

RESEARCH ARTICLE

Comparison of the arch perimeter discrepancy in Javanese class I malocclusion: modified kesling vs. lundström analysis method at Dental Hospital Universitas Airlangga 2018-2024

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ABSTRACT

Creating orthodontic treatment more efficiently in Indonesia requires the population's facial and jaw characteristics recognition as influenced by ethnic and gender characteristics. Myriad study model analysis methods are needed to evaluate a malocclusion's treatment plan, such as modified kesling and lundström analysis which calculate Jaw Arch Perimeter (JAP) and Dental Arch Perimeter (DAP). Prior studies of different ethnicities and genders across global populations have demonstrated variations in results. Therefore, it is necessary to compare those two methods to ascertain the final result of arch perimeter discrepancy in Javanese class I malocclusion. This study aims to prove the disparity in comparison of the arch perimeter discrepancy in Javanese class I malocclusion by modified kesling vs. lundström analysis method at Dental Hospital Universitas Airlangga 2018-2024. Applied inclusion criteria: Javanese ethnicity, age 18–25 years, permanent dentition (first molar to first molar), and no prior orthodontic treatment. It results in 53 samples. In lundström analysis, JAP is obtained by enumerating segmentally measuring pairs of teeth using a caliper. In the modified kesling, JAP is obtained by tracing the model on plastic mica. Then, continue by making pre-correction JAP with a marker and making post-correction JAP by measuring the ideal arch using a 0.1 mm copper wire. This study identifies a statistically significant final value difference between those two methods. This study identified statistically significant differences in arch perimeter values using modified kesling method and lundström analysis, whilst no significant differences in arch circumference by gender.

Keywords: arch length discrepancy; class I malocclusion lundström analysis; modified kesling

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INTRODUCTION

Indonesia is the fourth most populous country in the world, with a population of 278.69 million as of mid-2023.¹ However, 57.6% of Indonesians experienced dental and oral health problems, with malocclusion having a high prevalence rate of 80%, and only 0.3% receiving orthodontic treatment.² Malocclusion cases that are not appropriately handled have concerns related to dental health, quality of life issues arising from appearance, function, and the psychosocial impact of the teeth.³

A solution to create orthodontic treatment more efficiently is by recognizing the facial and jaw characteristics of a population; then, the norms'

findings will serve as a guide in Research regarding gender influence. It was discovered that the lack of space in men is significantly greater than in women, using the Kesling Method and ALD.⁴ Another research study also found that the average measurement of total arch length by Howe's Index was higher in male than female undergraduate students of Proto-Malay origin from the University of Sumatra Utara.⁵

One of the dental and oral care treatments is orthodontic treatment for malocclusion.⁶ In 1899, Edward angle invented the concept of ideal dental occlusion in describing dental relationships, including class I, class II, and class III.⁶ In class I malocclusion, there is a normal molar relationship,

but the teeth are not aligned along the line of occlusion. Dr. Martin Dewey developed angle's class I into five types, while class III is divided into three types. In 2024, the dewey types for class I malocclusion were revised into eight types.⁷

The modified kesling technique was developed by the Department of Orthodontic Faculty of Dentistry Universitas Gadjah Mada, simplifying the kesling analysis setup model method introduced in 1956. It is carried out indirectly by measuring the planned ideal arch, also known as the jaw arch perimeter (JAP), using transparent plastic on a glass plate, which refers to the plaster study model. Then, the measurement results were compared with the calculated sum of mesio-distal tooth widths from the dental arch perimeter (DAP) of the study model. Lundström analysis, established in 1960, involves dividing the plaster study model into six straight-line segments, starting from the distal aspect of the first permanent molar and encompassing the mesio-distal width of twelve teeth.^{8,9} Then, record the mesio-distal width of twelve teeth as DAP and each segment size as JAP. Finally, calculate the value by JAP minus DAP formulation to identify the differences between the required space and the available space as a spatial relationship.

The variables JAP and the DAP have similarities in the modified kesling and lundström analysis. Moreover, studies of JAP and DAP in different ethnicities and genders have shown variations in results in distinct regions worldwide. This study aims to investigate the disparity in comparison of the arch perimeter discrepancy in Javanese class I malocclusion using the modified kesling vs. lundström analysis method at Dental Hospital Universitas Airlangga from 2018 to 2024.

