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Mandibular radiomorphometry analysis of children with HIV and healthy individuals on digital panoramic radiographs by age and sex

Alongsyah Zulkarnaen Ramadhan[1,3*], Indra Gunawan[2,3], Ria Noerianingsih Firman[4], Farina Pramanik[4], Irna Sufiawati[5]

ABSTRACT

Objectives: The chronic systemic inflammatory process of HIV (Human Immunodeficiency Virus) infection in children leads B cell activity to accelerate the osteoclastogenesis process, which results in bone alterations. Long-term usage of highly active antiretroviral medication results in decreased bone quality in HIV patients (HAART). Digital panoramic images are useful for radiomorphometric analysis of the mandibular macrostructure. Mandibular bone is a bone quality analysis that is often performed.

Materials and Methods: This study comprised 86 digital panoramic radiographs of pediatric HIV patients and healthy persons. Secondary data in the form of digitized conventional panoramic radiographs of 43 pediatric HIV patients and 43 healthy individuals without clinical symptoms of HIV disease were utilized as a reference.

Results: Mandibular morphometry values by sex in children with HIV and healthy adults showed (MCI) p-value 0.009, (GMI) p-value 0.934, (GI) p-value 0.584, (Go-Co) p-value 0.090, and (Co-M) p-value 0.919. Meanwhile, the results of the study with mandibular morphometric values between children with HIV and healthy individuals index based on age revealed (MCI) p-value 0.490, (GMI) p-value 0.657, (GI) p-value 0.080, (Go-Co) p-value 0.147, (Co-M) p-value 0.158

Conclusion: Mandibular morphology differed between HIV-infected children and healthy persons as measured by digital panoramic radiographs, with changes in mandibular resorption thickness, mandibular bone width, and mandibular bone thickness. Furthermore, there were no differences in values, height, and length of the mandible, as well as variances based on age and sex.

Keywords: *HIV, Mandibular radiomorphometry, panoramic radiography*
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[1]Faculty of Dentistry, Universitas YARSI, Jakarta, Indonesia 10510

[2]Faculty of Dentistry, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia 57141

[3]Dentomaxillofacial Radiology Residency Program, Faculty of Dentistry Universitas Padjadjaran, Bandung, Indonesia 40132

[4]Department of Dentomaxillofacial Radiology, Faculty of Dentistry Universitas Padjadjaran, Bandung, Indonesia 40132

[5]Department of Oral Medicine, Faculty of Dentistry Universitas Padjadjaran, Bandung, Indonesia 40132

*Correspondence to:
Alongsyah Zulkarnaen Ramadhan
alongsyah.sprkg@gmail.com

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INTRODUCTION

HIV (Human Immunodeficiency Virus) is a virus that replicates in CD4+ T cells and monocytes/ macrophages, causing a significant reduction in the human immune system. HIV-AIDS infection in children is typically transferred vertically by the mother during pregnancy, childbirth, and breastfeeding. The disease's progression will then result in a collection of clinical symptoms known as Acquired Immunodeficiency Syndrome (AIDS). More than 20-30% of HIV-infected patients have a reduction in bone quality. Report the value of bone mineral density (BMD) is lower in HIV-infected children than in uninfected children, affecting growth, development, and bone quality.[1] BMD has a significant impact on the process of alveolar bone structure creation, particularly in the mandible, because low bone mineral density can contribute to alveolar bone resorption and periodontal disease.[2] HIV-infected people frequently have low bone mineral density. Antiretroviral therapy is a medicine used to treat HIV patients that has serious adverse effects, lowering BMD values by 2% to 6% over the first two years. Low BMD in HIV is caused by a complicated interaction between HIV infection and risk factors for decreased bone density that are aggravated by chronic HIV infection, such as poor nutrition, weight loss, tobacco use, alcohol, and low vitamin D levels.[3] Reduced immunity in HIV patients' bodies can alter the mechanism of osteoblasts and osteoclasts, disrupting the mechanism of bone development. Several prior studies in HIV patients who were being treated have found antiretroviral medication therapy (ARV) negative effects on bone condition.[4,5]

