RESEARCH ARTICLE

REVISED Differences in dental arch characteristics between genders in patients with suspected condylar hyperplasia in a North Sumatra subpopulation: a cross-sectional study [version 3; peer review: 3 approved]

Previously titled: Evaluation of dental arches in orthodontic patients with condylar hyperplasia in a North Sumatra subpopulation: a cross-sectional study

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Abstract

Background: Condylar Hyperplasia (CH) is a self-limiting mandibular condyle disorder that shows asymmetry progress in conjunction with associated occlusal changes as long as condylar growth is still active and leads to facial asymmetry. This study aimed to analysis the difference of dental arch characteristics based on genders in orthodontic patients with suspected CH in a North Sumatra subpopulation.
Methods: This is a retrospective study of suspected CH patient's clinical records who sought for the initial orthodontic treatment between January 2015 to March 2019. Patient with facial asymmetry (based on photography, posterior crossbite and midline deviation), the positive temporomandibular joint disorder in functional analysis, and no history of facial trauma were included in the study. Dental arch asymmetry was based on the measurement of dental midline deviation, canine tip in the dental arch, the distance of the upper canines from the palatal suture, and inter canine distance. The evaluation of dental arch was achieved by comparing arch width and length.
Results: There was a significant difference ($p<0.05$) of upper canine distance from the palatal suture in female patients when evaluating upper dental arch asymmetry. There was a moderate correlation ($r=0.379$) in midline deviation between upper and lower dental arch. The dimension and dental arch form were mid and flat, and there was moderate correlation ($r=0.448$) between the upper and lower dental arch form in these suspected CH patients.
Conclusion: Indeed skeletal asymmetry, the evaluation of the dental arch

Open Peer Review

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version 3 (revision) 12 Jun 2020		✓ report	
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characteristic symmetry and arch form showed asymmetric occlusal characteristics in orthodontics patient with suspected CH in the North Sumatera subpopulation. In treating these patients, we recommend the plaster cast evaluation as essential and routine procedure in order to understand the complexity of occlusal change due to active growth of condylar and limitation in radiography evaluation.

Keywords
dental arch, condylar hyperplasia, asymmetry, form

Any reports and responses or comments on the article can be found at the end of the article.

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REVISED **Amendments from Version 2**

We revise the manuscript based on valuable insights of those reviewers who willing to improve the quality of the manuscript itself as well as for our future work. To respond with the reviews that have been provided, we have made major revisions according to reviewers' comments.

1. Title revision
2. Abstract revision
3. The addition of several recommended references to increase the quality of writing is included in the introduction and discussion due to the reviewers' suggestion.

Any further responses from the reviewers can be found at the end of the article

Introduction

The unilateral non-neoplastic overgrowth of mandibular condyle that leads to occlusal interferences and joint dysfunction or pain, is identified as condylar hyperplasia (CH). The elongation of condylar head, neck, and lower arch corpus leads to the development of occlusal disharmony, dental compensation, and asymmetry due to continued abnormal growth that can be unilaterally or bilaterally (Bharathi *et al.*, 2014; Obwegeser & Makek, 1986; Wolford *et al.*, 2014). This deformity requires assessment in condylar growth and sometimes requires high condylectomy combined with orthognathic surgery and articular disc repositioning to achieve treatment stability (Lippold *et al.*, 2007; Wolford *et al.*, 2009). Sequential assessments (six to twelve month intervals) of CH aim to prevent worsening functional, esthetic, skeletal, and occlusal changes during orthodontic treatment. These examinations include clinical examinations, plaster cast analysis, and radiographic evaluations in the abnormal condylar lower arch growth. Since CH is a rare disorder, previous studies explore the multiple factors of mandibular growth asymmetry and development. The characteristics of CH are as follows: excessive or persistent growth of condyle leads to facial asymmetry with occlusal discrepancies and temporomandibular joint disorder as concurrent symptoms. It has severe asymmetry over a long-time period and can grow past the growth period gradually (Almeida *et al.*, 2015; Goulart *et al.*, 2018; Rajimakers *et al.*, 2012; Wolford *et al.*, 2014). The CH treatment modality is differ depending on affected structures, patient's age, severity of asymmetry, and the activity status of CH. (Lopez & Corral, 2015; Obwegeser & Makek, 1986; Wolford *et al.*, 2014).

Previous studies report several types of CH, based on radiographic and clinical characteristics that related to enlargement or hyperplasia of mandibular that will help the dental clinicians in understanding the complexity of facial asymmetry in 3 dimension (López *et al.*, 2019; Obwegeser & Makek, 1986; Wolford *et al.*, 2014). CH usually occurs during puberty and ceases at the same time as the completion of healthy growth (Rajimakers *et al.*, 2012; Wolford *et al.*, 2014). The types of CH including hemimandibular hyperplasia as condylar asymmetry in vertical direction, hemimandibular elongation as condylar asymmetry in horizontal direction, and hybrid (Obwegeser & Makek, 1986; Wolford *et al.*, 2014). The similar symptoms of glenoid fossa asymmetry and hemimandibular elongation that led to the difference in therapeutic approach and suggested for careful correlation of clinical findings and imaging tests (Lopez & Botero, 2017). CH affects women more than men with a 3:1 ratio (Nitzan *et al.*, 2008). It can also continue growing past the growth period (Almeida *et al.*, 2015; Obwegeser & Makek, 1986; Pacheco *et al.*, 2010). The investigation of facial asymmetry with CH complexity should be integrally planned during orthodontic treatment (Olate *et al.*, 2013). Previous report cases mentioned that condylectomy to stop CH, surgery to correct skeletal discrepancy, and facelifts, augmentation using medpor implants or fat grafts to achieve aesthetics in treatment objectives (Alyamani & Abuzinada, 2012; Lopez & Herrera-Guardiola, 2016; López *et al.*, 2017).

Previous studies report that CH adversely affects morphology and size of the mandible, it also alters the occlusion development along with dental arches (Goulart *et al.*, 2018; Mehrotra *et al.*, 2011; Wolford *et al.*, 2014). According to Purbiati's study in Indonesian sub-population student between 8 to 30 year old, male subject had a higher risk of mandibular asymmetry occurance 2.447 times than female (Purbiati *et al.*, 2016) In planning orthodontics treatment, changing the dental arch form can also influence treatment stability. In patients with facial asymmetry, dental alveolar compensation is one treatment choice when treating malocclusion without surgery intervention. Due to the genetic and enviromental factors influence occlusal development and limitation of radiography evaluation this study aims to analysis the dental arch asymmetry and form in pre-orthodontic patients with suspected CH based on genders

Methods

This is a retrospective study of the clinical records of suspected CH patients that sought for the initial orthodontic treatment at the Dental Hospital, Universitas Sumatra Utara between January 2015 and March 2019. The Research Ethics Committee of the Universitas Sumatera Utara Medical Faculty approved this study (378/TGL/KEPK FK USU-RSUP HAM/2019). Those patients who were treated with fixed orthodontics at the Dental Hospital, University of Sumatra have signed informed consent, which includes data collection for research purposes.

Participants

CH suspected subjects fulfilled the following characteristics: facial asymmetry based on photography, posterior cross bite and midline deviation in plaster casts analysis, and positive temporomandibular joint disorder in functional analysis from the dental records. Since this is a retrospective study of suspected CH patient's clinical records, we included the subjects with pain, clicking, crepitation, and other signs or symptoms of TMD from extra oral analysis in their dental record. This study excluded patients with a history of facial trauma and hereditary disorder based on their medical records, and patients whose records had unclear morphology of condylar and lower

arch features in pretreatment panoramic radiographs so that cannot be analyzed with asymmetry vertical mandibular with Kjellberg's technique (Hirpara *et al.*, 2016).

