Prediction of Mandibulofacial Asymmetry using Risk Factor Index and Model of Dentocraniofacial Morphological Pattern

Maria Purbiati[1], Miesje Karmiati Purwanegara[1], Linda Kusdhany[2], Laura Susanti Himawan[2]*

1. Department of Orthodontic, Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia.
2. Department of Prosthodontic, Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia.

Abstract

Patients with mandibulofacial asymmetry will suffering from aesthetical, psychological, functional disturbance, and has a poor prognosis. The aim of the research was to get the prediction index through the study of risk factors for prevention and early detection. The study was conducted in several schools in Jakarta, on 234 Indonesian physical characteristics aged 8-30 years. Data were obtained from questionnaires and examinations (clinical, functional, photographic, and radiographic examinations). The main risk factor is One-sided Sleep Habit and Temporomandibular Joint Disorder Sign.

It was detected that mandibulofacial asymmetry characterized a specific pattern of dental and skeletal morphology. Risk Factors Index and Model of Dentocraniofacial Morphological Pattern can be used to predict the occurrence of asymmetry mandibulofacial.

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Introduction

Malocclusion is one of dental problems in Indonesia with high prevalence. Malocclusion could affect general health, oral and stomatognatic function, and psychological aspect due to esthetic problem. Preventive and rehabilitative actions for malocclusion case are complicating by many factors including mandibulofacial asymmetry. Malocclusion with mandibulofacial asymmetry give a worse prognosis.(1,2)

Asymmetry is considered as a normal phenomenon, but will be a problem whenever it becomes a disturbance functionally and aesthetically, especially mandibular asymmetry. The most asymmetric patient complain is imbalance facial esthetics reasons. Recent study with large samples of 4,509 high school students in Korea showed that imbalanced tooth position reduced self-esteem. It was not only functional and aesthetical problem, Shackelford and Larsen from University of Michigan proved that facial asymmetry was one of indicators of psychological and emotional condition, as well as physiological problems, a similar result of Grammer and Thornhill research.(3,4,5)

Prevention and early treatment of malocclusion with mandibulofacial asymmetry had not had a clear protocol yet. It was often unoticeable by general practitioners in the front line of prevention. Prevention should be given more attention by the health practitioners and national health system. World Health Organization (WHO) was paying attention on prevention so that it could be integrated to health system. If chronical diseases or abnormalities were not being prevented, health management in every country would have problem of high cost health system in 2020. Disease or abnormality prevention had high economic value.(6,7)

For preventive effort, the most important step is to find etiology. Knowing the cause of asymmetry as the result of growth abnormality would open the window of management of malocclusion with mandibulofacial asymmetry. It

Corresponding author:
Maria Purbiati Indratoto, Dr, drg, SpOrt(K)
Lecturer
Department of Orthodontic
Faculty of Dentistry, Universitas Indonesia
Building B Level 2
Jalan Salemba Raya no 4, Jakarta 10430, Indonesia

E-mail: mariapurbiati@yahoo.com, maria.purbiati@ui.ac.id

was needed to detect the causing factors and its interactions. As it was the result of growth process, prediction factors were performed on growth factors. This research was done in order to predict the occurance of mandibulofacial asymmetry by finding the affecting factors and its characteristics.

Materials and methods

This population based cross-sectional research design was done at the government schools in Central and West Jakarta which were chosen due to heterogen Indonesian ethnics and social-economics reasons. Research target populations were pre-pubertal age, pubertal, and post-pubertal groups that met the sample criteria. After passing the ethical clearance, data was taken through questionnaires, clinical and functional examination, and analysis of extra-oral photographs, lateral and posteroanterior cephalometry.

Questionnaires consist of subject identity and demographic data including age and gender, history of mandibular trauma occured on natal and post-natal, bad oral and postural habit related to asymmetry (One-sided Chewing, One-sided Chin Shift, One-sided Chin Prop, and One-sided Sleep Habit) and Temporo Mandibular Disorder (TMD) Symptoms which was taken through 8 questionnaires of Temporo Mandibular Disorder Diagnostic Index (TMD-DI)[8]. Mandibular soft tissue and skeletal asymmetry determined by measuring the position of Menton to the Facial Midline on extra oral photograph and posteroanterior cephalogram. Genetic factor detected through fenotype manifestation of skeletal morphology and dental malocclusion diagnosed from clinical examination, lateral and posteroanterior cephalogram. Skeletal morphology consist of : Sagital aspect (Angles of SNA, SNB, ANB, Maxillary and Mandibular Length, Overjet), Vertical aspect (Ramus Length, Lower Anterior Facial Height/LAFH, Frankfurt Mandibular Angle/FMA, Occlusal Plane/OP, Overbite), and Transversal aspect (the difference between right and left of length of points Zygomatic/Z, Nasal/N, Jugulare/J, Antegonial/Ag, Upper and Lower Basal Arch Width/UBAW & LBAW, Upper and Lower Incisor to Mid Sagital Reference/U1-MSR & L1-MSR). Dental condition and malocclusion including Unilateral Posterior Crossbite, Crowding, Right and Left Molar and Canine Relationship, One-sided Missing Tooth, One-sided Severe Tooth Decay, Functional examination was useful to detect Vertical Occlusal Inteference and TMD Sign. There were 16 variables investigated as risk factors of mandibulofacial asymmetry.