Several studies have found abnormalities in mandibular bone from HIV patients' bone condition. According to research on the mandibular condyle, there is a change in the position of the head of the condyle with respect to the glenoid fossa in HIV-positive children and adolescents.[1] Another study discovered lower mandibular cortical thickness variations in children's mandibles, particularly in girls. There are differences in the value of mandibular cortical thickness in HIV-

infected children.[3]
Digital panoramic radiographs can also be used to assess bone development and mineralization, as well as morphological changes. Several studies were conducted to evaluate whether panoramic radiographs can be used to evaluate changes in the vertical and horizontal dimensions of the jaw.[1] Panoramic radiography are notorious for distorting and enlarging the image. Panoramic radiographs are useful for monitoring bone condition since they are simple, non-invasive, and have a low amount of exposure, allowing them to be used as a routine assessment.[1] Based on this phenomenon, the authors were interested in conducting a study to analyze mandibular morphometry between children with HIV and healthy individuals using digital panoramic radiographs through several mandibular cortical indices.

MATERIALS AND METHODS

This study used an analytical observational cross -sectional method. The population of this study was secondary data in the form of conventional panoramic radiographs that have been digitized in 43 children with HIV and 43 healthy individuals without clinical symptoms of HIV disease which is a reference from the Department of Oral Medicine, RSGM FKG UNPAD. The subjects in this study were panoramic data of children with HIV aged 5-16 years. Based on a total of 61 samples aged 5-11 years, and 25 samples aged 12-16 years. Based on sex, from a total sample of 86 that the gender in the group of healthy individuals and HIV-infected children, the majority were female with a total of 50 samples and 36 were male. The research in this study was carried out by direct examination on digital panoramic radiographs that met the inclusion criteria and then analyzed with the help of Image-J software to establish the value of mandibular cortical thickness. Panoramic radiographs of patients aged 5-11 years and 12-16 years based on the Ministry of Health of the Republic of Indonesia in pediatric HIV patients and healthy individuals, as well as radiographs of good quality, were included in this study. While the exclusion criteria included panoramic radiographs having pathological abnormalities in the area to be investigated, such as benign and malignant tumor lesions, jaw cysts, or fractures. Panoramic radiographs with systemic disease, diabetes mellitus, tuberculosis, hypertension, cardiovascular and developmental problems, congenital anomalies, and genetic disorders were also eliminated. Mandibular morphometry is determined by measuring 5 mandibular indexes:

Mandibular Cortical Index (MCI) on (Figure 1) digital panoramic radiograph is a visual measurement of both sides of the mandible based on the Klemetti method to assess the thickness and resorption pattern of the intracortical mandibular cortex. Morphological classification of the lower mandibular cortex was carried out by observing from the bilateral mental foramen. The mandibular cortex is classified into three categories based on its morphology. i.e. from C1 (normal cortex), with smooth, sharp and clear cortical endosteal margins on both sides. C2 (medium cortex), the endosteal margin of the cortex has semilunar abnormalities and C3 (eroded cortex) the endosteal margin of the cortex has a cortical layer of clearly visible porosity or forms an endosteal layer with thicker residues. The measurement scale is ordinal with units of measurement based on C1, C2 and C3.[6]

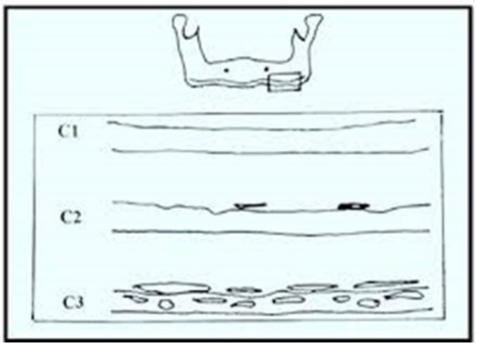

Figure 1. Mandibular Cortical Index[7]