Data analysis

Evaluation of dental arch symmetry was done using plaster casts taken from the patients' dental records.

Initial measurements. The well-trimmed plaster casts were positioned on millimeter rule paper and measurements were taken manually with a cephalometric and metal protractor. To determine the upper arch midline, a mark was located along the mid palatal suture. The symmetry axis of the upper arch midline was made by connecting the incisive papilla (As=Anterior superior) passing second palatal rugae to the most visible posterior upper arch landmark (Ps=Posterior superior) over the mid palatal suture. Once the Ps was marked, the end reference point was located on the border between the hard and soft palate. Then Ps mark of the upper arch was transferred to the lower arch (Pi=Posterior inferior) using a ruler positioned perpendicular and occluded upper and lower plaster casts. To determine the anterior lower arch point (Ai=Anterior inferior), the upper arch As was transferred to the lower arch using a ruler that occluded upper and lower plaster casts. The symmetry axis of the lower arch midline was obtained by connecting the Ai to the most visible posterior landmark (Pi) over the lingual frenulum to the posterior border of lower arch. After marking the midline symmetry axis, we can evaluate the dental arch asymmetry by measuring dental midline deviation (MD), canine tip in the dental arch (PC), distance of the upper canines from the palatal suture (DC) and inter canine distance (ICD) in the upper and lower arches (Scanavini *et al.*, 2012).

Angular and linear measurement of the dental arch asymmetry. Angular arch asymmetry was performed by measuring the right and left canines to the upper arch symmetry axis using a cephalometric protractor in the upper arch (this is known as midline deviation (MD) (Figure 1 and Figure 2). The position of the canine (PC) is the distance from the cusp tip on each side that were projected perpendicular to the symmetry axis using a metal protractor. Distance of canines (DC) is the linear measurement from right to left canine tips (Figure 3). This angular and linear measurement of upper and lower arch dental asymmetry has predictive accuracy and is marked as negative if shifted to the left (Scanavini *et al.*, 2012).

Evaluation of dental arch form. The evaluation of dental arch form by comparing arch width and length. Dental arch dimensions were as follows: L33 (inter canine width), from right canine cusp to left canine cusp; L66 (intermolar width), from right first molar cusp to left first molar cusp; L77 (posterior intermolar width), from right second molar cusp to left second molar cusp; L31 (sagittal dental arch), from the "arrow" of the anterior curve; L61, from the incisal edge to the line joining the mesiobuccal canines of the first molar; L71, the incisal edge to the line joining the distobuccal cusps of the second molar. These six factors characterized both the arch form and the dimension that will determine the dental arch ratio: L31/L33, L61/L66, L71/L77, L33/L66, L61/L71 (Figure 4 and Figure 5). The arch is classified as narrow if three dental arch ratios (L31/L33, L61/L66, L71/L77) are positive, the arch form is classified as wide if they are negative. The arch is classified as mid if none of those dental arch ratios significantly deviates from the average. The arch form is pointed if only the L31/L33 has a noticeable intensity significantly higher value than all the comparisons (L61/L66,

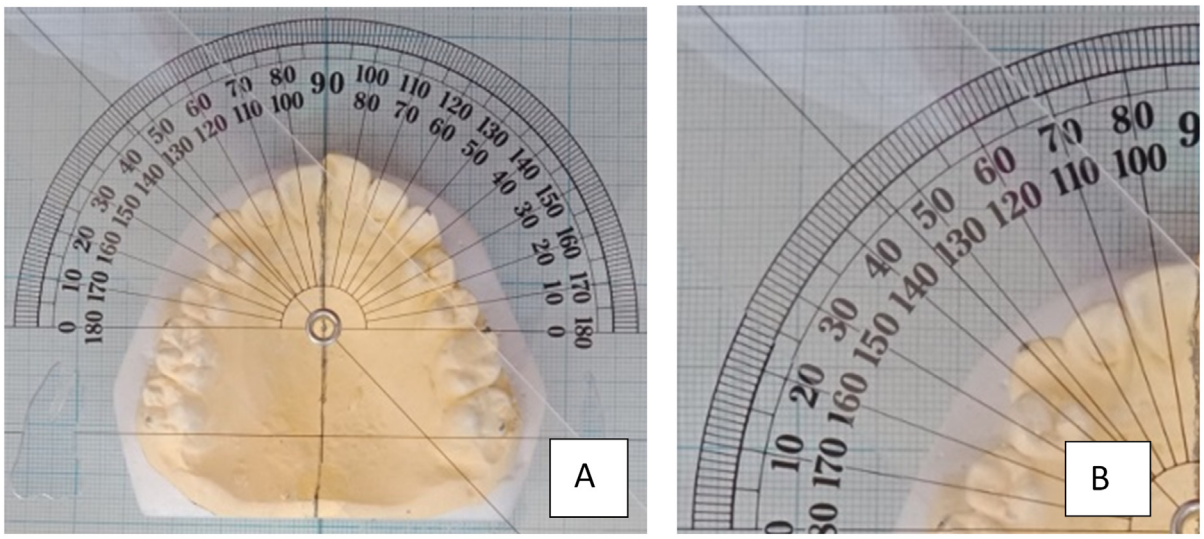

Figure 1. Measuring angular upper arch asymmetry. The plaster cast model is positioned with a protractor at the cusp of the right upper arch canine (**A**); the protractor shows that PC of right upper arch canine is 46°±1° (**B**).

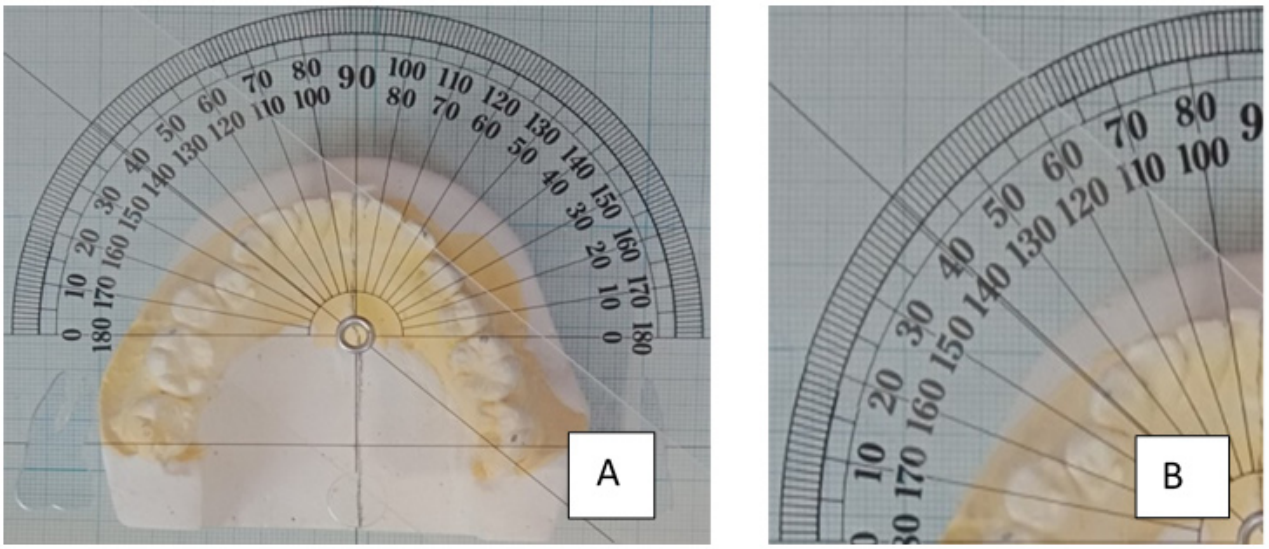

Figure 2. Measuring angular lower arch asymmetry. The plaster cast model is positioned with a protractor at the cusp of the right lower canine (**A**); the protractor shows that PC of right lower arch canine is 39°±1° (**B**).