Statistical analysis was including univariate, bivariate and multivariate testing. On categoric dependent variable and categoric independent variable, statistical analysis was using chi-square test, whereas on numeric dependent variable, it was using unpaired t-test. In cross-sectional design or prevalence study, risk estimation used was Prevalence Ratio (PR). PR was used to compare between mandibulofacial asymmetry prevalence to risk factor with asymmetry prevalence of non-risk group.

Multivariate analysis was done on variables by using backward stepwise selection with significancy of 0.25. Scoring model was made to build risk factor index and model of dentocraniofacial morphological pattern. These index were applied to subjects that represented each age group.

Results

Sample size of preliminary research was 564 subjects (symmetry determination was based on soft tissue symmetry only) were used to determine sample size of main research which was 234 subjects (symmetry determination was based on soft tissue and skeletal symmetry) and had over-reached sample-size estimation of 194 subjects. General proportion of asymmetry case in main research was 32.9% (from 234 subjects, 77 subjects with asymmetry and 157 subjects with symmetry).

They were 31.8% were from Pre Pubertal group, 35.8% of Pubertal, and 30.5% of Post Pubertal. Subjects showed increasing skeletal asymmetry along with increasing age, those were Pre Pubertal 9.1%, Pubertal 12.6%, and Post Pubertal 17.9%.

Sample size for reliability test was 25 subjects. Data was numeric and tested using Bland-Altman and paired t test. In general, mean of difference from each analysis was small and clinically insignificant with paired t-test result of $p>0.05$. Kappa test was used for functional examination variable with categoric data and gave result 0.869 with significancy level $p>0.000$.

There was a strong relationship between gender and mandibulofacial asymmetry (p=0.017; PR=1.292; 95% CI=1.034-1.613). The percentage of asymmetry was higher on male (44% of male subjects) than on female (27.7% of female subjects), which was statistically significant. Male had higher risk than female to have asymmetry, whether it was soft tissue, skeletal, or both. There was no statisticaly significant between asymmetry and chronological age.

There were seven variables obtained from questionnaires, those were Mandibular Trauma (2 variables), Bad Habits (4 variables), and TMD Symptom (1 variable). Data obtained for Mandibular Trauma during birth (Natal) and Post Natal trauma were not enough to have a significant correlation. Two of bad habits, those were One-sided Chewing Habit and One-sided Chin Shift, had not significant correlation with asymmetry. One-sided Sleep Habit had significant correlation (p=0.002) and One-sided Chin Prop was significantly correlated in a weaker degree (p=0.123). 146 subjects (62.4%) of 234 respondents were detected experienced TMD Symptom, where as 53 subjects of it (36.3%) were having mandibulofacial asymmetry.

Variable			Symmetry		Asymmetry		Total	p	PR	95% CI
Mandibular Trauma										
During Birth (Natal)	No	155	67.1%	76	32.9%	231	100.0%	1.000	1.006	0.450-2.252
	Yes	52	66.7%	1	33.3%	3	100.0%			
Post Natal	No	154	67.5%	74	32.5%	228	100.0%	0.398	1.351	0.604-3.022
	Yes	3	50.0%	3	50.0%	6	100.0%			
Bad Habits										
One-sided Chewing	No	58	63.7%	33	36.3%	91	100.0%	0.395	0.921	0.448-1.362
	Yes	99	69.2%	44	30.8%	143	100.0%			
One-sided Sleep Habit	No	83	77.6%	24	22.4%	107	100.0%	0.002***	1.331	1.113-1.592
	Yes	74	58.3%	53	41.7%	127	100.0%			
One-sided Chin Prop	No	75	72.8%	28	27.2%	103	100.0%	0.123*	1.163	0.974-1.389
	Yes	82	62.6%	49	37.4%	131	100.0%			
One-sided Chin Shift	No	123	68.3%	57	31.7%	180	100.0%	0.510	1.085	0.864-1.362
	Yes	34	63.0%	20	37.0%	54	100.0%			
Temporomandibular Disorders Symptom										
TMD Symptom	No	64	72.7%	24	27.3%	88	100.0%	0.196*	1.142	0.956-1.363
	Yes	93	63.7%	53	36.3%	146	100.0%			
Total		157	67.1%	77	32.9%	234	100.0%			