The mandibular width assessment on a digital panoramic radiograph through the Gonion Mandibular Index (GMI) on a digital panoramic radiograph is the distance from Gonion (Go) to the mandibular midpoint (M) measured in millimeters (Figure 2). Go is the most posteroinferior point at the angle of the mandible, and M is the projection of the mental spine on the lower edge of the mandible parallel to the vertical plane of the Anterior Nasal Spine ANS, the ratio measurement scale is in millimeters (mm).[8]

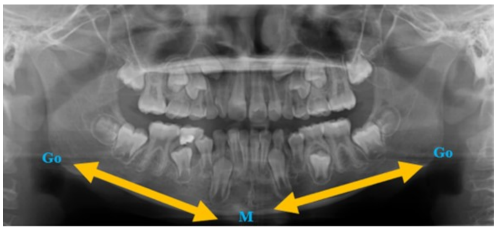

Figure 2. Gonion Mandibular Index[8]

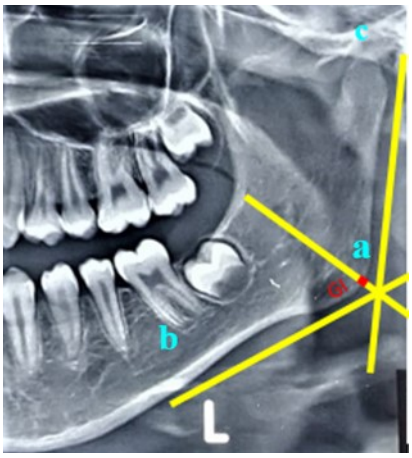

Figure 3. Gonion Index[9]

The measurement of the cortical thickness of the mandible using the Ledgerton method on a digital panoramic radiograph through the gonion index (GI) which is assessed on a line perpendicular to the imaginary line/line (a) tangent made at the intersection of the inferior border of the mandible (b) with the posterior border mandibular ramus (c) as shown in Figure 3. Ratio measurement scale in millimeters (mm).[9]

The mandibular height measurement on a digital radiograph is the distance from Go to Condylion (Co) measured in millimeters. Go is the most posteroinferior point on the mandibular angle and Co is the most superior point on the head of the mandibular condyle (Figure 4). Ratio measurement scale in millimeters (mm).[9]

Figure 4. Mandibular Height Index[8]

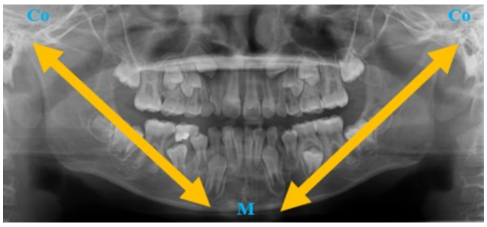

Figure 5. Mandibular Length Index[8]

The mandibular length measurement on a digital panoramic radiograph is where the CO point is the most superior point on the head of the mandibular condyle, while the M point is known to be located by projecting the mental spine on the lower edge of the mandible (Figure 5). Ratio measurement scale in millimeters (mm).[10]

RESULTS

Sample Characteristics

Based on Table 1, it can be seen from the total sample of 86 that the sex in the group of healthy individual children and HIV sufferers is the majority of women with a total of 50 samples. Likewise, in terms of age, most were aged between 5-11 years with a total of 61 samples. When compared between children with HIV and healthy individuals by sex and age, there is no difference in the number of samples.

Mandibular Morphometry Analysis by Sex

Table 2 shows the recapitulation of the mandibular cortical index (MCI) morphometric value by sex, the average value in the case of healthy individual boys having a higher score. In the case of girls, healthy individuals have higher rates than girls with HIV.

The average value of the GMI index in individual boys is higher than that of boys with HIV. The average value of the GMI index in healthy individual girls has a higher value than girls with HIV with a difference of 7.