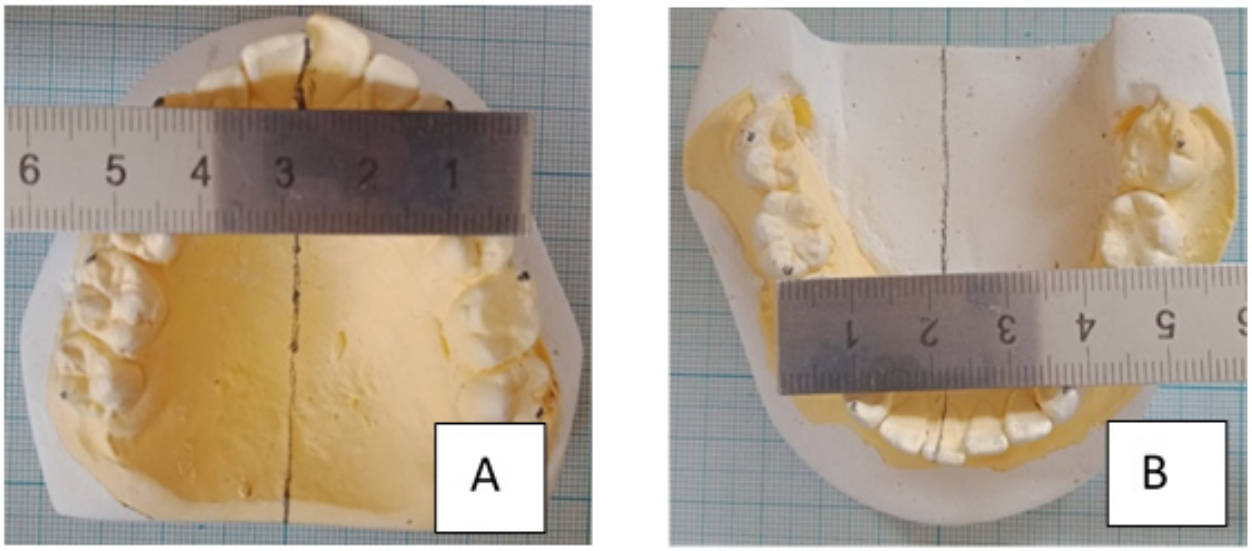

Figure 3. Measuring distance of the canines in upper and lower arch asymmetry.

L71/L77, L33/L66, L61/L71). The arch is classified as flat only if the L31/L33 has significantly lower value than all comparisons (L61/L66, L71/L77, L33/L66, L61/L71) (Raberin *et al.,* 1993). Those measurements were repeated in 15 days after obtaining the initial data to assess the reliability with intra-rater measurement.

Statistical analysis. Analyzing the significant difference of symmetrical angular and linear measurement of the dental arches based on gender was done using *paired independent pair t-test* ($p<0.05$). This study used the second measurement in analyzing symmetrical dental and dental arch form with *chi-square* and *Cramer's V correlation.* SPSS version 17.0 was used for data analysis.

Results

There were total of 14 male and 20 female patients who were suspected as CH patients between 18 to 27 years old based on

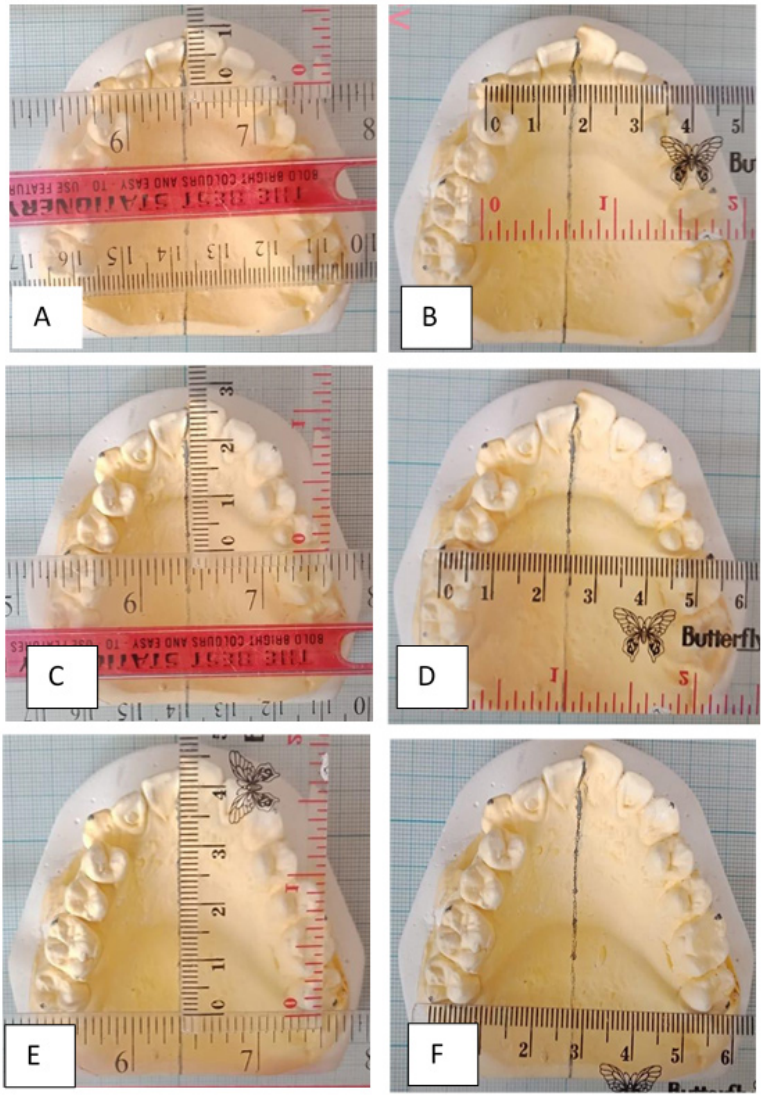

Figure 4. Measurement of upper dental arch form. The sagittal dental arch from the arrow of the anterior curve (L31) (**A**); from right canine cusp to left canine cusp is identified as intercanine width (L33) (**B**); the incisal edge to the line joining the mesiobuccal canines of the first molar (L61) (**C**); the dental arch dimension from right first molar cusp to the left first molar cusp is intermolar width (L66) (**D**); the incisal edge to the line joining the distobuccal cusp of the second molar (L71) (**E**); from right second molar cusp to the left second molar cusp is the posterior intermolar width (L77) (**F**).

date of birth stated in the medical record. Those subjects with suspected CH fulfilled some criterias, including:facial asymmetry based on photography analysis, positive temporomandibular joint disorder, vertical mandibular asymmetry based on pre treatment panoramic radiographs, and posterior cross bite. Table 1 shows the distribution of upper and lower arch dental symmetry in this study. Based on gender, there was no significant difference in upper and lower dental symmetry between male and female (Table 2). There was a significant difference ($p<0.05$) of upper canine distance from the palatal suture in female patients, but no significant difference in other symmetry variables between male and female (Table 3), There was also no significant difference of midline deviation between male and female in this study (Table 4). However, there was a moderate correlation (r=0.379) of midline deviation in upper and lower dental arches of this studied subjects (Table 5). In these CH patients, the dental arch form in upper and lower dental arch were mid and flat. There was also a moderate correlation (r=0.448) between upper and lower dental arch form (Table 6).