MATERIALS AND METHODS

The research employed an analytical observational method with a cross-sectional model study, calculating the arch perimeter discrepancy measurements. Research was conducted at the, from September to December 2024. This ethical approval has been certified as ethically cleared by the Dental Hospital Universitas Airlangga.

The samples consisted of 53 study models of Javanese patients with class I angle malocclusion, modified by dewey at Dental Hospital Universitas Airlangga, from 2018 to 2024. The sample size was determined by power analysis for a one-tailed paired-samples t-test, which indicated that a minimum sample size of 52 is required to yield a statistical power of at least 0.8 with an alpha of 0.05 and a medium effect size ($d = 0.5$). Sample inclusion criteria are complete permanent teeth from the first molar in the right region to the first molar in the left area, not being treated or having received orthodontic treatment, angle's class I classification (modified by dewey), Javanese patients, and in the age range of 18 – 25 years old. The modified kesling is a technique utilised to assess space necessities in orthodontic care refined by the Orthodontics Clinic, Faculty of Dentistry, Universitas Gadjah Mada. It is a streamlined version of the set up model analysis by kesling in 1956, aiming to assess the arch discrepancy (space requirements) once an ideal jaw arch is conceptualized, closely mirroring the patient's natural arch as much as feasible. The first procedural steps of the modified kesling method start with sample identification. Second, DAP (dental arch perimeter) measurement by recording the mesio-distal width of 12 teeth using a caliper in each jaw. Third, calculate the length of the jaw arch. A glass plate is placed on the study model, and then all teeth are projected onto the model. Fourth, make the JAP (jaw arch perimeter) by designing the ideal arch, referring to the pre-correction arch in both jaws. Fifth, the final phase involves assessing arch discrepancies by comparing the difference between the DAP and the JAP.

The lundström analysis method utilizes a study model in segments, dividing the jaw arch into six linear sections, each encompassing two teeth, starting with the first permanent molars. This method involves measuring the mesio-distal width of the teeth in each segment (JAP) and calculating the cumulative width of each tooth (DAP) to identify any discrepancies, often referred to as ALD. The outcomes of these calculations are then assessed for tooth crowding using the lundström analysis. When there is a lack of space, crowding occurs,

whereas when there is an excess of space, spacing results.¹⁰ The first procedure of the lundström analysis method starts by identity identification. Second, to find out the JAP by dividing the arch in each jaw into six segments which will be labelled S1 to S6 (two teeth in a segment). Third, the JAP is discovered by summing up those six segments with a digital calliper. Fourth, measuring the mesio-distal width of 12 teeth to find out the DAP using a digital calliper. Fifth, the difference between the two describes the remaining state of the room or the required space, revealing any lack or excessiveness within the jaw.⁸

The data of the modified kesling and lundström analysis will be checked using the kolmogorov-smirnov test of normality. If the data is normally distributed, the paired t-test will be used to analyze the relevance of the modified kesling and lundström analysis. Data processing of modified kesling and lundström analysis will be checked using the kolmogorov-smirnov normality test. If the data is normally distributed, the paired t-test will be used to analyze the relevance of the modified kesling and lundström analysis. The calculation of the mean, standard deviation, percentage of class I malocclusion types, and percentage of types was also carried out using the Statistical Package for the Social Sciences program.

RESULTS

The primary purpose of this study was to compare the final results of discrepancies in using the modified kesling method with those of the lundström analysis. The results showed that the average values of the maxilla and mandible for females were 90.74 and 83.88, respectively. While in the male sample, the average DAP was 89.32 (maxilla) and 84.57 (mandible).

The discrepancy calculation by modified kesling with a sample of 53, an average maxilla is -4.43 with $SD \pm 4.42$, with minimum and maximum of 12.93 and 5.87 , respectively. The same method obtained an average mandible of 3.63 with $SD \pm 4.37$, minimum and maximum

obtained respectively of -12.86 and 3.69 . Then, the discrepancy calculation in both jaws by lundström analysis with a sample of 53, an average maxilla of -1.35 with $SD \pm 4.21$ with minimum and maximum obtained respectively of -12.51 and 9.37 . The same method obtained an average mandible of -5.07 with $SD \pm 4.52$, with minimum and maximum obtained respectively of -11.26 and 7.01 .

