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Mandibulary dental arch form differences between level four polynomial method and pentamorphic pattern for normal occlusion sample

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ABSTRACT

The aim of an orthodontic treatment is to achieve aesthetic, dental health and the surrounding tissues, occlusal functional relationship, and stability. The success of an orthodontic treatment is influenced by many factors, such as diagnosis and treatment plan. In order to do a diagnosis and a treatment plan, medical record, clinical examination, radiographic examination, extra oral and intra oral photos, as well as study model analysis are needed. The purpose of this study was to evaluate the differences in dental arch form between level four polynomial and pentamorphic arch form, and to determine which one is best suitable for normal occlusion sample. This analytic comparative study was conducted at Faculty of Dentistry Universitas Padjadjaran on 13 models by comparing the dental arch form using the level four polynomial method based on mathematical calculations, the pattern of pentamorphic arch and mandibular normal occlusion as a control. The results obtained were tested using statistical analysis T student test. The results indicate a significant difference both in the form of level four polynomial method and pentamorphic arch form, when compared with mandibular normal occlusion dental arch form. Level four polynomial fits better, compare to pentamorphic arch form.

Key words: Mandibular dental arch form, level four polynomial method, pentamorphic pattern

ABSTRAK

Tujuan perawatan ortodontik adalah untuk mendapatkan estetik, kesehatan gigi dan jaringan sekitarnya, hubungan oklusal, dan stabilitas. Keberhasilan perawatan ortodontik dipengaruhi oleh beberapa faktor, seperti diagnosis dan rencana perawatan. Untuk mendapatkan diagnosis dan rencana perawatan, medical record, pemeriksaan klinis, pemeriksaan radiografis, gambaran extra and intra oral, diperlukan analisis studi model. Tujuan penelitian ini adalah untuk mengetahui adanya perbedaan bentuk lengkung gigi polinominal tingkat empat dan pola pentamorphic, serta menentukan yang mana yang lebih cocok untuk sampel dengan oklusi normal. Penelitian ini dilakukan di Fakultas Kedokteran Gigi Universitas Padjadjaran dengan sampel pada mahasiswa yang memiliki oklusi normal dan bersifat analitik komparatif. Penelitian dilakukan terhadap 13 model studi dengan membandingkan cara membentuk lengkung gigi menggunakan metoda polinomial yang dihasilkan berdasarkan perhitungan matematik, pola pentamorphic dan sampel oklusi normal rahang bawah sebagai kontrol. Hasil penelitian diuji dengan menggunakan analisis statistik T student. *Hasil penelitian menunjukkan adanya perbedaan yang*

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bermakna, baik pada bentuk lengkung gigi metoda polinomial tingkat empat maupun pola pentamorphic, bila dibandingkan dengan ukuran lengkung gigi oklusi normal rahang bawah. Polinomial tingkat empat lebih baik dibandingkan pola pentamorphic.

Key words: *Bentuk lengkung gigi rahang bawah, metoda polinomial tingkat empat, pola* pentamorphic arch

INTRODUCTION

The aim of an orthodontic treatment is to achieve aesthetic, dental health and the surrounding tissues, occlusal functional relationship, and stability. The success of an orthodontic treatment is influenced by many factors, such as diagnosis and treatment plan. In order to do a diagnosis and a treatment plan, medical record, clinical examination, radiographic examination, extra oral and intra oral photos, as well as study model analysis are needed.[1]

Study model analysis is used to analyze the relationship of maxilla and mandible in sagittal, transversal, vertical directions, and the number of teeth on each jaw, the magnitude of need and space excess, the ratio of suitability of teeth size on maxilla and mandible, as well as determining the shape of dental arch.[2]

Basically, the shape of dental arch is divided into three types: square, tapered, and ovoid.[3] The basic principle in orthodontic treatment is the shape of dental arch before the orthodontic treatment must be maintained.[4] The dimension and stability of dental arch shape is one of the determining factors of an o thodontic treatment result.[5]

The shape of maxilla arch is the main reference in determining a diagnosis and an orthodontic treatment plan.[5] The width between molars and canines must be maintained after an orthodontic treatment in order to gain stability and balance with the muscles around mouth, therefore, expansion in mandible arch is more limited compared to maxilla's.[6]