Table 1. Result of Bivariate Analysis of Mandibular Trauma, Bad Habits, and TMD Symptom on Mandibulofacial Asymmetry. ***P<0.05 = strong; **0.05<p<0.1 = moderate; *0.1<p<0.25 = weak

Data of functional abnormality variable consisted of Vertical Occlusal Interference (premature contact) and TMD Sign. In this research, both variables were highly correlated to mandibulofacial asymmetry.

There were significant difference between symmetry and asymmetry on skeletal morphology on sagital aspect, those were SNA, SNB, ANB, Maxillary Length, Mandibular Length; on vertical aspect were LAFH, Mandible Ramus Length, Anterior Overbite; and on transversal aspect were Z, N, J, Ag, UBAW, OP, U1-MSR, L1-MSR. Dental condition and maloclussion which gave significant difference were Molar and Canine Relationship; Unilateral Posterior Crossbite, One-sided Missing Tooth, and One-sided Severe Tooth Decay. No significant difference on Anterior Overbite, FMA, LBAW, UBAW-LBAW, and Crowding.

Skeletal asymmetry group had specific morphology pattern which were asymmetry group had smaller SNA parameter, larger SNB, smaller ANB, larger mandibular length, smaller overbite, they were also had larger ramus length, larger LAFH, smaller FMA, larger OP, larger Ag distance, and larger L1-MSR compared to symmetrycal group.

Multivariate analysis summarized that six variables from the final analysis result affected on mandibulofacial asymmetry. The risk value based on Prevalence Risk (Ratio Odds prevalence under 30%), with sequence of role factor (wald value):

1. Subject that had One-sided Sleep Habit had a higher risk of mandibulofacial asymmetry occurance 2.762 times than Non One-sided Sleep Habit
2. Subject that had TMD Symptom had a higher risk of mandibulofacial asymmetry occurance 2.668 times than Non TMD Symptom subjects
3. Male subject had a higher risk of mandibulofacial asymmetry occurance 2.447 times than Female.
4. Subject that had Vertical Occlusal Interference had a higher risk of mandibulofacial asymmetry occurance 3.687 times than non Vertical Occlusal Interference.
5. Subject that had TMD Sign had a higher risk of mandibulofacial asymmetry occurance 1.612 times than non TMD Sign.
6. Subject that had Class III skeletal relationship/small ANB had a higher risk of mandibulofacial asymmetry occurance 2.082 times than Non Class III.

It was also proven that other risk factor that affected on the occurance of mandibulofacial asymmetry were Gender, One-sided Sleep Habit, TMD Symptom, TMD Sign, Vertical Occlusal Interference, and upper and lower arches relationship/ANB. Main risk factor with the biggest Wald value were One-sided Sleep Habit and TMD Sign, with Logistic regression (risk factor of regression model):

P Logit (mandibulofacial asymmetry) = -2.558 + (0.895) Gender + (1.016) One-Sided Sleep Habit + (0.478) TMD Symptom+ (0.981) TMD Sign + (1.305) Vertical Occlussal Interference + (0.733) Sagital Jaw Relationship.

P value (Probability of Mandibulofacial Asymmetry) was subject/patient probability to have mandibulofacial asymmetry during examination or in the future based on risk factor that had been detected during examination which was : p%.

Scoring model was made to build risk factor index with score of cut off point which was 14 (sensitivity 62.3%, Specificity 70.1%, and the area under the ROC curve 0.662). Every variable was code 0 and 1, and the variable value determined proportionaly. Total score was between 0 to 34. Score less than 14 interpreted as Low Risk, whereas score 14 or more than 14 interpreted as High Risk.

Manual and computer program softwares were made for easy everyday usage by general practitioner or specialist in computer-based area and non computer. (Table 2 and 3)

TEMPOROMANDIBULAR DISORDER DIAGNOSTIC INDEX (TMD-DI)			
No	**Question Lists**	**Code**	**Filling Instruction**
1	Do you have symptom such as headache?		**Fill in code with:** 0 = Never 1 = Sometimes 2 = Often 3 = Always
2	Do you have symptom such as pain during close and open mouth?		
3	Do you have symptom of joint trismus when getting up in the morning?		
4	Do you have symptom of pain around neck?		
5	Do you have symptom of tinnitus?		
6	Do you clench your teeth when in worries?		
7	Do you clench your teeth when in anger?		
8	Do you clench your teeth when concentrating?		
TOTAL SCORE			
Total Score : 0 – 24 Total Score ≤ 3 : Temporomandibular Disorder Symptom Code = 0 Total Score > 3 : Temporomandibular Disorder Symptom Code = 1			

Table 2. Temporomandibular Disorder Diagnostic Index (TMD-DI).