Discussion

The dental arch evaluation is an essential issue in orthodontic treatment. We performed a retrospective study of clinical records of suspected CH patients in order to evaluate dental arch symmetry. The failure in early identification of CH can lead to unfavorable esthetic and functional orthodontic treatment resulting in the development of asymmetry (Almeida *et al.*, 2015; Lopez & Corral, 2015). Identifying the growth pattern occurring

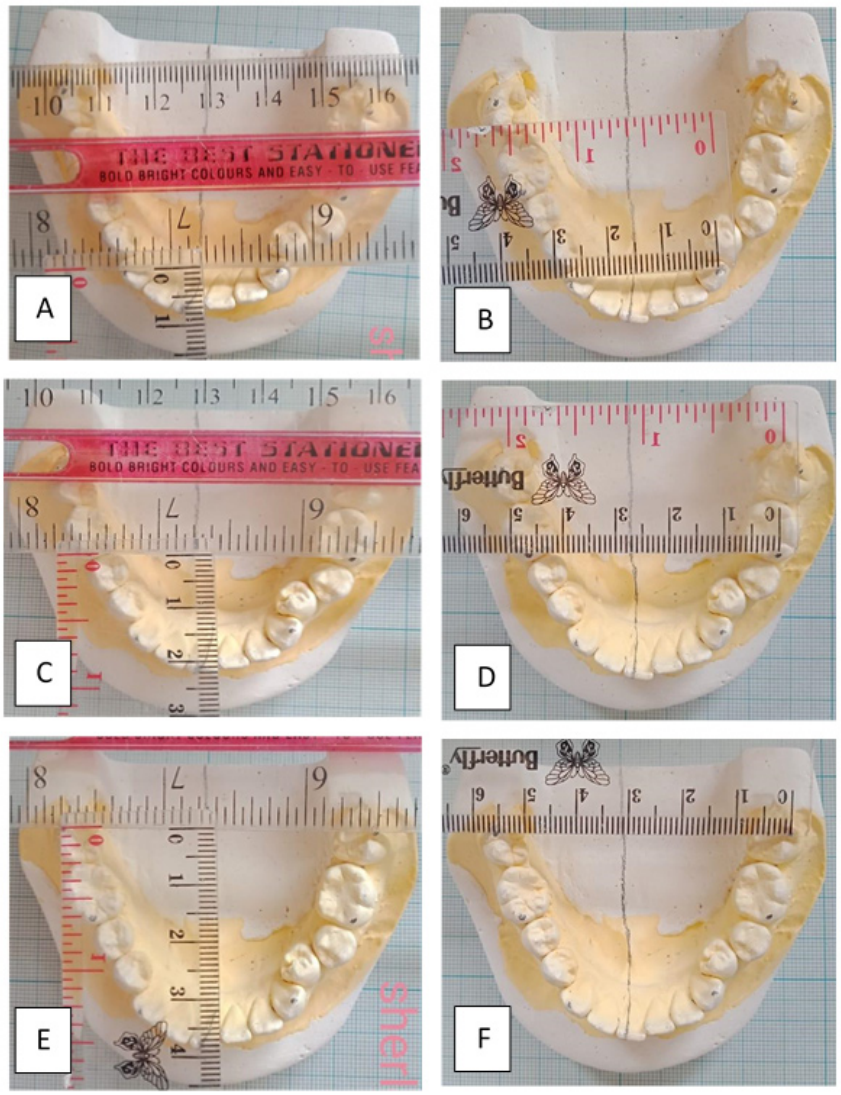

Figure 5. Measurement of lower dental arch form. The sagittal dental arch from the arrow of the anterior curve (L31) (**A**); from right canine cusp to left canine cusp is identified as intercanine width (L33) (**B**); the incisal edge to the line joining the mesiobuccal canines of the first molar (L61) (**C**); the dental arch dimension from right first molar cusp to the left first molar cusp is intermolar width (L66) (**D**); the incisal edge to the line joining the distobuccal cusp of the second molar (L71) (**E**); from right second molar cusp to the left second molar cusp is the posterior intermolar width (L77) (**F**).

in CH and deciding the activity of condylar growth are important in treating any malocclusion with lower arch asymmetry. Wolford *et al.* introduced an updated classification system based on growth, clinical, histological, and imaging characteristics (Wolford *et al.*, 2014). Progressive unilateral growth expansion of condyle, leads to facial asymmetry, malocclusion, and indirectly affects the upper arch development, also shifting off the chin towards the unaffected side (Goulart *et al.*, 2018; Wolford *et al.*, 2014). A study by Mehrotra *et al.* in 2011 on five Indian adult active CH patients reported that facial asymmetry was the most common clinical finding, followed by midline shifting, protruded chin, contralateral cross bite, and upper arch occlusal canting (Mehrotra *et al.*, 2011). CH clinical findings show midline shifting along with chin deviation to contralateral side with related posterior cross bite (Almeida *et al.*, 2015). Generally, patients with active CH present facial asymmetry transversally, vertically or combined (Nitzan *et al.*, 2008). There was a significant difference in soft-tissue asymmetry between CH subjects and controls as observed in three-dimensional photographs which can be used in evaluation of progressive worsening occlusion while radiography is limited (Verhoeven *et al.*, 2013).

Most studies have also reported that CH occurs between ages 10 and 30 years with abnormal growth of the hyperplasia cases

Table 1. Distribution of upper and lower dental arch symmetry in condylar hyperplasia patients.

	Variable	Min (*)	Max (*)	Mean±SD (*)
Upper dental arch	MD (°)	-8	7	-0.765±2.544
	PC Right (°)	30	52	40.250±4.747
	PC Left (mm)	26	54	40.941±5.585
	DC Right (mm)	8	23	16.794±2.253
	DC Left (mm)	12	20	17.559±1.673
Lower dental arch	MD (°)	-12	10	-1.750±5.207
	PC Right (°)	24	49.5	32.794±5.282
	PC Left (°)	24	54	36.147±6.762
	DC Right (mm)	9	18	13.147±2.155
	DC Left (mm)	10	18	14.088±2.002

*Negative, the midline deviates to the left-side; positive, deviates to the right-side.

MD : Midline Deviation

PC : Canine tip in the dental arch

DC : Distance of upper canine from the palatal suture

Table 2. Difference of angular and linear measurement for symmetrical analysis in upper and lower dental arch based on gender.

	Variable	Gender	N	Mean±SD (*)	*p*
Upper dental arch	MD(°)	Male	14	0.036±2.707	0.358
		Female	20	-1.325±2.330	
	Right PC(°)	Male	14	38.750±4.004	0.150
		Female	20	41.300±5.035	
	Left PC(°)	Male	14	39.607±5.115	0.232
		Female	20	41.875±5.835	
	Right DC(mm)	Male	14	17.536±2.098	0.228
		Female	20	16.275±2.262	
	Left DC(mm)	Male	14	17.393±2.021	0.943
		Female	20	17.675±1.426	
Lower dental arch	MD(°)	Male	14	-1.250±4.154	0.549
		Female	20	-2.100±5.913	
	Right PC(°)	Male	14	32.821±6.043	0.944
		Female	20	32.775±4.844	
	Left PC(°)	Male	14	35.214±7.645	0.318
		Female	20	36.800±6.191	
	Right DC(mm)	Male	14	13.036±2.231	0.711
		Female	20	13.225±2.155	
	Left DC(mm)	Male	14	13.714±2.128	0.492
		Female	20	14.350±1.920	

*Negative, the midline deviates to the left-side; positive, deviates to the right-side. Statistically significant difference ($p<0.05$).

MD : Midline Deviation

PC : Canine tip in the dental arch

DC : Distance of upper canine from the palatal suture

Table 3. Difference of symmetry variables of upper and lower dental arch based on gender.

