## The Effect of Changes in Vertical Dimension to Facial Harmony Based on Arnett and Bergmann's Analysis

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### Abstract

The vertical dimension of the face is an important aspect that needs to be considered in orthodontic treatment to achieve facial balance. Changes in vertical dimensions that occur can affect aesthetics, where the resulting soft tissue profile is a measure of the success of the treatment. To determine the effect of changes in vertical dimensions on the value of facial harmony after orthodontic treatment based on Arnett and Bergmann analysis on skeletal Class I malocclusions in the two study sample groups.

The research sample consisted of lateral cephalometric photos before and after treatment of 60 adult patients who were divided into 2 groups, extraction and non extraction of the first premolars. Measurements were made using Software Image J 1.52a in 2018 and statistical tests to see the effect of changes in vertical dimensions on facial harmony values after orthodontic treatment in skeletal Class I malocclusions based on Arnett and Bergmann analysis, which were then compared between the extraction and non extraction groups.

Based on the results of the paired t test in the two sample groups, there was no significant difference in the effect of facial vertical changes (MP-SN) on facial harmony values with an overall (p > 0.05) in Class I malocclusion. There was no difference in the effect of changes between both groups of samples with an overall (p > 0.05. Changes in the vertical dimension of the face did not significantly affect the total facial harmony value, both in the extraction and no extraction groups.

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#### Introduction

Malocclusion could be one of the factors influencing many dental diseases such as an increase in caries and periodontal disease.1 Malocclusion occurs due to abnormal growth and development which causes an imbalance in dentocraniofacial morphology.2,3,4 One of Angle's classifications of malocclusion is class I.5-10 This malocclusion is the malocclusion with the greatest prevalence of about 44% of the population with normal anteroposterior relations.5

Orthodontic treatment of class I malocclusion in non-growing patients can be done with camouflage treatment, either with or without extraction, so that it can cause the

\*Corresponding author: Maorina Desta , Department of Orthodontics, Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia. E-mail: maorinadesta77@gmail.com possibility of changes in vertical dimension.4,7,11-14 This change causes the mandible to rotate clockwise and increases facial height.<sup>11,15</sup>Sivakumar and Valiathan stated that were significant differences in vertical there dimension in the extraction and non-extraction groups in Class I malocclusions, where these changes were relatively larger in the extraction group.<sup>16</sup> According to Cusinamo and McLaughlin, there was no difference in vertical changes that occurred without or after premolar extraction.<sup>17</sup> Hosseinzadeh-Nik et al mentioned that treatment with and without premolar extraction did not result in a reduction in facial vertical dimension.<sup>18</sup>

The vertical dimension of the face is an important aspect to consider in orthodontic treatment.<sup>19</sup> Failure to control vertical growth can lead to more complex treatments, poor outcomes and relapse after treatment. A thorough assessment and accurate diagnostic evaluation of discrepancies is required in the vertical pattern of the face to ensure successful treatment.<sup>15,20</sup> Changes in vertical dimensions that occur can affect aesthetics.<sup>8,9,13</sup>

 $Volume \cdot 16 \cdot Number \cdot 2 \cdot 2023$ 

Aesthetics is the main reason for patients seeking orthodontic treatment. Therefore, the ultimate goal of treatment modern dentistry must pay attention to the value of facial harmony to obtain maximum aesthetics.<sup>9,10,21-25</sup>

Since the discovery of cephalometry in 1931 by Broadbent, the aesthetic harmony of the face has been regarded as something scientific and objective because it can be measured.<sup>26</sup> Arnett and Bergman's analysis is one of the soft tissue profile cephalometric analyzes that has been widely adopted by orthodontists and maxillofacial surgeons. Facial soft tissue analysis has harmony value parameters as the key to determining facial esthetics in orthodontic treatment.<sup>12,16,17</sup>

The value of facial harmony according to Arnett's research is the value of facial balance which is assessed from four regions, namely intramandibular harmony, between jaws, orbit to jaw and total facial harmony. Assessment of harmony in women and facial men is different.<sup>23,27,28</sup> But these are not significantly different except for the A'-B' relationship, the rim'and Glabela-Pog' orbitals.27 In 2005 Pog' Hameed A conducted a study according to Arnett and Bergman analysis on skeletal Class I and II patients visiting a pediatric hospital in Pakistan and obtained results that were not significantly different.<sup>29</sup> Kalha et al also conducted the same study in 2008 on the Indian population, the results were also not significantly different.<sup>30</sup>

Based on this background, the authors are encouraged to identify and evaluate the effect of changes in the vertical dimension of the face on the value of facial harmony based on Arnett and Bergmann's analysis before and after treatment of skeletal Class I malocclusions with and without extractions at USU FKG RSGM.