The method to determine the shape of dental arch can be performed manually or mathematically. The determination of dental arch was manually carried out by Hawley and Williams, while the mathematically one was conducted by Lu, Pepe, Richards et al. using level two to level eight of polynomial principles; Cubic spline by BeGole; Parabole by Jones and Richmond; Elips by Currier; Catenary by Pepe; Beta function by Braun et al.; and Conic sections by Biggerstaff and Sampson.[7]

In 1970, Ricketts designed five kinds of dental arch patterns called the pattern of pentamorphic dental arch, based on the result of his research for five years on the Caucasoid population in America and it was applied to the pre-adjusted bioprogressive bracket formulation. Pentamorphic pattern is still applied in all countries, including Indonesia.[8]

Dental arch shape should be described in a mathematical curve with high flexibility level, so that the curve can adjust the shape and the size of dental arch, including the asymmetry. The determination of the shape and size of dental arch is mathematically generated from mathematical formula based on the coordinate information obtained from the reference points that have been determined in study models. One of the mathematical calculations that can be used is polynomial.[9]

Polynomial is a mathematical function of polynom equation that has a simple structure because it only consists of exponent and addition. Polynomial regression is a method used for finding out the value of coefficient in mathematical equation with regression curve approach in polynomial regression. The curve is used to describe the correlation between numbers of pairs of x and y coordinates data. If the relationship between x and y variables is not linear, but a curve, then the regression equation used is the non linear curve regression. One of the non linear curve regressions is polynomial regression.[10]

Level four polynomial provides the description of the shape of a natural dental arch both in regular and irregular teeth as well as in asymmetry of dental arch. Similar studies conducted by Biggerstaff, Pepe, Richard, Fujita, Kageyama, Miyake and Adaskevicius state that level four po-

lynomial is accurate in predicting the shape of an individual dental arch shape and it can be used as a guide pattern of a brace arch shape.[9]

The determination of dimension and dental arch shape are very important since they influence the stability of an orthodontic treatment result, therefore the shape of dental arch should have been determined before an orthodontic treatment is performed. The determination of shape and dental arch size uses level four polynomial method and it is carried out by a computer program, producing more accurate predictions of dental arch shape and size for every individual.[9]

Pentamorphic pattern is an average standard pattern of the Caucasoid race's dental arch, while in Indonesia, one of the most dominant race is Deuteromalay race. Pentamorphic pattern is not necessarily right for other races due to the factor that influences the shape and size of dental arch is race or genetic factor. Based on race difference among European and Indonesian, the author wanted to find out whether or not there was a difference in mandible dental arch shape between level four of polynomial method and pentamorphic pattern in the samples with normal occlusion, and also to find out the level of suitability of better dental arch shape between polynomial method and pentamorphic pattern.

METHODS

The population of the research was all students of Faculty of Dentistry of Padjadjaran University starting the class of 2003-2007. Samples were included to inclusion criteria: Male and female Deuteromalays race; Class I Angle classification; All permanent teeth were complete, except the third molar; Overbite and overjet were normal; the center line of teeth on maxilla and mandible were suitable; the length of jaw arch < 1.5 mm (according to malalignment index of Van Kirk and Pennel)[11]; no discrepancies in teeth shape and size; teeth restoration (filling) was minimum and did not cover the part of dental interproximal; and never been in an orthodontic treatment either removable or fixed.

The samples were selected based on the inclusion criteria, then maxilla and mandible molding process were carried out, and then foundry was conducted in order to obtain study models, the center line was made on the study model using a pencil and a ruler. Make the Facial Axis of Clinical Crown (FACC) and the point of Facial Axis (FA) using a 2B pencil on labial and buccal surfaces of the second left to the second right mandible molar then put 14 pieces of braces on 14 points of Facial Axis (FA) as the reference using multipurpose white glue, a simetograph was placed and fixed on the scanner. The mandible of study models were placed on the simetograph with the occlusal surface facing the scanner and the center line facing the study models coincide with the center line on the simetograph, lastly perform the scanning.

The scan result data was stored in the computer, scanning was performed to thirteen study model samples. After scanning was performed to them, the simetograph was removed from the scanner, then the pentamorphic pattern and a ruler as a handy tool for calibration were scanned. The scan result data was stored in the computer.