	Sex	Variable	Side	Mean	*p*
Upper dental arch	Male	PC(°)	Right	38.75±4.00	0.185
			Left	39.61±5.11	
		DC (mm)	Right	17.53±2.10	0.672
			Left	17.40±2.02	
	Female	PC(°)	Right	41.30±5.04	0.534
			Left	41.87±5.84	
		DC (mm)	Right	16.28±2.26	0.010*
			Left	17.68±1.43	
Lower dental arch	Male	PC(°)	Right	32.82±6.04	0.551
			Left	35.21±7.65	
		DC (mm)	Right	13.04±2.23	0.449
			Left	13.71±2.13	
	Female	PC(°)	Right	32,78±4.84	0.126
			Left	36.80±6.20	
		DC (mm)	Right	13.23±2.16	0.102
			Left	14.35±1.92	

Statistically significant difference (p<0.05).

PC : Canine tip in the dental arch

DC : Distance of upper canine from the palatal suture

Table 4. Difference of midline deviation based on gender in condylar hyperplasia patients.

Midline deviation		Male, n (%)	Female, n (%)	*p*
Upper dental arch	Normal	6 (42.9)	9 (45)	0.429
	Shifted to the right	3 (21.4)	1 (5)	
	Shifted to the left	5 (35.7)	10 (50)	
Lower dental arch	Normal	1 (7.1)	4 (20)	0.512
	Shifted to the right	6 (42.9)	6 (30)	
	Shifted to the left	7 (50)	10 (50)	

Statistically significant difference ($p<0.05$).

Table 5. Correlation of midline deviation in upper and lower dental arch in in condylar hyperplasia patients.

Dental Arch Asymmetry		Lower arch			*p*	*r*
		Normal	Shifted to the right	Shifted to the left		
Upper arch	Normal	3	8	4	0.039*	0.379
		20.0%	53.3%	26.7%		
	Shifted to the right	1	2	1		
		25.0%	50.0%	25.0%		
	Shifted to the left	1	2	12		
		6.7%	13.3%	80.0%		

Statistically significant difference ($p<0.05$).

Table 6. Correlation of upper and lower dental arch form in condylar hyperplasia patients.

Dental Arch Form		Lower arch		*p*	*r*
		Mid	Flat		
Upper arch	Mid	9	4	0.014*	0.448
		69.2%	30.8%		
	Flat	5	6		
		23.8%	76.2%		

Statistically significant difference ($p<0.05$).

and the hemimandibular hyperplasia occurs at significantly younger age (Bharathi *et al.*, 2014; Goulart *et al.*, 2018; Lopez & Herrera-Guadiola., 2016; López *et al.*, 2017; Pacheco *et al.*, 2010). The 3-dimensional radiographs and quantitative techniques are useful for evaluation, classification, or follow up of CH although the emergence of panoramic radiographs might be suitable for screening CH in some emerging countries. (Nolte *et al.*, 2015). There were no significant association between vertical mandibular asymmetry and temporomandibular disorder symptom (Mendoza-García *et al.*, 2019; Sofyanti *et al.*, 2018a) whilst there was a specific pattern of dental and skeletal morphology with temporomandibular disorder sign in Indonesian subpopulation between 8 to 30 year old. The absence of 3D diagnostic radiography in this study encountered photography, positive posterior cross bite from plaster cast, and positive temporomandibular disorder in a cohort of 18 to 27 year old patients based on initial dental record.

Table 1 shows that in our patients the midline shifted to the left on the upper and lower arch. This result might be supported by Haraguchi *et al*'s study that reported a higher proportion of wider left hemiface in the post pubertal stage than prepubertal stage in 1800 Japanese subjects (Haraguchi *et al.*, 2008). However, this study result was different to a clinical study in Brazilian twin girls with CH who presented with facial asymmetry and skeletal class III whose chin and lower arch midline tend to deviate to the right side (Goulart *et al.*, 2018).

Even though previous study reported that CH affects more women than men, with a 3:1 ratio (Nitzan *et al.*, 2008); however, there was no significant difference of angular and linear measurement for symmetrical analysis in upper and lower dental arch based on gender in this study (Table 2) that similar with Rajimaker's study that there was no evidence that the side affected by CH was linked to sex (Rajimakers *et al.*, 2012). There was also no significant difference of symmetry variables in upper and lower arch dental arch of CH patients based on gender, except the upper canines distance from the palatal suture of female patients (Table 3) that might be related to the anatomical characteristics of female arch rather than hyperplasia process. While this study included the positive temporomandibular joint disorder as a concurrent symptoms with facial asymmetry, this dysfunction is not a pathognomonic sign of the pathology (López *et al.*, 2019) and might not always correlated to CH as well as posterior cross bite and midline deviation (Purbiati *et al.*, 2016). The outcome of this study was also suggested by Al-Zubair, which reported that the location of the central incisor and canines to each other and to other teeth is the most potent factor in determining dental arch asymmetry (Al-Zubair, 2019). Thus, the characteristics of brackets should be well understood by the clinician to obtain the desired teeth movement in achieve proper dental arch, correct angle classification or torque of the posterior teeth in CH treatment (Lopez & Herrera-Guardiola, 2016).

According to Scanavini *et al,* the differences of midline deviation in normal and class II malocclusion, is midline deviation dominant toward the left in the upper arch in each group (Scanavini *et al.*, 2012). In this study, the different PC between the upper canines distance from the palatal suture were higher in the lower arch than the upper arch. As with the analysis of midline deviation, the lower arch showed a higher degree of asymmetry than its counterpart upper arch. In the current study, the average values of midline deviation were greater than in the previous study regardless of the type of the malocclusion. Since this study focused on CH patients, the variance of symmetry showed a moderate correlation in midline deviation of dental arch symmetry (Table 4) and dental arch form (Table 5). The presence of condylar hyperactivity influenced the degree of malocclusion with facial asymmetry and diversity of CH (Alyamani & Abuzinada, 2012; Lopez & Corral, 2015; Pacheco *et al.*, 2010; Pinto *et al.*, 2016).

Prasad *et al.* reported that dental arch width of untreated South Indian adults which had minimal crowding and spacing, is associated with gender, race and vertical facial morphology. Then, it was important to consider the individualized arch wires (Prasad *et al.*, 2013) In Saudi normal population, it is suggested using a nickel titanium arch wire that will produce the lowest mean absolute error, cause minimal change in the dental arch form, and less customization of stainless steel wires necessary (Al-Barakati *et al.*, 2016). If there was a failure to preserve the arch form, it might increase the probability of relapse (Bayome *et al.*, 2011). Relapse related to improper arch wire changes can affect periodontal breakdown, recurrence of crowding of buccal segments, or increased crowding of labial segments particularly while inter-canine width and inter-molar width have been expanded. In the present study, relatively stocky arch guide showed mid and flat arch form for both upper and lower dental arch in the studied patients. This is also similar to the lower dental arch form of a Papuan population, which showed that prevalence of mid arch form was highest whilst the pointed lower arch form was the least in lower arch analysis of 18 to 25 year old Papuan students in Manado (Saputra *et al.*, 2016). Another Indonesian sub-population study also reported that there was only significant difference of upper dental arch for full dentition of Buginese, Makassarese, and Torajanese individuals, which was null in the lower dental arch (Rieuwpassa *et al.*, 2012).