The value of the GI index in healthy individual boys is higher than that of boys with HIV. The value

Table 1. Data Characteristics

CHARACTERISTICS	GROUPS		TOTAL
	HEALTHY INDIVIDUALS	CHILDREN WITH HIV	
Sex			
Male	17 (47.2%)	19 (52.8%)	36 (100.0%)
Female	26.(52.0%)	24 (48.0%)	50 (100.0%)
Total	**43 (50.0%)**	**43 (50.0%)**	**86 (100.0%)**
Age			
5-11 year old	31 (50.8%)	30 (49.2%)	61 (100.0%)
12-16 year old	12 (48.0%)	13 (52.0%)	25 (100.0%)
Total	**43 (50.0%)**	**43 (50.0%)**	**86 (100.0%)**

Table 2. Mandibular Morphometry Analysis by Sex

MORPHOMETRY	SEX					
	Male		Deviation	Female		Deviation
	Healthy Individuals	HIV		Healthy Individuals	HIV	
MCI						
Normal	14	0	14	15	4	11
Mildly to Moderately Eroded	3	18	15	11	20	9
Severely Eroded	0	1	1	0	0	0
GMI	65.21±6.17	57.96±5.05	7.25	62.97±7.48	55.97±7.66	7
GI	0.71±0.10	0.61±0.09	0.10	0.65±0.11	0.57±0.10	0.08
Go-Co	28.99±1.79	29.93±4.22	0.94	28.87±2.30	27.44±3.70	1.43
Co-M	70.18±3.13	69.55±7.04	0.63	68.51±4.74	67.62±7.59	0.89

Table 3. Mandibular Morphometry Analysis by Age

Morphometry	AGE					
	5-11 Year old		Deviation	12-16 Year old		Deviation
	Healthy Individuals	HIV		Healthy Individuals	HIV	
MCI						
Normal	22	3	19	7	1	6
Mildly to Moderately Eroded	9	26	17	5	12	7
Severely Eroded	0	1	1	0	0	0
GMI	62.1± 6.81	55.39±6.80	6.74	68.31±5.56	60.21±4.99	8.1
GI	0.64±0.10	0.57±0.08	0.07	0.78±0.05	0.63±0.12	0.15
Go-Co	28.31±1.82	27.28±3.76	1.03	30.48±2.01	31.45±3.32	0.97
Co-M	68.17±4.25	66.28±7.60	1.89	71.75±2.93	73.53±2.94	1.78

Table 4. Mann-Whitney Statistical Test Results on Mandibular Morphometry CMI, GMI, GI, Go-Co AND M-Co

Hypothesis	Morphometry	GROUP		P value
		HIV	Healthy Individuals	
H1	**MCI**			0.000
	C1	4 (12.1%)	29 (87.9%)	
	C2	38 (73.1%)	14 (26.9%)	
	C3	1 (100.0%)	0 (0.0%)	
H2	**GMI**	56.85 6.64	63.86 7.00	0.000
H3	**GI**	0.58 0.10	0.68 0.11	0.001
H4	**Go-Co**	28.54 4.08	28.92 2.10	0.245
H5	**Co-M**	68.47 7.33	69.17 4.22	0.990

Table 5. Mann-Whitney Statistical Test Results on Mandibular Morphometry CMI, GMI, GI, Go-Co AND M-Co by Sex

Hypothesis	Morphometry	SEX						P-Value
		Male		Devia-tion	Female		Deviation	
		Healthy Individuals	HIV		Healthy Individuals	HIV		
H6	MCI							0.009
	C1	14	0	14	15	4	11	
	C2	3	18	15	11	20	9	
	C3	0	1	1	0	0	0	
	GMI	65.21±6.17	57.96±5.05	7.25	62.97±7.48	55.97±7.66	7	0.934
	GI	0.71±0.10	0.61±0.09	0.10	0.65±0.11	0.57±0.10	0.08	0.584
	Go-Co	28.99±1.79	29.93±4.22	0.94	28.87±2.30	27.44±3.70	1.43	0.090
	Co-M	70.18±3.13	69.55±7.04	0.63	68.51±4.74	67.62±7.59	0.89	0.919

Table 6. Statistic Test Results of Mandibular Morphometry CMI, GMI, GI, Go-Co AND M-Co Using Two-Way ANOVA by Age

