between Down Syndrome and normal patients.

Declaration of Interest

The authors report no conflict of interest.

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