# Materials and methods

This type of research is observational analytic with cross sectional design. The research was conducted at the Orthodontic Specialist Clinic, USU Dental and Oral Teaching Hospital (RSGMP) in February 2021. Samples were patients from a population with a skeletal diagnosis of Class I malocclusion with ANB = 2°-4° as many as 60 samples were divided into two groups, 30 for the group without premolar tooth extraction and 30 for the group with extraction.

The inclusion criteria of this study are as

follows all skeletal Class I patients with ANB angle =  $2^{\circ}$ -  $4^{\circ}$  who have completed fixed orthodontic treatment, male and female patients aged 18-35 years, cephalometric radiographs before and after treatment were in good condition, number of complete permanent teeth at the time before treatment without taking into account the presence or absence of third molars, there were congenitally no missina teeth/agenesis, there were no supernumerary teeth or anomalous features, and there was no interproximal grinding and tooth extraction prior to treatment.

The research tools were a tracing box, patient tracing acetate paper (0.003 inches thick, 8x10 inches) Ortho Organizer brand, Nikon D90 DSLR camera and Nikon DX AF-S NIKKOR lens 18-105 mm, Excell UFO 260 tripod, black cardboard, tape and scissors, and the 2018 J 1.52a image software. The material of this study was lateral cephalometric radiographs before and after treatment of skeletal Class I patients with or without the extraction of two premolars.

Research procedure are management of a license from the Faculty of Dentistry, University of North Sumatra and a research approval letter from the Health Sector Research Ethics Commission, collection of pre- and posttreatment lateral cephalometric radiographs from the patient. skeletal class I according to the exclusion and inclusion criteria obtained from the medical records of the Orthodontic Specialist Clinic RSGMP FKG USU, landmarks were traced on acetate paper above the illuminator box with a 4H pencil to measure ANB, the black cardboard is cut in the middle with the same size as the lateral cephalometry then placed on top of the tracing box, photographs were taken from the lateral cephalogram which was placed on top of the tracing box (the middle of the cut black cardboard) using a Nikon D90 camera with a Nikon DX AF-S NIKKOR 18-105 mm lens which was positioned using a tripod with a distance of from the lateral cephalometry, 50 cm determination of landmark points and reference lines for measurement, to obtain valid data, an operator test was first carried out to determine the cephalometric points before and after treatment (10 cephalometric photos) with an intra operator test. If the first and second determinations do not differ, then the operator is eligible to carry out these measurements and the measurement results obtained are recorded then

the data is processed and analyzed.

Data analysis used before and after treatment was paired T test if the data was normally distributed and Wilcoxon if the data was not normally distributed. Furthermore, to see the correlation between variables, Pearson's correlation test will be used if the data is normally distributed and Spearman's correlation if the data is not normally distributed.

## Results

Analysis of the mean values of the variables in the sample group without depilation, it was found that changes in the vertical face (MP-SN) and facial harmony values (Md1-Pog', LLA-Pog', B'-Pog', NTP-Pog', Sn' -Pog', A'-B', ULA-LLA, Or'-A', Or'-Pog', Facial Angle, G'-A' and G'-Pog') were not significant before and after orthodontic treatment overall p>0.05 (Table 1).

Variable	Pre (X±SD)	Post (X±SD)	p-value
MP-SN	34.98±6.75	35.09±7.92	0.886
Intramandibular relation			
Md1-Pog'	5.2168±0,71	5.2632±0,81	0.644
LLA-Pog'	4.1043±0,67	4.2705±0,77	0.554
B'-Pog'	2.2069±0,60	2.2839±0,60	0.492
NTP-Pog'	34.1234±5.44	34.0770±5.03	0.380
Inter Jaw Relation			
Sn'-Pog'	9.2911±1.07	9.3415±1.03	0.599
A'-B'	6.4168±0,78	6.4615±0,78	0.643
ULA-LLA	2.5917±0,47	2.6233±0,42	0.098
Orbita to Jaw			
Or'-A'	5.5178±0.75	5.6389±1.20	0.586
Or'-Pog'	13.9046±2.20	14.2317±1.51	0.649
Facial Balance			
Facial Angle	170.9498±4.52	171.5565±5.25	0.823
G'-A'	12.3523±1.15	12.4766±0.94	0.646
G'-Pog'	21.0688±1.23	21.2388±1.55	0.582

**Table 1.** Changes in Mean Vertical Facial Dimension (MP-SN) and Facial Harmony Values in the Sample Group Without Removal of the Maxillary First Premolar.