Hypothesis	Morphometry	AGE						P-Value
		5-11 Year old		Deviation	12-16 Year old		Deviation	
		Healthy Individuals	HIV		Healthy Individuals	HIV		
H7	MCI							0.490
	C1	22	3	19	7	1	6	
	C2	9	26	17	5	12	7	
	C3	0	1	1	0	0	0	
	GMI	62.1± 6.81	55.39±6.80	6.74	68.31±5.56	60.21±4.99	8.1	0.657
	GI	0.64±0.10	0.57±0.08	0.07	0.78±0.05	0.63±0.12	0.15	0.080
	GO-CO	28.31±1.82	27.28±3.76	1.03	30.48±2.01	31.45±3.32	0.97	0.147
	CO-M	68.17±4.25	66.28±7.60	1.89	71.75±2.93	73.53±2.94	1.78	0.158

of the GI index in healthy individual girls has a higher value than girls with HIV. The Go-Co index value in healthy individual boys has a lower value than boys with HIV.

The Go-Co index value in healthy individual girls has a higher value than girls with HIV. The average value of the Co-M index in healthy individual boys has a higher value than boys with HIV. The Co-M index value in healthy individual girls has a higher value than HIV-infected girls.

Mandibular Morphometry Analysis by Age

Table 3 shows the recapitulation of normal mandibular cortical index (MCI) morphometric values based on the age of 5-11 years which is higher than that of children with HIV, while 12-16 years of age the value of healthy individual children has a higher number than children with HIV. The value (MCI) is moderate at the age of 5-11 years, the value of healthy individual children has a higher number than children with HIV and 12-16 years the value of healthy individual children has a higher number than children with HIV. The value (MCI) eroded at the age of 5-11 years, the value of healthy individual children had a higher number than children with HIV with a difference of 1 and 12 -16 years.

The GMI morphometric value based on the age of 5-11 years, healthy individual children have a higher number than children with HIV, while 12-16 years the value of healthy individual children has a higher number than children with HIV.

The GI index value at the age of 5-11 years, healthy individual children have a higher score than children with HIV with a difference of 0.07, while 12 -16 healthy individual children have a higher score than children with HIV.

The Go-Co index value based on the age of 5-11 years, healthy individual children have a higher number than children with HIV, while 12-16 years the value of healthy individual children has a higher number than children with HIV.

The Co-M index value based on the age of 5-11 years, the value of healthy individual children has a higher number than children with HIV. while the age of 12-16 years the value of children with HIV has a higher value than children of healthy individuals.

Statistical Analysis

Hypothesis testing was carried out as an effort to determine whether there was a difference between the morphometric values in children with HIV and healthy individuals. This analysis used a comparison test between the mandibular cortical morphometric index (MCI), gonion mandibular index (GMI), gonial index (GI), gonion - condylion (Go-Co), Mandibular midpoint - condylion (M-Co) in children with HIV and healthy individuals.

The comparison test criteria used the Mann Whitney test because the results of the calculation of the normality and homogeneity test showed that the data did not have a normal and homogeneous distribution. Based on the results of the calculations in Table 4, the values of mandibular cortical morphometric index (MCI), gonion mandibular index (GMI) and gonial index (GI) between children with HIV and healthy individuals have significant (significant) differences. Thus, hypotheses 1, 2 and 3 were accepted, but hypotheses 4 and 5 were rejected. So it can be concluded that only the morphometric values of the mandibular cortical index (MCI), gonion mandibular index (GMI) and gonial index (GI) were significantly different between children with HIV and healthy individuals.

Based on the results of the calculations in Table 5 there is a significant difference. This can be seen from the probability value (p-value) which is smaller than 0.05. Meanwhile, the values of the gonion mandibular index (GMI), gonial index (GI), gonion-condylion (Go-Co) and Mandibular midpoint-condylion (M-Co) in children with HIV and healthy individuals by sex were not statistically significant ($p > 0.05$). Thus, Hypothesis 6 is rejected.