In interceptive orthodontic treatment, dental arch coordination should be evaluated during occlusal changing during mandibular growth. The development asymmetry of the lower arch might be due to the condylar growth activity and joint function and it is common that a growth period elapses after the patient's asymmetric growth is completed (Pacheco *et al.*, 2010). In order to provide the optimal orthodontic treatment, Lopez' studies suggested that the differential diagnosis of CH requires overwhelmed understanding of aetiology until differences therapeutic approach based on clinical findings, radiography analysis, and histological characteristics of condylar hyperactivity. (Lopez & Corral, 2015; López *et al.*, 2017)

The asymmetry upper dental arch showed highly significant difference between right and left posterior arch segment whilst anterior segment showed no significant difference in class I occlusion of Iraqi young adult (Allabban *et al.*, 2017). There was significantly larger condylar length and the condylar sum of maximum values in the affected side and also positive correlation between the increased dimensions of the articular eminence and the more posterior position of the glenoid fossa in suspected Colombian CH patients (Lopez & Botero, 2020). Further study, such as case-control study, genetic investigation, histology findings and follow-up of the treatment progress may help clinicians to understand the multi-characteristics of CH among races. Ethnicity also influences the development of dental arch form related with symmetry point. Genetic and environmental factors can influence the development of left-right patterning during embryogenesis and remain in the masseter muscle in adults, including the *PITX2* promoter (Sofyanti *et al.*, 2018b). In the future, evaluation of plaster casts during orthodontic treatment is a requirement especially in treating malocclusion with mandibular asymmetry in order to anticipate the biomechanics of certain arch wire type. The clinicians should be careful in using arch wire coordination to obtain optimal occlusal relationship in order to maintain treatment stability while treating orthodontic patients with suspected CH due to dentoalveolar compensation of asymmetric growth (Al-Barakati *et al.*, 2016; Bayome *et al.*, 2011; Lopez & Herrera-Guardiola, 2016; Prasad *et al.*, 2013).

Conclusion

Indeed skeletal asymmetry, the evaluation of the dental arch characteristic symmetry and arch form showed asymmetric occlusal characteristics in orthodontics patient with suspected. However, there was no significant differences of dental arch characteristic based on genders in these studied subjects. In treating these patients, plaster cast evaluation is recommended as essential and routine procedure in order to understand the complexity of occlusal characteristics due to active growth of condylar and limitations in radiography evaluation during treatment. This phenomenon is marked as one obstacle in treating growing patients while CH is not detected early.

Data availability

Harvard Dataverse: Replication Data for: Angular and linear measurement of the dental arch asymmetry and dental arch form, https://doi.org/10.7910/DVN/GONORA (Sofyanti *et al.*, 2020).

Acknowledgements

We would like to thank the Prana Ugiana Gio for the technical statistical analysis.

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Open Peer Review

Current Peer Review Status: ✔ ✔ ✔

Version 3

Reviewer Report 22 June 2020

https://doi.org/10.5256/f1000research.27046.r64676

✔ **Diego Fernando López**
Departamento de Ortodoncia, Universidad del Valle, Cali, Colombia

The authors have adequately followed the recommendations made and those that cannot be corrected due to the nature of the study have been presented as limitations of the study in the discussion section.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Orthodontics, condylar hyperplasia, facial asymmetry.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 2

Reviewer Report 01 June 2020

https://doi.org/10.5256/f1000research.26748.r63485

✔ **Maria Purbiati**
Department of Orthodontics, Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia

Introduction:
Some literature stated that CH could be performed bilaterally even though mostly unilateral. It will be more clear if the terminology is used as unilateral CH or CH. The terminology of CH only is referring to the research subjects including both unilateral and bilateral overgrowth. It should be stated consistently from

the beginning (from the title).

Methods:
Too many criteria in determining facial asymmetry which will generate heterogeneous samples that lead to wide variation of samples. It seems the aim of the study to evaluate the dental arch in facial asymmetry subjects, thus extra oral (photography) or skeletal (PA cephalometric) parameter will be enough to differentiate a facial asymmetry. Then TMJ assessment was not correlated to this as well as dental record (posterior crossbite and midline deviation) which in some cases were not inline with the facial or skeletal asymmetry.

Data analysis:
Data analysis means statistical data analysis. Measurements should be explained as research methods. Measuring a 3-dimensional object will be more accurate by laser or digital device, such as Coordinate Measuring Machine.

Result:
Wide range of age including growing and non-growing patients. Asymmetry is a result of growth and development. Dividing into two groups will give deeper analysis.

Asymmetry is a qualitatively relative comparison between right and left side. This study's aims seem to describe dental arches condition in a facial asymmetry due to CH. So that, the amount of the measurement itself was not really important information. For this instance, categorical data (symmetrical and asymmetrical) would serve a better analysis than quantitative data, and would be emphasizing the intended context consistently,thus developing a sharp conclusion. Otherwise it needed control group for quantitative comparison.

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Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Orthodontics, Facial Aesthetics, Asymmetry, 3 dimension imaging, Orthognathic surgery

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 05 Jun 2020

Ervina Sofyanti, Universitas Sumatera Utara, Medan, Indonesia

Dear Dr. Maria Purbiati,
Thank you very much for your kind assistance in reviewing our manuscript. We have revised some sections as follows:

- **Introduction**

Some literature stated that CH could be performed bilaterally even though mostly unilateral. It will be more clear if the terminology is used as unilateral CH or CH. The terminology of CH only is referring to the research subjects including both unilateral and bilateral overgrowth. It should be stated consistently from the beginning (from the title).

We thank you for the suggestion. We have added the information in the introduction section. However, we cannot state consistently from the beginning due to suspected CH and the limited of radiograph that supposed to be 3D CBCT as the gold standard diagnostic.

- **Methods:**

Too many criteria in determining facial asymmetry which will generate heterogeneous samples that lead to a wide variety of samples. It seems the aim of the study to evaluate the dental arch in facial asymmetry subjects, thus extraoral (photography) or skeletal (PA cephalometric) parameter will be enough to differentiate facial asymmetry. Then TMJ assessment was not correlated to this as well as a dental record (posterior crossbite and midline deviation) which in some cases were not in line with the facial or skeletal asymmetry.

We thank you for the comment. Based on the previous study, CH is a self-limiting pathology in the condylar head that affecting facial symmetry and occlusion and may be associated with pain and dysfunction. Therefore we try to make a selection case base on those criteria without 3D radiography that supposed to be the gold standard.

- **Data analysis:**

Data analysis means statistical data analysis. Measurements should be explained as research methods. Measuring a 3-dimensional object will be more accurate by laser or digital device, such as Coordinate Measuring Machine.

We thank you for the kind suggestion. Due to the certain limitation of radiography and since this was a retrospective study, we will revise in the future study. We have added the statement in the

discussions as followed: The 3-dimensional radiographs and quantitative techniques are useful for evaluation, classification, or follow up of CH although the emergence of panoramic radiographs might be suitable for screening CH in some emerging countries.

- **Result:**

Wide range of age including growing and non-growing patients. Asymmetry is a result of growth and development. Dividing into two groups will give a deeper analysis.

Thank you for the kind review. Since we know that age is a factor which should be considered in determining the treatment modality, we have limited the age of sample from 10 to 30 year old based on previous studies about CH. Further study will require more samples in order to make a classification based on a growing pattern.

Asymmetry is a qualitatively relative comparison between the right and left sides. This study's aims seem to describe the dental arch's condition in facial asymmetry due to CH. So, the amount of measurement itself was not really important information. For this instance, categorical data (symmetrical and asymmetrical) would serve a better analysis than quantitative data and would be emphasizing the intended context consistently, thus developing a sharp conclusion. Otherwise, it needed a control group for quantitative comparison.

Thank you for your kind advice. We will consider the control group in future studies. As additional information, we compare the result with a subpopulation of Indonesian that aged between 8 to 30-year old based on Purbiati's study.

Competing Interests: We declare no competing interest

Reviewer Report 26 May 2020

https://doi.org/10.5256/f1000research.26748.r63488

?

Diego Fernando López
Departamento de Ortodoncia, Universidad del Valle, Cali, Colombia

- The authors make an investigation in which they observe characteristics in the dental arches of patients with suspected condylar hyperplasia (HC). Since they do not use a group of patients without suspected HC as a control group, they can only provide descriptive statistics and the only comparison they can make is between genders or according to age. Therefore the title should mention "differences in dental arch characteristics between genders in patients with suspected HC".