Furthermore, to prove whether the difference is truly real (significant), we need to interpret the results of the paired sample t-test contained in the paired sample test. Based on the data analysis, based on the output paired sample test above, if it has a sig. (2-tailed) value < 0.05 , then the data has a significant difference; if not, the data is not significantly different. Furthermore, the sig value in the data above is $< .001$, meaning there is a significant average difference.

Based on the descriptive calculation by a total of 53 samples showed in Table 1, the DAP calculation, the average value of the maxilla and mandible of females were 90.74 and 83.88 respectively. While in the male sample, the average DAP calculation results were 89.32 in the maxilla and 84.57 in the mandible.

Based on the output "paired sample test" in Table 2 and Table 3, if it has a sig. (2-tailed) value < 0.05 , then the data has a significant difference; if not, then the data is not significantly different. Moreover, the sig value in the data above is $< .001$, meaning there is a significant average difference.

From the data analyzed by ANOVA, some discrepancies were found between the upper and lower jaws when using the modified kesling method and lundström. Table 4 showed from the three existing class 1 dewey types, Angle class 1 type 1 is the sample with the largest number, namely 36 out of 53. It is also known from table 4 that the longest JAP is in Dewey class 1 type 6 using the modified kesling method with a mean of 93.36 ± 3.05 and the longest DAP is in dewey class 1 type 3 with a mean of 94.08 ± 7.81 . Then, in the mandible, it is known that the longest JAP is in dewey class 1 type 6 using lundström with a

Table 1. Analytic description modified kesling and lundström method

		n	Minimum	Maximum	Mean	Std. Deviation
Female (DAP)	Maxilla	45	81.18	108.78	90.74	5.51
	Mandible	45	74.08	98.55	83.88	4.93
Male (DAP)	Maxilla	8	80.16	95.25	89.32	5.03
	Mandible	8	80.45	89.04	84.57	3.09
Modified Kesling	Maxilla	53	-12.93	5.87	-4.43	4.42
	Mandible	53	-12.86	3.69	-3.63	4.37
	Maxilla	53	-12.51	9.37	-1.35	4.21
	Mandible	53	-11.26	7.01	-0.57	4.52

Table 2. Paired t-test result for maxilla group

Paired differences								
Pair 1	Maxilla of Modified Kesling – Maxilla of Lundström Method	Mean	Std. Deviation	95% Confidence Interval of the Difference		t	df	Sig.(2- tailed)
				Lower	Upper			
		-3.08	4.03	-4.19	-1.96	-5.5	52	<.001*

*There is a significant correlation (p-value < 0.05)

Table 3. Paired t-test result for mandible group

Paired differences								
Pair 1	Mandible of Modified Kesling – Mandible of Lundström Method	Mean	Std. Deviation	95% Confidence Interval of the Difference		t	df	Sig.(2- tailed)
				Lower	Upper			
		-3.06	4.29	-4.24	-1.88	-5.19	52	<.001*

*There is a significant correlation (p-value < 0.05)

mean of 88.73 ± 4.02 and the longest DAP is in dewey class 1 type 3 with a mean of 86.17 ± 6.54 .

Then, the result of the post hoc calculation was continued to see the differences in detail between the results of each dewey type, until it was found that there were some non-significant differences. By the Table 5, Table 6, Table 7, and Table 8 dewey's modifications for angle's class I, types 1 to 6, and types 3 to 6. Moreover, other differences in the mandible were observed using the same method between type 1 and type 2, as well as between type 2 and type 3. On the other hand, lundström's analysis reveals intergroup

differences in the calculation only in the maxilla, specifically between dewey's modifications for angle's class I type 1 to type 6 and type 3 to type 6.

The result of the gender ratio portrays an imbalance in the sample with a more excellent female ratio. By Table 1 it shows that 45 of 53 samples were female, with 84.9 in percentage. The male samples are only 8 out of 53 samples with 15.1 percentage. Based on the independent t-test analysis of both methods in table 9 and table 10, modified kesling and lundström, on the male and female gender, it shows a p-value > 0.05, which means there is no significant difference.