Determination method of level four polynomial dental arch shape

The scan result data of the study models were imported into the Autocad program and calibrated 1:1 so that the scan result fits the actual size of the study models. Record every x and y coordinate point based on 14 reference points, as seen in the Figure 1. In Figure 1; (1) Shows the calibration size 1 cm is equal to 1 cm scan result; (2) Location of coordinates (x,y) = (0,0) on the center line between the lower left and right incisive teeth; (3) Assistive line to determine Facial Axis of Clinical Crown (FACC); (4) A cross mark (blue) is the intersection point between the most outer brace cuts attached to the models and the assistive line of Facial Axis of Clinical Crown (FACC). Record the coordinates (x,y); (5) Width measurement between teeth 7-7, 6-6, 5-5, 4-4, 3-3, 2-2, 1-1 with the reference to the cross mark (blue) as the teeth width measure of the study models.

The next phase was inserting 14 data of x and y coordinate points (into the available input data column) into the level four polynomial formulation that has been programmed in Excel. The result was the value of level four polynomial calculation and can be seen in the Figure 3.

Re-import the calculation value resulted

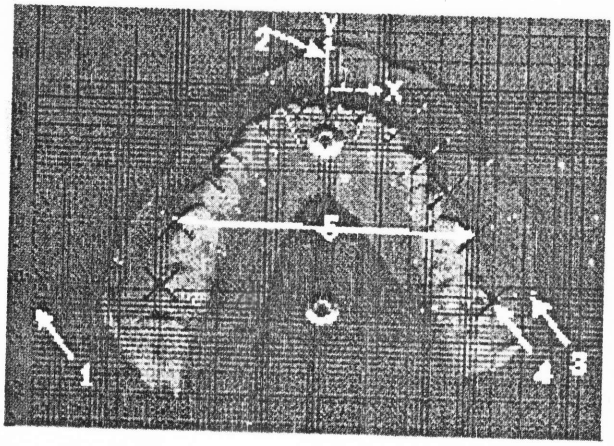

Figure 1. The scan result of the study models that have been imported into the autocad program.

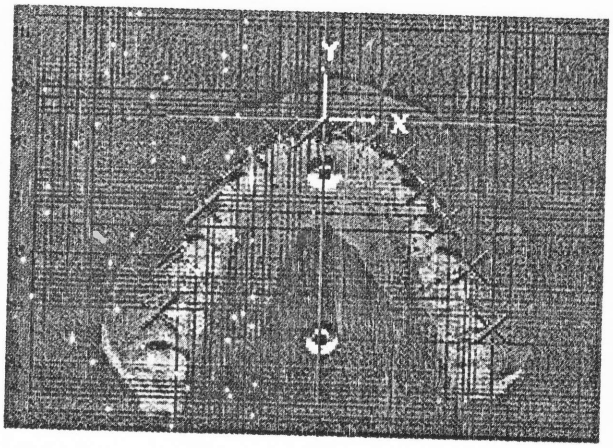

Figure 2. The result of polynomial prediction from excel programme.

from the level four polynomial method in the output data into the autocad program. The result is a apprediction of mandible arch individually, then make fourteen cross marks and record the coordinates (x,y) at the intersection point between the assistive line made with dental arch shape of level four polynomial method as can be seen in the Figure 2. Figure 2 description were: (1) The output data resulted from the polynomial prediction from the excel program that is re-inserted into the autocad program. The polynomial prediction is in the form of a curve (green); (2) The cross mark (red) is the intersection point between the assistive line and the shape of dental arch of level four polynomial; (3) Width measurement between teeth 7-7, 6-6, 5-5, 4-4, 3-3, 2-2, 1-1 with the cross mark as the reference (red) is teeth width measure of level four polynomial.

The method of determining the shape of pentamorphic dental arch pattern

Scan result data of pentamorphic pattern was imported into the autocad program, then was calibrated 1:1, so the scan result fits the

