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The Relationship between Pont, Bolton Analysis, DMF Index and the Severity of Malocclusion at SDN Gambut 10, Banjar Regency, South Kalimantan, Indonesia

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Research Article

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ABSTRACT

Background: Malocclusion is abnormal relationship between upper and lower jaw. Malocclusion can lead to not only facial aesthetics dissatisfaction, difficulty in speaking, chewing and swallowing, but also temporomandibular joint disorder and orofacial pain. There are several factors that can cause malocclusion, such as: genetics (hereditary), overall health history, oral habit and local factors (e.g.: misplaced tooth germ, agenesis, and caries). These factors can be observed by measuring jaw length and width, jaw discrepancy as well as caries severity level.

Purpose: To analyze the relationship between some etiology of malocclusion and the severity of malocclusion.

Methods and materials: This was a cross-sectional observation research to analyze the severity of malocclusion and its possible cause of etiology. Alginate impression was taken on all 104 students in grade 4-6, then poured with type III dental plaster to create study models. Several measurements were made on the models: premolar and molar width (Pont's analysis), tooth size discrepancy (Bolton's analysis), and jaw discrepancy. The severity of malocclusion was determined based on ICON index, while the severity of caries was categorized using DMF index. The data obtained were displayed in the form distribution and percentage based on gender, then Chi-square test was performed to analyze the relationship between the variables.

Results and Conclusion: The characteristics of malocclusion in grade 4-6 students at SDN Gambut 10 are mild level of malocclusion with constriction of both upper and lower jaw. There is correlation between constriction in molar region and lower jaw crowding with the severity of malocclusion. Malocclusion occurs due to various etiological factors, thus its severity cannot be determined by some factors alone.

Keywords: Malocclusion, ICON, Etiology of Malocclusion

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Background

Malocclusion is abnormal relationship between upper and lower jaw.[1] Malocclusion can lead to not only facial aesthetics dissatisfaction, difficulty in speaking, chewing and swallowing, but also temporomandibular joint disorder and orofacial pain.[2] Malocclusion and its impact to oral function and facial aesthetics have become significant points in the field of oral health. According to World Health Organization (WHO), malocclusion is the third biggest problem in oral health, after periodontal disease and dental caries.[2] Based on Indonesia's National Basic Health Research in 2018, the prevalence of oral health problem in Indonesia was 57.6%, while in South Kalimantan province was 60%. The prevalence of malocclusion in elementary school students was 15,6%.[4] There were still no data regarding malocclusion South Kalimantan Province. SDN Gambut 10 is one of the elementary schools in Banjar Regency, South Kalimantan province. Based on previous study, it was known that 9 out of 10 students at SDN Gambut 10 grade 3 suffered from malocclusion. However, its etiology was still unknown.

Orthodontic diagnosis and treatment planning can be aided by using study model. As the 3-dimensional jaw printing, various measurements can be done on the study model.[5] Arch width in each jaw (maxilla and mandible) can be analyzed using Pont's and Bolton's analysis. Besides, arch length discrepancy also plays an important role in determining orthodontic treatment plan. These methods are very useful for dentists and orthodontists to determine the etiology of malocclusion, which relates to orthodontic treatment plans, including the decision to perform tooth *slicing*, expansion, extraction, or combination of those to obtain good occlusion.[6] However, the normal values used in those analyses were made for the Caucasian ethnic group, as the original researches were done on Caucasians. Caucasians tend to have narrower jaws and more pointed noses compared to other ethnic groups.[7] On the other hand, Mongoloid ethnic group dominates most of Indonesia. As one of the 38 provinces in Indonesia, South Kalimantan was dominated by Banjar sub-ethnic group.[8-10] South Kalimantan region mostly consists of wetland areas, whose civilians may have special malocclusion

characteristics. There was still no data available on the characteristics of malocclusion in this sub-ethnic group.

Based on the explanation above, research regarding the severity of malocclusion cases and their etiology in students in 4th to 6th grade at SDN Gambut 10, Banjar Regency, South Kalimantan was performed. There has been no previous research regarding the etiology of malocclusion in wetland communities, including SDN Gambut 10.