Table 4. Malocclusion Class 1 Dewey Types Mean

	n	Mean	
		Maxilla ± SD	Mandible ± SD
DAP Type 6	4	89.03 ± 4.02	86.04 ± 3.99
JAP Kesling Type 6	4	93.36 ± 3.05	88.73 ± 4.02
JAP Lundström Type 6	4	91.27 ± 3.98	88.29 ± 2.83
DAP Type 1	36	89.99 ± 5.12	83.43 ± 4.44
JAP Kesling Type 1	36	84.60 ± 4.95	79.10 ± 4.44
JAP Lundström Type 1	36	88.88 ± 4.45	82.98 ± 3.54
DAP Type 2	5	89.91 ± 1.78	82.90 ± 2.71
JAP Kesling Type 2	5	87.53 ± 4.51	82.43 ± 3.09
JAP Lundström Type 2	5	89.11 ± 3.30	82.67 ± 4.19
DAP Type 3	8	94.08 ± 7.81	86.17 ± 6.54
JAP Kesling Type 3	8	88.33 ± 7.82	80.46 ± 6.88
JAP Lundström Type 3	8	89.50 ± 6.84	83.37 ± 5.04

Table 5. Post hoc test of maxilla by modified kesling

(I) TYPES	(J) TYPES	Mean difference (I-J)	Sig.
Type 6	Type 1	9.72	<.001*
	Type 2	6.70	.008
	Type 3	10.0	<.001*
Type 1	Type 6	-9.72	<.001*
	Type 2	-3.01	.008
	Type 3	0.35	.804
Type 2	Type 6	-6.70	.008
	Type 1	3.01	.008
	Type 3	3.36	.110
Type 3	Type 6	-10.0	<.001*
	Type 1	-0.35	.804
	Type 2	-3.36	.110

*There is a significant correlation (p-value < 0.05)

Table 6. Post Hoc Test of Maxilla by Lundström

(I) Types	(J) Types	Mean difference (I-J)	Sig.
Type 6	Type 1	3.34	.120
	Type 2	3.03	.246
	Type 3	6.81	<.008*
Type 1	Type 6	-3.34	<.120
	Type 2	-.306	.873
	Type 3	3.46	.032*
Type 2	Type 6	-3.03	.264
	Type 1	.306	.873
	Type 3	3.77	.105
Type 3	Type 6	-6.81	<.008*
	Type 1	-3.46	.032*
	Type 2	-3.77	.105

*There is a significant correlation (p-value < 0.05)

DISCUSSION

The primary purpose of this study was to compare the final results of the discrepancy in using the modified kesling method with the lundström analysis. The average result in both methods shows a significant difference which is contrary to previous research conducted by Purwono in 2018. These differences may be caused by a complex adaptive system; the human

dentition is influenced by genetic, epigenetic, and environmental factors and smaller samples which 30. This complexity lends anthropological value, as it can be utilized to shed light on human evolution and behavior.¹¹ Heredity is a decisive etiological factor in malocclusions in which palatal dimensions play a role, and it is suggested that appropriate orthodontic or orthopedic procedures be used at a young age to reduce or prevent

Table 7. Post Hoc Test of Mandible by Modified Kesling

(I) Types	(J) Types	Mean Difference (I-J)	Sig.
Type 6	Type 1	7.01	.001*
	Type 2	3.15	.230
	Type 3	8.39	<.001*
Type 1	Type 6	-7.01	.001*
	Type 2	-3.85	.042*
	Type 3	1.38	.364
Type 2	Type 6	-3.15	.230
	Type 1	3.85	.042*
	Type 3	5.24	.021*
Type 3	Type 6	-8.39	<.001*
	Type 1	-1.38	.364
	Type 2	-5.24	.021*

Table 8. Post Hoc Test of Mandible by Lundström

(I) Types	(J) Types	Mean Difference (I-J)	Sig.
Type 6	Type 1	2.69	.262
	Type 2	2.47	.416
	Type 3	5.04	.073
Type 1	Type 6	-2.69	.262
	Type 2	-.214	.921
	Type 3	2.35	.187
Type 2	Type 6	-2.47	.416
	Type 1	.214	.921
	Type 3	2.56	.322
Type 3	Type 6	-5.04	.073
	Type 1	-2.35	.187
	Type 2	-2.56	.322