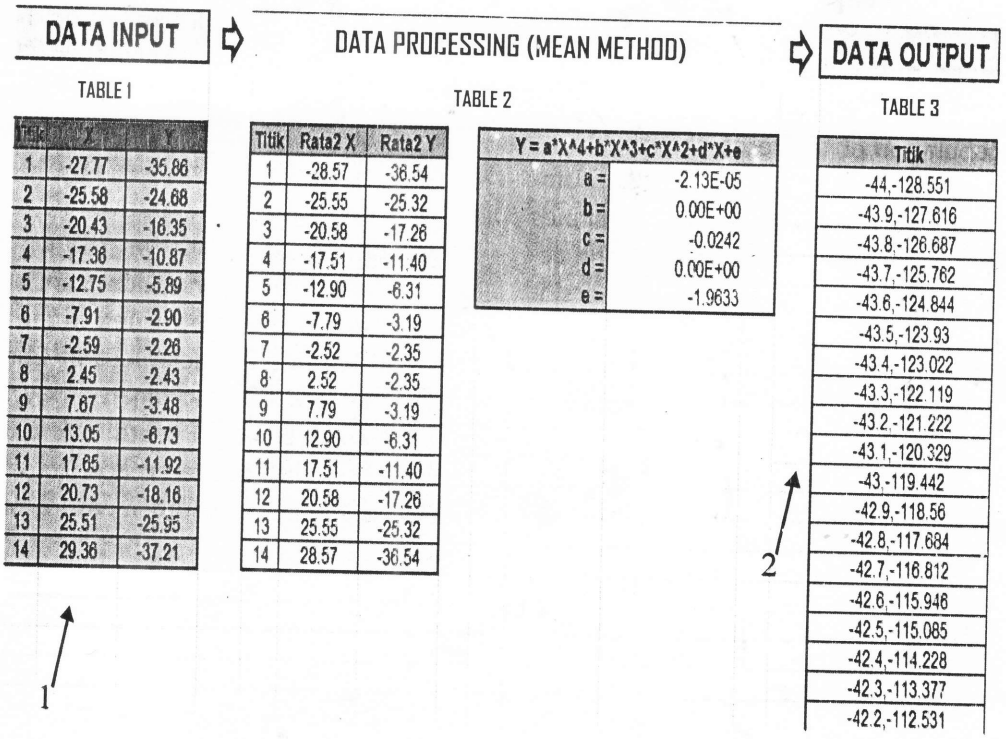

Figure 3. The formulation of level four polynomial that has been programmed in Excel. (1) Data of coordinate points (x,y) were inserted into the data input, (2) The result of level four polynomial calculation can be seen in the output data.

actual pentamorphic pattern size. To compare the dental arch shape of the study models as the control, the level four polynomial method and the pentamorphic pattern, superimpose was conducted to the three of them.

Then choose one of the pentamorphic pattern dental arch shapes that best suits the mandible dental arch shape of the study models as in the Figure 4. After choosing the most suitable dental arch shape, make 14 cross marks at the intersection point between the assistive line made with pentamorphic pattern as shown in Figure 5. In Figure 5, were: (1) Cross mark is an intersection point between the assistive line and the study models as the control (blue), level four polynomial (red) and pentamorphic pattern (tappered) (yellow); (2) Width measurement between teeth 7-7, 6-6, 5-5, 4-4, 3-3, 2-2, 1-1 which is the teeth width measure in pentamorphic pattern.

Based on the coordinate points data (x,y) and width between teeth 7-7, 6-6, 5-5, 4-4, 3-3, 2-2, 1-1 in the study models as the control, level four polynomial method and pentamorphic pattern, the statistical analysis was then performed to determine if there was any difference in mandible dental arch shape.

RESULTS

The statistical result on the space difference between the teeth 37-47, 36-46, 35-45, 34-44, 33-43, 32-42, 31-41 on thirteen samples with normal occlusion either as a control, level four polynomial method, or pentamorphic pattern, as seen in Table 1. Description in Table 1 were: (C-PL): Space difference between samples with normal occlusion as the control (C) and samples with normal occlusion using level four polynomial method (PL); (C-PM): Space difference between samples with normal occlusion as the control (C) and samples with normal occlusion using pentamorphic pattern (PM); (PL-PM): Space difference between samples with normal occlusion using level four polynomial method (PL) and pentamorphic pattern (PM); The mean difference, the average difference of space between teeth, dental group 7-7, dental group 6-6, dental group 5-5, dental group 4-4, dental group 3-3, dental group 2-2, and dental group 1-1 in thirteen samples; Std, Standard deviation; n: The number of samples measured; t count, t-test calculation result; t table, value based on t student distribution table; * significant; and ^{0} non significant.