Every software (manually or computer-based) must fill in Temporomandibular Disorder Diagnostic Index (TMD-DI) in order to completing the Risk Factor Index table.

MANDIBULOFACIAL ASYMMETRY RISK FACTOR INDEX			
No	**Question Lists**	**Code**	**Fill in Code with**
1	**Gender**		1 = Male 0 = Female
2	**One-sided Sleep Habit**		1 = Yes 0 = No
3	**Temporo Mandibular Disorder Symptom**		1 = Yes 0 = No
4	**Temporo Mandibular Disorder Sign**		1 = Yes 0 = No
5	**Vertical Occlusal Interference**		1 = Yes 0 = No
6	**Sagital Jaw Relationship**		1 = Class III 0 = Class I dan II
Total Score			
Scoring Interpretation		**LOW/HIGH RISK**	

Table 3. Risk Factor Index to Predict Mandibulofacial Asymmetry.

Multivariate analysis was done also for morphology variables. Significant model could be the model of dentocraniofacial morphology pattern to predict mandibulofacial asymmetry. This model could be use as the guideline to establish diagnosis of asymmetry case. It would be risk value based on Prevalence Risk and it was put in sequence according to risk factor role (based on Wald value): Subject with larger degree of Occlusal Plane (OP) Canting would have higher risk of mandibulofacial asymmetry 1.347 times than subject with smaller degree of Occlusal Plane (OP) canting. The bigger tipped of Occlusal Plane (OP), the higher mandibulofacial asymmetry risk.

Subject with smaller ANB angle had higher risk of mandibulofacial asymmetry 0.518 times than larger degree of ANB. The smaller ANB, the higher mandibulofacial asymmetry risk.

Subject with different Canine Relationship between left and right had higher risk of mandibulofacial asymmetry 1.679 times than subject with same Canine Relationship.

Subject with Unilateral Posterior Crossbite had higher risk of mandibulofacial asymmetry 3.959 times than subject without Unilateral Posterior Crossbite.

Subject with smaller Overbite had bigger risk of mandibulofacial asymmetry 0.892 times than subject with larger Overbite. The smaller the overbite, the higher risk of mandibulofacial asymmetry.

4. Subject with bigger difference of Antegonial (Ag) distance between right and left to MSR had bigger risk of mandibulofacial asymmetry 1.090 times than subject of smaller difference. The bigger the difference, the higher risk of mandibulofasial asymmetry.
5. Subject with bigger distance of Upper Midline to MSR had bigger risk of mandibulofacial asymmetry 1.164 times than subject with smaller distance. The bigger distance, the higher risk of mandibulofacial asymmetry.

Logistic Regression:
P Logit (dentocraniofacial morphological pattern of mandibulofacial asymmetry) = 2.124 –(0.658) Sagital Jaw Relationship – (0.114) Overbite + (0.298) Occlusal Plane Canting + (0.086) Difference of Mandible Angle Position of Right and Left + (0.152) Distance of Lower Midline to Facial Midline + (0.518) Canine Relationship + (1,376) Unilateral Posterior Crossbite P value (Probability of Mandibulofacial Asymmetry) interpretation was subject/patient probability to have mandibulofacial asymmetry during examination or in the future based on dentocraniofacial morphological pattern that was detected during treatment : p%.

When regression component of Dentocraniofacial Morphological Pattern was numeric scale and substancially could not be changed into categoric, the software could not be made into scoring model but building a regression model. (Table 4).

MODEL OF DENTOCRANIOFACIAL MORPHOLOGICAL PATTERN TO PREDICT MANDIBULOFACIAL ASYMMETRY			
No	**Question Lists**	**Score**	**Filling Instruction**
1	Sagital Jaw Relationship		Score = cephalometry analysis result
2	Anterior Overbite		
3	Occlusal Plane Canting		
4	Difference of Right and Left Mandible Angle Position		
5	Position of Lower Midline		
6	Right and Left Canine Relationship		1 = Different 0 = Same
7	Unilateral Posterior Crossbite		1 = Yes 0 = No
L Value			
Probability (P)		%	

Table 4. Regression Model of Dentocraniofacial Morphological Pattern to Predict Mandibulofacial Asymmetry.