Table 9. Modified Kesling Female and Male Maxilla Independent T-Test

	Levene's Test	Sig (2-tailed)	Mean Difference
Female	.932	.501	-1.42
Male			-1.42

Table 10. Lundström Analysis Female and Male Mandible Independent T-Test

	Levene's Test	Sig (2-tailed)	Mean Difference
Female			.68
Male	.377	.706	.68

undesirable genetic influences on palatal width, depth, and length. Furthermore, eating habits vary by population influence the size of the human dentition.¹¹ According to Harris and Smith (1982), while genetic variation significantly impacts arch width and length, environmental factors significantly influence occlusal characteristics such as overjet, overbite, molar relationship, crowding, and rotations.¹²

This study identified four types of dewey, namely type 1 characterized by crowding at the anterior teeth of the upper jaw, type 2 with upper jaw incisors in labioversion or proclination, type 3 involving an anterior crossbite, and type 6 featuring generalized spacing or diastema on both jaws. The calculation by the Modified Kesling revealed intergroup differences in both the maxilla and mandible between dewey's modifications for angle's class i, types 1 to 6, and types 3 to 6. Moreover, other differences in the mandible were observed using the same method between

type 1 and type 2, as well as between type 2 and type 3. On the other hand, lundström's analysis reveals intergroup differences in the calculation only in the maxilla, specifically between dewey's modifications for angle's class i type 1 to type 6 and type 3 to type 6.

This difference might happen due to some factors that cause discrepancies are different. Namely, the type 6 is depicted by the existence of a diastema, which reduces the length of the DAP, although the length of the jaw arch remains normal. Then, space is distributed due to the migration of neighboring teeth to the empty area. This results in a mismatch compared to the other types. Meanwhile, in type 3, JAP is insufficient for the dental arch perimeter due to genetic or developmental factors such as large tooth size. Moreover, rotation or incorrect tooth position can cause the arch impression to look shorter. Type 1 is another type that is like type 3. A study by Devakrishnan et al in 2021 revealed that teeth

in the preferentially crowding group had bigger DAP, especially in such specific teeth (lateral incisors, also second premolars in the maxilla, and the canines, and first-second premolars in the mandible).¹³

As the statistical calculation of modified kesling on the mandible, there is a mismatch between type 1 (crowding) and type 2 (incisor proclination). It may occur due to crowding having a relationship with a larger DAP and a shorter JAP, while type 2 shows an expanded DAP due to incisor proclination, but still within a regular JAP line. Another significant difference was also seen between type 2 (proclination) and type 3 (anterior crossbite), which, while both presenting with less severe crowding, have significantly different incisor orientations. In type 2, the upper incisors are labioverted, or proclined, which increases the DAP. Meanwhile, in type 3, the upper incisors are positioned lingually to the lower incisors, resulting in an anteroposterior mismatch without significantly increasing the DAP or JAP.¹³

This study was conducted using secondary data at the Dental Hospital Universitas Airlangga, a total sampling of 53 samples was obtained according to the inclusion and exclusion criterias with eight male samples (15.09%) and 45 female samples (84.91%). Due to this percentage, the distribution of gender in this data is uneven. It is caused by the tendency of females to undergo dental care that is not only related to function but also influences the psychological well-being of the female gender, with substantial implications for body image and adaptation.¹⁴

The calculation of the dental arch perimeter by the mesiodistal size of the teeth between females and males in the Javanese tribe showed no significant difference in the upper or lower jaw. This is also in accordance with previous studies, which stated that the mesiodistal width of male teeth was more significant than female teeth using bolton analysis ratio showed no difference. There was no statistically significant difference in the size of the teeth of Javanese men and women who experienced angle class I malocclusion with

bolton analysis. This could be because the bolton analysis ratio compares the mesiodistal width of the lower jaw teeth with the mesiodistal width of the upper jaw teeth.¹⁵

CONCLUSION

The study's results, based on a sample of 53 Javanese patients with class 1 malocclusion at Dental Hospital Universitas Airlangga, compare the final value in measuring arch perimeter with the modified kesling and lundström analysis methods; there are significant differences. Significant statistically result in the results of arch perimeter discrepancy in 4 types of dewey class I malocclusion, except for mandible with the lundström analysis method. There are no significant differences in the results of dental arch perimeter (DAP) between male and female genders.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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