In Table 1, it can be seen that the test result of space difference between samples with normal occlusion as the control (C) and samples with normal occlusion using level four polynomial method (PL); space difference between samples with normal occlusion as the control (C) and samples with normal occlusion using pentamorphic pattern (PM); space difference between samples with normal occlusion using level four polynomial method (PL) and pentamorphic pattern (PM) using t-test analysis, it can be concluded that there was a significant difference (t count was bigger than t table), except the space difference between samples with normal occlusion using level four polynomial method (PL) and pentamorphic pattern

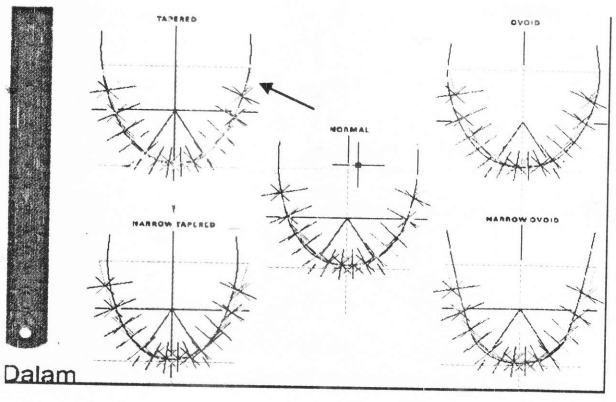

Figure 4. Superimpose between dental arch shape of the study models (control), level four polynomial in five types of pentamorphic dental arch shape.

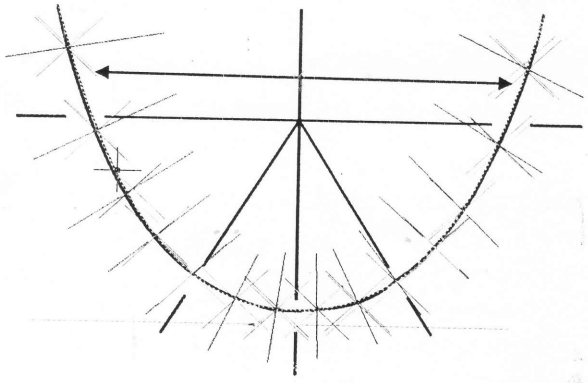

Figure 5. Superimpose of dental arch shape of the study models (control) (blue), level four polynomial (red) and pentamorphic (tappered) (yellow).

Table 1. Statistical calculation result on space difference in thirteen samples with normal occlusion

Teeth		Statistic				
		Mean diff	std	n	t count	t tab
7-7	(C-PL)	0.20	0.13	13	5.55*	2.18
	(C-PM)	1.67	1.05	13	5.74*	2.18
	(PL-PM)	1.60	0.96	13	6.02*	2.18
6-6	(C-PL)	0.49	0.22	13	8.03*	2.18
	(C-PM)	1.00	0.72	13	4.99*	2.18
	(PL-PM)	1.20	0.66	13	6.52*	2.18
5-5	(C-PL)	0.56	0.33	13	6.06*	2.18
	(C-PM)	1.14	0.47	13	8.71*	2.18
	(PL-PM)	0.83	0.40	13	7.60*	2.18
4-4	(C-PL)	0.51	0.28	13	6.51*	2.18
	(C-PM)	0.57	0.53	13	3.83*	2.18
	(PL-PM)	0.48	0.39	13	4.47*	2.18
3-3	(C-PL)	0.40	0.38	13	3.85*	2.18
	(C-PM)	0.55	0.40	13	4.92*	2.18
	(PL-PM)	0.53	0.40	13	4.79*	2.18
2-2	(C-PL)	0.14	0.11	13	4.47*	2.18
	(C-PM)	0.18	0.14	13	4.62*	2.18
	(PL-PM)	0.21	0.17	13	4.42*	2.18
1-1	(C-PL)	0.03	0.03	13	4.26*	2.18
	(C-PM)	0.04	0.03	13	4.01*	2.18
	(PL-PM)	0.00	0.01	13	1.76^0	2.18

(PM) on space between teeth 1-1.

The biggest average space difference between teeth 7-7, 6-6, 5-5, 4-4, 3-3, 2-2, 1-1 in samples with normal occlusion as the control (C) and samples with normal occlusion using level four polynomial method (PL) was 0.56 mm, that was between teeth 5-5 while the biggest average space difference between teeth 7-7, 6-6, 5-5, 4-4, 3-3, 2-2, 1-1 in samples with normal occlusion as the control (C) and samples with normal occlusion using pentamorphic pattern (PM) was 1.67 mm, that is between teeth 7-7. The comparison result in the average space difference between teeth 7-7, 6-6, 5-5, 4-4, 3-3, 2-2, 1-1 in samples with normal occlusion using level four polynomial method (PL) and pentamorphic pattern shows a descending value where the biggest value difference in space average between teeth 7-7 was 1.6 mm and the smallesr in space average between teeth 1-1 was 0 mm.