Materials and Methods

Approval was received for this study from the local ethical review committee (reference number: 048/KEPKG-FKGULM/EC/III/2023, approved on March, 23rd 2023). This was a cross-sectional observation research to analyze the severity of malocclusion and its possible etiology. Total sampling was done on students at SDN Gambut 10, Banjar Regency, South Kalimantan with the inclusion criteria: age 9-12 years old (grade 4-6), residing in South Kalimantan, and willing to participate in this research. The exclusion criteria were samples that could not be taken impression or the impression could not be analyzed.

There were 104 students in grade 4-6 in SDN Gambut 10. Alginate impression was taken on all 104 samples, then poured with type III dental plaster to create study models. Several measurements were made on the models: premolar and molar width (Pont's analysis), tooth size discrepancy (Bolton's analysis), and arch length discrepancy. The severity of malocclusion was determined based on ICON index, while the severity of caries was categorized using DMF index. The data obtained were displayed in the form distribution and percentage based on sex, then Chi-square test was performed to analyze the relationship between the variables.

Pont's Analysis

The result of Pont's analysis can be used to determine whether dental arch expansion in the premolar and molar region needs be done during orthodontic treatment. The following parameters are required to calculate the index:[11]

- The sum of the mesiodistal width of 4 maxillary incisors (SI)
- The measured premolar value (PPV) is obtained by measuring the inter-premolar width from the distal pit of the maxillary first premolar on both sides
- The measured molar value (MMV) is obtained by measuring the inter-molar width, which is measured from the mesial pit of the maxillary first permanent molar on both sides.
- The calculated premolar value is obtained using the formula: (SI/80) x 100
- The calculated molar value is obtained using the formula: (SI/64) x 100

Bolton's Analysis

Bolton's analysis is widely used to determine the discrepancy between the size of maxillary and mandibular teeth. The mesiodistal width of 12 maxillary teeth from the incisor to the first permanent molar on either side is measured (Figure 1). Then, the sum of the mesiodistal width of 12 mandibular teeth is measured. The overall ratio is calculated using the formula (the sum of 12 mandibular teeth divided by the sum of 12 maxillary teeth) times 100. Similarly, the anterior ratio is calculated using the formula (the sum of 6 mandibular anterior teeth divided by the sum of 6 maxillary anterior teeth) times 100. The normal values of the overall and anterior Bolton ratios were determined to be 91.3% and 77.2%, respectively. The overall ratio greater than 91.3% suggests that the mandibular teeth material is in excess, while an overall ratio of less than 91.3% suggests the mandibular teeth material is deficient in comparison to those in maxillary. The anterior analysis follows the same principle.[12]

Arch Length Discrepancy (ALD)

ALD may manifest itself as crowding or spacing in dental arches. Arch length discrepancy is the difference between the available space minus the required space, where the available space represents the basal region available in the dental arch (Figure 2), and the required space is the sum of the mesiodistal length of existing teeth.[13]

ICON Index

Occlusal trait scores include:

1. Upper and lower segment alignment
2. Anterior vertical relationship, centerline, impacted teeth, upper and lower buccal

segment alignment, buccal segment AP relationship, buccal segment vertical

relationship, crossbite, missing teeth

3. Esthetic assessment based on IOTN esthetic component, overjet, reverse overjet,

upper and lower incisor inclination relative to occlusal plane, upper arch crowding/

spacing, lip competenc

ICON index measures several points, which include:[14]

1. Upper and lower segment alignment
2. Anterior vertical relationship, centerline, impacted teeth, upper and lower buccal segment alignment, buccal segment antero-posterior relationship, buccal segment vertical relationship, crossbite, missing teeth
3. Esthetic assessment based on IOTN esthetic component, which visually scores: overjet, reverse overjet, upper and lower incisor inclination relative to occlusal plane, and upper arch crowding/spacing.

DMF Index

This index determines the number of decayed (D), missing (M) and filled (F) teeth on dental surfaces. The sum of those tooth surfaces was divided by the total number of evaluated surfaces (molars and premolars having five surfaces and incisors and canines having four surfaces).[15]

Figure 1: Measuring the mesiodistal width of the second right premolar using caliper.[13]

Figure 2: Measuring available space with brass wire.[13]

Results

The most common type of malocclusion found was Angle class I malocclusion (92%), followed by Angle class II (4%) and class III (4%), with anterior crowding. Anterior crowding was marked with a negative value of space discrepancy on each maxilla and mandible. Space discrepancy is the contrast between mesiodistal teeth size and the length of the alveolar base on each jaw. Descriptive data of each arch length and space discrepancy are shown in Table 1.