It has been tested that score which was fit with probability level from Model of Dentocraniofacial Morphological Pattern were in line with risk level on Risk Factor Index and also fit with symmetry or asymmetry manifestation. Therefore, Risk Factor Index and Model of Dentocraniofacial Morphological Pattern could be used to predict mandibulofacial asymmetry.

Discussion

The difference of asymmetry prevalence between this research and other research (in Japan and North Carolina) was on sample subjects base. Previous research data were taken from university orthodontic clinic, whereas this research was population based. Orthodontic clinic or hospital based subject had higher prevalence of facial asymmetry as the subjects were malocclusion patients in orthodontic clinic. Prevalence of facial asymmetry in North Carolina 34% and in China 21%. Various manifestation of facial asymmetry can occure from the undetectable case until the clinically obvious case. Maeda et all showed that the prevalence of skeletal mandibular asymmetry was 26.2%, whereas maxilla was 6.1%. Similar result showed by Severt and Proffit with the prevalence of asymetry on upper facial 5%, maxilla 36%, and the higest was on mandible 74%. These result was showing that facial asymmetry mostly occure on the lower portion of face, especially mandible, as mandible is most movable and unstable part comparing with other part of human skull. Moreover, any changing of size, shape, and position of mandible will affect obviously to facial appearance. [9,10,11]

Mandibulofacial asymmetry was the result of skeletal and soft tissue growth that needed long laten time. There was a difficulty to obtain case history from very young subjects. There was also a difficulty in making direct diagnosis on field because it needed radiograph examination to have accurate diagnosis of facial symmetry. That was why the best design to answer research questions accurately, dependably, effectively, and efficiently would not be cohort or case-control. [12]

Mandibulofacial asymmetry affected dental occlusion and management. Asymmetry hindered the malocclusion management whether on growing or adult patients. Up to now, treatment results were far from ideal, especially on compromised or camuflage treatments. If asymmetry has happened and been persistent,

treatment even surgical corrected will be disturbed by muscle ability to keep the asymmetry and make the treatment results unstable with high possibility of relaps.

Growth disturbance such as asymmetry could be detected extra and intra orally in clinical examination referred to facial midline. Asymmetry would lead to functional anomaly including temporomandibular joint, dental abrasion, or lingual dysfunction. High incidence of temporomandibular disorder was also detected on patients with mandibular asymmetry, especially on mandible working side. On those cases, condyle head was positioned more posteriorly, articulare disc was dyslocated anteriorly, and symptoms of joint disorders such as clicking happened on anterior movement. It was known that joint disorder could happened from mild to severe, such as clicking, pain, trismus, also chewing muscle, neck, and back stiffness, which were hard to heal and affecting patient's activities.[13-18] Those research were testing the relationship of temporomandibular condition and asymmetry. This research combine many assumed risk factors. It confirmed statements that TMD Symptoms as well as TMD Sign were related and play a role in forming mandibulofacial asymmetry. On variable interaction tests, TMD Sign itself related to the asymmetry and gave stronger effect in combination to TMD Sypmtom and four other variables in the scoring model.

The result of clinical and statistical analysis in this epidemiology research showed that there were risk factors which affected mandible asymmetry. As the final result, there were mandibulofacial asymmetry risk factor index, and regression model of dentocraniofacial morphological pattern that had been tested to samples of Pre-pubertal, Pubertal, and Post-pubertal age and could be used to predict mandibulofacial asymmetry.

Conclusions

The Mandibulofacial Asymmetry Risk Factor Index, which including asymmetry risk factors: One-side Sleep Habit and Temporomandibular Disorder Sign, Gender, Temporomandibular Disorder Symptom, Vertical Occlusion Interference, Sagital Jaw Relationship, could be used to predict mandibulofacial asymmetry in the same time of examination or in the future by detecting whether any risk factors in the patients. Every dentist could easily use the manual or computerized index software for prevention purposes. For the high risk level of growing patients dentist or orthodontist can do interseptive treatment to avoid the severity of mandibulofacial asymmetry.

There were also specific characteristic of dental and skeletal pattern of mandibulofacial asymmetry patients. In the diagnostic process, orthodontists could use this model software to count probability of patient to have mandibulofacial asymmetry through patient's dentocraniofacial morphology condition. After detecting the risk and probability, preventive effort could be performed and treatment efficacy could be achieved by eliminating bad habits, treatment for morphological corrections, thus enhancing the treatment result and quality of life.

Declaration of Interest

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