Variable	Pre (X±SD)	Post (X±SD)	p-value
MP-SN	37.9521±5.88	36.3036±6.03	0.158
Intramandibular relation			
Md1-Pog'	5.3532±0,68	5.3449±0,81	0.442
LLA-Pog'	4.2742±0,84	4.2458±0,72	0.378
B'-Pog'	2.3322±0,69	2.2570±0,57	0.392
NTP-Pog'	30.9057±4.21	31.5084±3.89	0.609
Inter Jaw Relation			
Sn'-Pog'	9.7200±0.90	9.5462±1.05	0.612
A'-B'	6.6388±0,66	6.4048±0,78	0.588
ULA-LLA	2.4257±0,48	2.2860±0,56	0.226
Orbita to Jaw			
Or'-A'	6.1928±0.67	6.0401±0.72	0.161
Or'-Pog'	13.3418±1.17	14.3314±1.01	0.388
Facial Balance			
Facial Angle	168.9331±4.47	168.6083±5.02	0.071
G'-A'	12.7537±0.85	12.6973±0.81	0.273
G'-Pog'	21.6153±1.17	21.4094±1.29	0.413

**Table 2.** Changes in Mean Vertical FacialDimensions (MP-SN) and Facial HarmonyValues in the Sample Group with Removal of theMaxillary First Premolar.

Analysis of the mean values of the variables in the sample group with depilation, it was found that changes in the vertical face (MP-SN) and facial harmony values (Md1-Pog', LLA-Pog', B'-Pog', NTP-Pog', Sn' -Pog', A'-B', ULA-LLA, Or'-A', Or'-Pog', Facial Angle, G'-A' and G'-Pog') were not significant before and after orthodontic treatment overall p>0.05 (Table 2).

Based on table 3, it can be seen that in the group without extraction, after orthodontic treatment there was an increase in the vertical dimension of the face (MP-SN) of  $0.11 \pm 4.18$ .

Vertical dimension	Difference X±SD	Harmony Value	Difference X ± SD	r	p-value
	Vertical dimension		Harmony Value		
MP-SN	0.11 ± 4.18	Intramandibular relation			
	(p = 0.886)	Md1-Pog	0.05 <u>+</u> 0.64	0.644	p = 0.698
		LLA-Pog	0.17 <u>+</u> 0.68	0.554	p = 0.193
		B'-Pog'	0.08 <u>+</u> 0.61	0.492	p = 0.492
		NTP-Pog	-0.05 <u>+</u> 5.84	0.380	p = 0.966
		Inter Jaw Relation			
		Sn'-Pog'	0.05 <u>+</u> 0.94	0.599	p = 0.772
		A'-B'	0.04 <u>+</u> 0.65	0.643	p = 0.712
		ULA-LLA	0.03 <u>+</u> 0.60	0.098	p = 0.775
		Orbita to Jaw			
		Or'-A'	0.12 <u>+</u> 0.97	0.586	p = 0.501
		Or'-Pog'	0.33 <u>+</u> 1.68	0.649	p = 0.294
		Facial Balance			
		Facial Angle	0.61±2.99	0.823	p = 0.275
		G'-A'	0.12 <u>+</u> 0.91	0.646	p = 0.457
		G'-Pog'	0.17 <u>+</u> 1.60	0.582	p = 0.566

**Table 3.** The Effect of Changes in the VerticalDimension of the Face on the Value of FacialHarmony in the Sample Group Without Removalof the Maxillary First Premolars.

Based on table 3 above, it can be seen that in the group without extraction, after orthodontic treatment there was an increase in the vertical dimension of the face (MP-SN) of  $0.11 \pm 4.18$ .