The average statistical test result of the total sum of all dental groups starting from dental group 7-7 to dental group 1-1 can be seen in Table 2. Table description: Average difference: Average value of space difference between teeth, starting from dental group 7-7 to dental group 1-1 in thirteen samples; Std: Standard deviation; N: The number of samples measured; t count: t-test calculation result; t table: value based on t student distribution table; and *: significant.

Table 2. The average statistical test result of all dental groups

	Statistic				
	Mean Diff	std	n	t count	t tab
(C-PL)	0.33	0.303	91	10.51*	2.18
(C-PM)	0.73	0.769	91	9.11*	2.18
(PL-PM)	0.69	0.720	91	9.20*	2.18

The average statistical test result of the total sum of all dental groups, either dental groups 7-7, dental groups 6-6, dental groups 5-5, dental groups 4-4, dental groups 3-3, dental groups 2-2, or dental groups 1-1 was significant in: (1) space difference between samples with normal occlusion as the control (C) and samples with normal occlusion using level four polynomial method (PL); (2) space difference between samples with normal occlusion as the control (C) and samples with normal occlusion using pentamorphic pattern (PM); (3) space difference between samples with normal occlusion using level four polynomial method (PL) and pentamorphic pattern (PM) because the result of t-count was bigger than t table.

Level four polynomial method shows the difference average value of 0.33 mm compared to the samples with normal occlusion, while the difference average value in pentamorphic pattern was 0.73 mm compared to the samples with normal occlusion.

DISCUSSION

The research result shows the difference of a significant dental arch shape size either in level four polynomial method or in pentamorphic pattern if it is compared to the size of mandible teeth in samples with normal occlusion. The size of pentamorphic pattern is the research result of size average and dental arch shape conducted by Ricketts to Caucasoid race, thus if the

pentamorphic pattern is compared to the samples with normal occlusion to Deuteromalay race generates a significant statistical test difference. It was supported the research conducted by Kook et al. and Miyake et al.[12] which indicate that race difference causes the difference in dental arch shape.

In addition, the shape and size of dental arch is the individual variations that it cannot be represented by average shape and size as in pentamorphic pattern. The shape and size of dental arch should be planned for each individual in conducting an orthodontic treatment.[4]

The research result on the difference between level four polynomial method and samples with normal occlusion also shows a statistically significant difference. This is because the dental arch shape with a really symmetrical normal occlusion on both left and right sides is rarely found either in transversal or sagittal direction as well as regular and without any disposition in dental arrangement.[13] Instead of using ideal samples, this research uses samples with normal occlusion so that a slight irregularity, rotation in mild degree, dental asymmetry in location and position both in transversal and sagittal directions were included to inclusion criteria.

According to Salzmann ideal occlusion is a hypothetical formula that does not exist and will not happen to a person, and according to Graber a perfect contact of upper and lower teeth is ideal, but it is only present in full arrangement of dentures made by prostodonty experts.[11]

To determine the shape of dental arch which has a better suitability level can be seen in Table 1, rows (C-PL) and (C-PM) with different average column, the statistical analysis result always shows smaller average difference than (C-PM), which means the level four polynomial is suitable with normal samples compared to the pentamorphic pattern.

In addition, the suitability level of a better dental arch shape can be seen in the statistical analysis result (Table 2), the comparison of space average starting from dental group 7-7 to 1-1 in level four polynomial (PL) and pentamorphic pattern (PM) show a significant difference. The suitability of a better dental arch shape can be seen in Table 2, rows (C-PL) and (C-PM) with different average column, the statistical analysis result shows smaller average difference of all dental groups (C-PL) than (C-PM) which means the level four polynomial is more suitable with the samples with normal occlusion compared to the pentamorphic pattern.

Besides, pentamorphic pattern shows an expansion for 1.67 mm on the space between teeth 7-7, 1 mm on the space between teeth 6-6 and 1.14 mm on the space between teeth 5-5 if compared to the samples with normal occlusion. This indicates that the shape of dental arch which was more suitable with samples with normal occlusion in mandible is level four polynomial method.

CONCLUSION

Based on the research result, it can be concluded that dental arch shape is the individual morphology pattern which has certain size and cannot be generalized, consequently there is a difference in the shape of mandible dental arch either in dental arch shape with level four polynomial method or pentamorphic pattern. In addition, dental arch shape should be diagnosed before an orthodontic treatment performed. Level four polynomial method can be used as a guidance in shaping an individual dental arch clinically because based on this research, level four polynomial method has a better dental arch shape suitability than pentamorphic pattern.

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