Based on Pont's analysis, there were arch constrictions both in premolar and molar regions in all samples. Mild premolar arch constriction occurred the most (69.2%), followed by moderate (26.9%) and severe constriction (3.8%). In the molar region, mild constriction was found at 61.5%, while moderate constriction was 23.1% and severe constriction was 15.4%. Based on Bolton's analysis, it was known that there was nonconformity of teeth size in the mandible (on anterior teeth in 76.9% of samples, and overall teeth in 65.4% of samples) (Table 2).

The severity level of malocclusion based on ICON index showed that most malocclusion cases were categorized as easy (42.3%), followed by moderate (23%), difficult (18.5%), and extremely difficult (11.5%) (Table 3). There was no significant difference in the ICON score between men and women samples ($p<0.05$). Based on DMF category results, it was shown that most samples had very low and low carious teeth (Table 4).

Kolmogorov-Smirnov test and Levene's homogeneity test showed that all data above were normal and homogeneous. Based on independent T-test results, there was no significant difference in all variables between men and women, except in the maxillary arch length. The mean of maxillary arch length in male samples was significantly higher than that in female samples ($p<0.05$). However,

there were no significant difference in mandibular arch length and space discrepancies.

There was a correlation between maxillary molar arch constriction, mandibular space discrepancy and the severity of malocclusion, although there was no significant correlation between the severity of malocclusion and other etiological variables of malocclusion in this study (Table 5).

Table 1. Mean of arch length and space discrepancies based on gender.

Gender	Maxillary arch length (mm)	Mandibular arch length (mm)	Maxillary space discrepancy (mm)	Mandibular space discrepancy (mm)
Men	102.69 ± 5.60	92.92 ± 4.52	-1.53 ± 6.36	-0.84 ± 1.48
Women	97.08 ± 5.99	89.65 ± 4.04	-1.81 ± 3.92	-2.38 ± 0.90

Table 2. Mean of Pont's and Bolton's analysis variables.

	Pont's Analysis		Bolton's Analysis			
Gender	Maxillary premolar length (mm)	Maxillary molar length (mm)	6 maxillary anterior teeth (mm)	6 mandibular anterior teeth (mm)	12 maxillary teeth (mm)	12 mandibular teeth (mm)
Men	38.88 ± 2.42	47.35 ± 3.40	49.65 ± 4.17	39.35 ± 3.44	104.23±7.63	94.12 ± 4.51
Women	38.19 ± 4.66	47.27 ± 6.31	46.92 ± 4.15	39.50 ± 2.72	98.88 ± 3.43	92.04 ± 5.04

Table 3. ICON category result

	Easy (score 0-29)	Mild (score 30-49)	Moderate (score 50-62)	Difficult (score 63-76)	Very difficult (score >77)
Men	12 (11.5%)	4 (3.8%)	12 (11.5%)	12 (11.5%)	12 (11.5%)
Women	32 (30.8%)	0 (0%)	12 (11.5%)	8 (7.6%)	0 (0%)
Total	**44 (42.3%)**	**4 (3.8%)**	**24 (23%)**	**20 (18,5%)**	**12 (11.5%)**

Table 4. DMF category result

	Very low (score <3)	Low (score 4-6)	Moderate (score 7-9)	High (score >10)
Men	35 (33.7%)	0 (0%)	0 (0%)	7 (6.7%)
Women	28 (27.9%)	21 (20.2%)	14 (13.5%)	0 (0%)
Total	**63 (60.6%)**	**21 (20.2%)**	**14 (13.5%)**	**7 (6.7%)**

Table 5. P values of correlation between etiology of malocclusion with Malocclusion Severity Level (ICON)

	Pont premolar analysis	Pont molar analysis	Anterior Bolton analysis	Overall Bolton analysis	Maxillary space discrepancy	Mandibular space discrepancy	DMF
ICON	0.317	0.026*	0.262	0.139	0.107	0.005*	0.392

Note: * significant

Discussion

This research was done on grade 4-6 elementary school students (age range 9-12 years old) because the second phase of mixed dentition happens in this age range. In addition, growth spurt, which is the peak acceleration of skeletal growth and development, occurs in the age range in boys and girls.[16] The prevalence of dental patients with the age of 9-12 years old are also quite high, and they are expected to be able to cooperate well and follow dental procedures, including undergoing dental impressions.[17-19] As early malocclusion had been detected and its possible etiological factors had been known, it is better to have earlier intervention treatment to prevent it become worse.[18]