Based on the results of the calculations in Table 6, the values of the mandibular cortical morphometric index (MCI), gonion mandibular index (GMI), gonial index (GI), gonion-condylion (Go -Co) and Mandibular midpoint-condylion (M-Co) children with HIV and healthy individuals based on age did not have a significant difference. This can be seen from the probability value (p-value) greater than 0.05, thus Hypothesis 7 is rejected.

DISCUSSION

HIV infection in children has been shown to decrease bone and mandibular quality due to systemic disorders and the use of antiretroviral drugs can result in changes in mandibular cortical morphometry in children with HIV. Because of the rapid bone development that occurs throughout infancy, HIV infection has a different BMD effect in children than in adults, therefore if exposed, the risk of bone fracture is higher. The authors' study concentrated on HIV-infected children as the primary demographic analyzed, as this is a major problem in bone mass development.[11]

Several studies have been conducted to evaluate whether panoramic radiographs can be used to evaluate changes in the vertical and horizontal dimensions of the jaw. Panoramic radiographs are known to tend to distort and enlarge the image.[12] According to research published in 2011 by Molina et al, panoramic radiographs can be utilized as an alternative modality in measuring changes in jaw dimensions in vertical and horizontal directions.[13] Panoramic radiographs have the advantage that they can be used as an examination. Panoramic radiographs have the advantage of being able to be used as an early detection in dental and jaw examinations, as well as being fast, inexpensive, and requiring a low dose of x-ray radiation. Panoramic radiographs are useful for diagnosing systemic bone quality, assessing the shape of the cortex, inferior mandible, and detecting decreased bone quality in the jaw, such as the presence of osteoporosis when there is radiolucency of the mandible and a diminished cortical layer.[14]

In the study of Vikulina T, et al in 2010, the cause of poor mandibular bone quality in children with HIV was the number and activity of osteoclast cells exceeding the number and activity of osteoblast cells.[15] This situation results in a decrease in bone mass in the body. Long-term use of antiretroviral drugs in HIV-infected children has advanced risks such as osteopenia and osteoporosis. Longitudinal data on BMD show that HIV-infected children with cumulative antiretroviral treatment have a lifetime impact on BMD. Because the peak BMD in children has not been attained, so that if disturbed in childhood, it will interfere for life and increase the risk of osteoporosis and bone fractures. According to the data, HIV-infected children had lower BMD than HIV-infected adults.[16]

T. Sudjaritruk's study in 2017 on 98 patients with vertically transmitted HIV patients who were transmitted during pregnancy (aged 12-20 years), and taking ARV drugs, described a decrease in bone quality in osteopenia and osteoporosis of around 60%. The decrease in bone mineral density in about 28% of HIV-infected patients occurs over 2.5 years.[17] Mandibular cortical morphometry changes by 30% - 50% structurally change from the mandibular bone condition of HIV patients studied by Azhari et al in 2015.[18]

Based on this study, it can be seen that there is a significant difference in the morphometric index values of the mandibular cortical index (MCI), gonion mandibular index (GMI) and gonial index (GI) between children with HIV and healthy individuals. This is in accordance with the research of Vikulina T in 2010 and Azhari in 2015 which stated that there were differences in bone quality scores between children with HIV and healthy individuals. BMD values were lower based on the mandibular cortical index and fractal dimensions in children with HIV compared to healthy individual children as controls.[18,19]

CONCLUSION

According to the findings of this investigation, this study concluded that:

i. There were differences in resorption thickness, width and cortical thickness in the mandible on digital panoramic radiographs between HIV-infected children and healthy individuals.
ii. There was no difference in height and length of the mandible on digital panoramic radiographs between children with HIV and healthy individuals.
iii. There was no difference in mandibular morphometry through digital panoramic radiographs between children with HIV and healthy individuals based on age and sex.

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FOOTNOTES

All authors have no potential conflict of interest to declare for this article. This research was registered and approved by the Research Ethics Committee. All procedures conducted were in accordance with the ethical standards.

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