- With respect to materials and methods, the authors use a millimeter rule to take measurements. There are now digital micrometric gauges as well as digital compasses to establish more accurate

measurements that deliver decimals and thus provide measurements that may lead to statistically significant differences. (Measurements should be taken with these instruments that provide better accuracy).

- Additionally, the overlap of the upper palatal midline over the lower arch may be very inaccurate with manual techniques. At present, scanned models, tomography and the use of software reduce these errors in the method, which, although the study mentions that it values intra-operative variability, the method itself, being manual and on plaster models, allows inaccuracy.

- Being an observational retrospective study in study models it would have been very easy to have a control group to compare those same measures with patients without suspected HC.

- The study group was between the ages of 10 and 30. At ages close to 10 years, the upper canines have generally not erupted, nor have the second molars or even the premolars. Measures of intercanine or intermolar distance may vary between permanent and temporary dentition. This should be mentioned in the study. It could be a serious method error.

- The study does not mention whether the patient sample had active or passive condylar hyperplasia. There is a clear difference between a present metabolic activity assessed with a bone scan with growth already stopped.

- The study doesn't mention what kind of hyperplasia the patients had. It was Hemimandibular Elongation (horizontal vector), Hemimandibular Hyperplasia (vertical vector) or hybrid form. Authors such as Obwegeser *et al.* in 1984, Wolford *et al.* (2014) and Lopez *et al.* (2019), mention it adequately.

- The inclusion criteria mention that patients should have temporomandibular dysfunction within their diagnostic process. On the one hand, temporomandibular dysfunction is not a pathognomonic sign of the pathology. (There may be condylar hyperplasia without temporomandibular dysfunction). On the other hand, if this variable is taken, the occlusal findings could be the result of the dysfunction or hyperplasia? This should be mentioned in the discussion.

- In the results, the distance of the upper canines from the mid-palatal suture in women appears to be statistically significant. This finding could be related to the anatomical characteristics of female arches and not to arches of hyperplastic patients. This could be solved, using a control group.

- There are dental measures that could have been easily taken in the models and that would increase the variables of the study, such as: the angle classification, the torque of the posterior teeth.

- Finally, HC is an alteration that produces anatomical changes due to condylar overgrowth and positional changes due to the displacement of the jaw towards the contralateral side. Therefore, the long or hyperplastic side should be compared with the short or contralateral side in the variables taken.

- The conclusions postulate that asymmetric occlusal changes were observed in these patients, but the only statistically significant change was the superior canine distance in women. This should not be such a general conclusion and secondly this finding could be both occlusal and skeletal.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
No

Are sufficient details of methods and analysis provided to allow replication by others?
No

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Orthodontics, condylar hyperplasia, facial asymmetry.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 30 May 2020

Ervina Sofyanti, Universitas Sumatera Utara, Medan, Indonesia

Dear Prof. Diego Fernando Lopez,
We thank the reviewer for the valuable comments and hope that the suggestions will improve the quality of our manuscript.

Response to Reviewer:

- **The authors make an investigation in which they observe characteristics in the dental arches of patients with suspected condylar hyperplasia (HC). Since they do not use a group of patients without suspected HC as a control group, they can only provide descriptive statistics and the only comparison they can make is between genders or according to age. Therefore, the title should mention " Differences in dental arch characteristics between genders in patients with suspected condylar hyperplasia in a North Sumatra subpopulation: a cross-sectional study ".**

We thank the reviewer for the suggestion. Previously we used the “evaluation” term to emphasize the characteristic of asymmetry and form of dental arch in CH case. According to the reviewer's suggestion, we have revised the title to “Differences in dental arch characteristics between genders in patients with suspected CH in a North Sumatra subpopulation”.

- **With respect to materials and methods, the authors use a millimeter rule to take measurements. There are now digital micrometric gauges as well as digital compasses to establish more accurate measurements that deliver decimals and thus provide measurements that may lead to statistically significant differences.**

(Measurements should be taken with these instruments that provide better accuracy).

We thank the reviewer for the valuable comment. The measurement in this work was taken by millimeter ruler, we are adding measurement error in the manuscript:
- Figure 1. Measuring angular upper arch asymmetry. The plaster cast model is positioned with a protractor at the cusp of the right upper arch canine (A); the protractor shows that PC of right upper arch canine is 46 ± 1° (B).
- Figure 2. Measuring angular lower arch asymmetry. The plaster cast model is positioned with a protractor at the cusp of the right lower canine (A); the protractor shows that PC of right lower arch canine is 39°±1° (B).

- **Additionally, the overlap of the upper palatal midline over the lower arch may be very inaccurate with manual techniques. At present, scanned models, tomography and the use of software reduce these errors in the method, which, although the study mentions that it values intra-operative variability, the method itself, being manual and on plaster models, allows inaccuracy.**

We thank the reviewer for the kind suggestion. The current measurement only gives the rough estimation/approximation to determine dental arch asymmetry and form, therefore accurate techniques in dental arch asymmetry including dimension in form and asymmetry analysis will be considered in near future. This statement will be mentioned in the discussion as limitation part of this study. In the manuscript: Although the procedure measurement was precise, using the millimeter ruler in analyzing arch form was a limitation in this study and should be revised with scanned models, tomography or the use of software in the further study.

- **Being an observational retrospective study in study models it would have been very easy to have a control group to compare those same measures with patients without suspected HC.**

We thank the reviewer for the advice. We decided to focus only on the suspected CH case, instead of control group due to determine the characteristics of dental arch asymmetry since we hypothesis that individual arch form based on race diversity, might present significant differences in the anatomic characteristics of the dental arch. Perhaps for our future study, we will conduct through detailed comparison with control group as suggested by the reviewer.

- **The study group was between the ages of 10 and 30. At ages close to 10 years, the upper canines have generally not erupted, nor have the second molars or even the premolars. Measures of intercanine or intermolar distance may vary between permanent and temporary dentition. This should be mentioned in the study. It could be a serious method error.**

We thank the reviewer for the comment. We will add the following sentence according to the reviewer's suggestion in the discussion. Most studies have reported that CH occurs between ages 10 and 30 years with abnormal growth of the hyperplasia cases. The hemimandibular hyperplasia occurs at significantly younger age. In the beginning, we include the sample with full erupted teeth until second molar in order to provide good measurement in this study. We want to apologize that we missed to input the meant age of this study that ranged from 18 to 27 year old and fulfilled the inclusion criterias.

- **The study does not mention whether the patient sample had active or passive condylar hyperplasia. There is a clear difference between a present metabolic activity assessed with a bone scan with growth already stopped**.

We thank the reviewer for the suggestion. However we have mentioned that we used panoramic radiography due to in some emerging countries, like Indonesia, the CBCT recently progress then retrospective study found with limited radiograph. Nolte et al., 2015 was also mentioned about panoramic radiographs were suitable for screening CH, although the diagnostic standard was to

assess the condylar growth activity using bone scintigraphy"
Therefore the following statement was incorporated into the manuscript:
The treatment objectives of previous report case mentioned that condylectomy to stop CH, surgery to correct skeletal discrepancy, and facelifts, augmentation using medpor implants or fat grafts to achieve aesthetics (Alyamani & Abuzinada, 2012; Lopez & Herrera-Guardiola, 2016; Lopez et al., 2017). The investigation of facial asymmetry with CH complexity should be integrally planned during orthodontic treatment (Olate et al., 2013). Then, similar symptoms of glenoid fossa asymmetry and hemimandibular elongation that led to the difference in therapeutic approach and suggested for careful correlation of clinical findings and imaging tests (Lopez & Ruiz, 2017).