There was no significant difference in the severity of malocclusion between male and female samples. The same result was also found on other variables, such as arch width and length, teeth size, as well as the severity of caries. This result was in line with Farani's research (2021), which reported that gender does not influence the occurrence of malocclusion because men and women have the same possibility of malocclusion.[20-21] Malocclusion can be caused by differences in the size of the teeth and jaw arches, which are more related to genetic factors than to gender.[21] However, the results of this study contradict other studies which stated that men tend to have a higher severity level of malocclusion than girls do.[21]

In this research, the observed etiological factors were: arch length and width, teeth size and caries severity level. There was a correlation between arch constriction in the maxillary molar area, mandibular space discrepancy and the severity level of malocclusion. Upper molar arch constriction may be caused by various things, for example: caries proximal, habitual mouth breathing, finger biting, mastication muscle imbalance, and genetic factors. Space discrepancy that was found in this research was in the form of a lack of arch length compared to teeth size. This can also be caused by proximal caries, premature loss of teeth, and genetic factors. The majority of samples had tooth displacement to the mesial, which would also cause the shortening of arch length. The presence of proximal caries, as well as missing teeth, may cause mesial tooth migration which will result in the reduction of arch length and tooth spacing.[22-24] Moreover, premature primary tooth loss may lead to the loss of permanent tooth

eruption reference, which will further cause arch shortening and the worsening of malocclusion.[25]

It was found that there was no significant correlation between the severity level of malocclusion (based on ICON index) and observed etiological factors. It was due to the etiology of malocclusion was very complex. Kusnoto (2014) explained that there were several factors that lead to malocclusion, which were categorized into general and local factors. General factors include congenital, hereditary, environmental, malnutrition, and bad habits, while local factors are anomalies in the number of teeth, tooth shape, tooth size, caries and premature extraction of deciduous teeth.[26] Other research also stated that the longer the duration and the frequency of bad habits, the worse the severity of malocclusion.[27]

Dental caries can cause the shortening of arch length,[22] as interproximal caries can reduce mesiodistal tooth size and cause the adjacent tooth to migrate to the mesial. It can result in crowded teeth as well as abnormal molar relations.[28] Severe caries in primary molars will also cause the disintegration of tooth crowns and may alter the chewing habit in children over time. As a result, temporomandibular joint disorder may occur, which may lead to the worsening of malocclusion.[22] However, no correlation was found between the severity of caries and the severity of malocclusion in this study. This result was in line with research by Fadel (2022) and Luzzi (2011).[29-30] On the other hand, research by Zhou (2016) agreed that there was a significant correlation between the severity of caries and the incidence of malocclusion in younger-age children.[22] Research by Singh (2011) also stated the same opinion while using the other malocclusion severity index, namely the *Dental Aesthetic Index*.[31] The reason why the results in this study were not significant was because the majority of respondents had very low and moderate caries. Besides, the dental caries index used in this study (DMF) did not measure interproximal caries in particular.[32]

The exact etiology of malocclusion that has the strongest correlation with the level of malocclusion severity is still not found yet. Further studies need to be carried out on the other possible etiological factors, such as: genetics, the presence of bad habits as well the history of local factors (tooth persistence or premature loss). The findings about the constriction of the jaw arch in the molar area may also implicate that Pont's analysis may not apply to the Banjar tribe aged 9-12 years old. Additionally, time delays in pouring casting with dental plaster during the study model procedure may also cause measurement errors. To overcome this matter, it is suggested to use an intraoral scanner to obtain more precise measurement results and more comfortable for samples. However, measurement using the intraoral scanner was not done in this study as it was still unavailable in our area and it cost a lot to provide it.

Conclusions

The characteristics of malocclusion in grade 4-6 students at SDN Gambut 10 are mild level of malocclusion with constriction of both the upper and lower jaw. There is a correlation between constriction in the molar region and lower jaw crowding with the severity of malocclusion. Malocclusion occurs due to various etiological factors, thus its severity cannot be determined by some factors alone

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Conflict of Interest Statement

The authors declare no conflict of interest.

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