- **The study doesn't mention what kind of hyperplasia the patients had. It was Hemimandibular Elongation (horizontal vector), Hemimandibular Hyperplasia (vertical vector) or hybrid form. Authors such as Obwegeser et al. in 1984, Wolford et al. (2014) and Lopez et al. (2019), mention it adequately.**

We thank the reviewer for the kind suggestion. Due to the certain limitations of radiography and since this was retrospective study led to our limitation in made the classification.
The references have been updated accordingly in the text:
Previous studies report several types of CH, based on radiographic and clinical characteristics that related to enlargement or hyperplasia of mandibular that will help the dental clinicians in understanding the complexity of facial asymmetry in 3 dimension (Obwegesser & Makek, 1986; Wolford et al., 2014; Lopez et al., 2019)

- **The inclusion criteria mention that patients should have temporomandibular dysfunction within their diagnostic process. On the one hand, temporomandibular dysfunction is not a pathognomonic sign of the pathology. (There may be condylar hyperplasia without temporomandibular dysfunction). On the other hand, if this variable is taken, the occlusal findings could be the result of the dysfunction or hyperplasia? This should be mentioned in the discussion.**

We thank the reviewer for the kind suggestion. Since the orthognatic surgery was not popular in our province, the treatment approach was only orthodontic treatment and stability of treatment was questioned. In this study, the similar symptoms make difficult, so that in my conclusion we suggested for dental arch evaluation in treating the orthodontic patients with suspected CH. We have revised by mentioning in discussion: "This findings related to the positive temporomandibular joint disorder as a concurrent symptoms with facial asymmetry, although this dysfunction is not a pathognomonic sign of the pathology.

- **In the results, the distance of the upper canines from the mid-palatal suture in women appears to be statistically significant. This finding could be related to the anatomical characteristics of female arches and not to arches of hyperplastic patients. This could be solved, using a control group.**

We thank the reviewer for the kind advice. We will consider about the control group in future study which related to asymmetry of glenoid fossa analysis as differential diagnosis for hemimandibular elongation (Lopez & Ruiz, 2017).

- **There are dental measures that could have been easily taken in the models and that would increase the variables of the study, such as: the angle classification, the torque of the posterior teeth.**

We thank the reviewer for the kind recommendation. Since these variables of the study will be fundamental for longitudinal study which is very important in treating the development of asymmetry occurred in CH. We have added this suggestion and will be considered in the future study. By understanding the characteristics of brackets, the clinician can obtain the desired teeth movement in achieve proper dental arch (Lopez et al., 2016).

- **Finally, HC is an alteration that produces anatomical changes due to condylar overgrowth and positional changes due to the displacement of the jaw towards the contralateral side. Therefore, the long or hyperplastic side should be compared with the short or contralateral side in the variables taken.**

We thank the reviewer for the comment. The following statements was added in the manuscript according to Lopez, 2017: “Previous studies reported Finishing treatment in the soft tissues usually require condylectomy to stop CH, surgery to correct skeletal discrepancy, and res correction, especially in patients with longstanding condylar hyperplasia, and soft tissue procedures include facelifts, augmentation using medpor implants or fat grafts to achieve aesthetics as alternative treatment in patients longstanding CH (Alyamani & Abuzinada, 2012; Lopez et al., 2017).
“Such as: The similar symptoms of glenoid fossa asymmetry and hemimandibular elongation that led to the difference in therapeutic approach and suggested for careful correlation of clinical findings and imaging tests (Lopez & Ruiz, 2017)
Thus, the characteristics of brackets should be well understood by the clinician to obtain the desired teeth movement in achieve proper dental arch (Lopez et al., 2016).

- **The conclusions postulate that asymmetric occlusal changes were observed in these patients, but the only statistically significant change was the superior canine distance in women. This should not be such a general conclusion and secondly this finding could be both occlusal and skeletal.**

We thank the reviewer for the suggestion. The following statement was incorporated in the conclusion of manuscript: “Indeed skeletal asymmetry, the evaluation of the dental arch characteristic symmetry and arch form showed asymmetric occlusal characteristics in orthodontics patient with suspected CH in North Sumatera subpopulation”.

Competing Interests: We declare no competing interests

Version 1

Reviewer Report 12 May 2020

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This study aimed to evaluate dental arches by analyzing dental arch asymmetry and form in orthodontic patients with CH in a North Sumatra subpopulation. Retrospective study design in 34 patients, 10-30 years old.

Abstract:

- Adequate.

Introduction:
- Adequate.

Methods:

Participants Inclusion:
- CH suspected subjects fulfilled the following characteristics: facial asymmetry based on photography, posterior cross bite and midline deviation in plaster casts analysis, and positive temporomandibular joint disorder in functional analysis.

- It is unclear if patients needed to have all of these? The reason for asking, a fair amount of patients with CH do not have any functional issues with the TMJ joint.

- At what time points were the records taken and studied? The same protocol for all patients? And at what ages?

Results:
- Age of inclusion? Would the authors expect a difference in the still active versus the non-active growth patients? If so please show the actual ages at inclusion and follow-up. And add a paragraph to the results about this.

- I do not see the patients classified as being either left or right side CH? Were they grouped? That does not make a lot of sense to me, especially when looking at the deviation of midline. Please elaborate.

Discussion:
- Adequate

Tables:
- The legend should include explanation of the abbreviations used in the table.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 05 Jun 2020

Ervina Sofyanti, Universitas Sumatera Utara, Medan, Indonesia

Dear Dr. Maarten J. Koudstaal,
We want to thank you for providing us with valuable advice for the manuscript.

- **CH suspected subjects fulfilled the following characteristics: facial asymmetry based on photography, posterior crossbite and midline deviation in plaster casts analysis, and positive temporomandibular joint disorder in functional analysis.**

We thank the reviewer for the suggestion. Since this is a study from a retrospective study of suspected CH patient's clinical records, we assessed that any pain, clicking, crepitation, pain, and other sign or symptom of positive temporomandibular joint disorder from the extraoral analysis will be included.

- **It is unclear if patients needed to have all of these? The reason for asking, a fair amount of patients with CH do not have any functional issues with the TMJ joint.**

We thank you for the comments. We include all these criteria in select cases based on patients' information medical records. We include patients with symptoms and/or TMD signs based on dental records.

- **At what time points were the records taken and studied? The same protocol for all patients? And at what ages?**

We thank you for kindly advising. The orthodontics patient's data medical records was collected and selected during January 2015 and March 2019. However, this information was collected by different orthodontic clinicians and the age of patients based on the date of birth stated in the medical record. We have also revised the resources data by adding the sample's age. (Sofyanti E, Boel T, Satria D, et al.: Replication Data for Angular and linear measurement of the dental arch asymmetry and dental arch form. Harvard Dataverse, V1, UNF:6:GiTmDSqATBmhdCM366FFoQ== [fileUNF],2020. http://www.doi.org/10.7910/DVN/GONORA).

- **Results: Age of inclusion? Would the authors expect a difference in the still-active versus the non-active growth patients? If so please show the actual ages at inclusion and follow-up. And add a paragraph to the results about this.**

We thank you for the reviewer's advice. Based on the date of birth, the samples were selected between 10 to 30 years old in this study according to the previous study that reports about the age of condylar hyperplasia patients in the discussion phase. (Pacheco et al., 2010; Bharathi et al., 2014; Lopez & Herrera-Guadiola., 2016; Lopez et al., 2017; Goulart et al., 2018). The limitation of this study was less information about the activity of condylar growth due to the dental hospital didn/t have 3D CBCT in that time to evaluate the condylar precisely.

- **I do not see the patients classified as being either left or right side CH? Were they grouped? That does not make a lot of sense to me, especially when looking at the deviation of the midline. Please elaborate.**

Based on previous medical records, we include samples with a deviation of midline in occlusion transversally. In this study, we analyzed the upper and lower arch based on Scanavini and Raberin method in the plaster cast of suspected CH as mentioned in the material and method based on previous studies about CH clinical findings.

Competing Interests: We declare no competing interest