The results of the study on intramandibular relations found that the Md1-Pog' value increased by 0.05±0.64. This suggests extrusive movement of the lower incisors. The value of LLA–Pog' increased by 0.17±0.68 and B'–Pog' increased by 0.08±0.61 indicating that the length of the lower lip relative to Pogonion was due to the extrusion of the incisors. The NTP–Pog' value decreases by -0.05±5.84 indicating clockwise rotation of the mandible.

The results of the value of the relationship between the jaws showed that the value of Sn' -Pog' increased by  $0.05 \pm 0.94$  indicating extrusion. This is in line with the increase in the A' – B' value of  $0.04 \pm -0.65$  and the ULA - ALL value of  $0.03 \pm 0.60$ , which indicates the correction of the deep bite case in class I malocclusion, where the distance between the upper and lower jaws and the distance between

Volume · 16 · Number · 2 · 2023

the upper and lower lips increase in size.

From the results of the orbital to jaw value, the Or' – A' value increased by  $0.12 \pm 0.97$  and the Or' - Pog' value increased by  $0.33 \pm 1.68$ . This indicates an increase in the length of the orbit to the jaw due to extrusion movement.

The results on facial balance showed that the face angle value increased by  $0.61\pm2.99$ . The value of G' - A' increases by  $0.12\pm0.91$  and G' - Pog' increases by  $0.17\pm1.60$  indicating an elongated face.

The results of the treatment showed that there was an effect of changes in vertical dimension to the value of facial harmony (intramandibular relations, relations between jaws, orbit to jaw and facial balance), where an increase in vertical dimension was followed by an increase in the value of facial harmony in cases without extraction, but this effect was not significant with an overall p value of >0.05.

	Difference	Harmony Value	Difference	r	
Vertical	$X \pm SD$		$X \pm SD$		-value
dimension	Vertical		Harmony		
	dimension		Value		
		Intramandibular relation			
		Md1-Pog'	-0.01±0.67	r = 0.442	p = 0.947
		LLA-Pog'	-0.03±0.87	r = 0.378	p = 0.860
	1.63± 6.24 p=0.158)	B'-Pog'	-0.08±0.70	r = 0.392	p = 0.563
		NTP-Pog'	0.60±3.59	r = 0.609	p = 0.366
		Inter Jaw Relation			
		Sn'-Pog'	-0.17±0.86	r = 0.612	p = 0.283
100 011		A'-B'	-0.23±.66	r = 0.588	p = 0.062
MP-SIN		ULA-LLA	-0.14±0.65	r = 0.226	p = 0.247
		Orbita to Jaw			
		Or'-A'	-0.15±0.90	r = 0.161	p = 0.361
		Or'-Pog'	-0.01±1.22	r = 0.388	p = 0.963
		Facial Balance			
		Facial Angle	-0.32±6.48	r = 0.071	p = 0.786
		G'-A'	-0.06±1.01	r = 0.273	p = 0.761
		G'-Pog'	-0.21±1.34	r = 0.413	p = 0.408

**Table 4.** The effect of changing the vertical dimension of the face on the harmony value of the face in the sample group with removal of the maxillary first premolar.

In the group with extraction (table 4), there was a decrease in the vertical dimension after treatment of  $-1.63 \pm 6.24$ .

The results of the value of the intramandibular relation showed that the Md1-Pog' value decreased by  $-0.01 \pm 0.67$ , which means that intrusion occurred with the extraction of the premolars. The LLA – Pog' value decreased by  $-0.03\pm0.87$  and B' – Pog' decreased by  $-0.08\pm0.70$ . This suggests a reduction in the length of the lower lip relative to the Pogonion due to intrusion of the teeth. The NTP – Pog' value increases by  $0.60 \pm 3.59$  indicating counterclockwise rotation of the mandible.

The results of the value of the relationship between the jaws found that the value of Sn' - Pog' decreased by  $-0.17 \pm 0.86$  indicating an intrusion. The value of A' - B' decreased by  $-0.23 \pm .66$  resulting in a shortened maxillary and mandibular relationship. In class I bimaxillary protrusion malocclusion with this reduction in value it can be concluded that the overbite is corrected. The ULA - ALLA value decreased by  $-0.14 \pm 0.65$  which means that in class I bimaxillary malocclusion protrusion with lips that are difficult to close. There is a reduction in this value, meaning that the lips are more relaxed and closed.

The results of the Orbita to jaw value were obtained with the Or' – A' value decreasing by -0.15  $\pm$  0.90 and the Or' – Pog' value decreasing by -0.01  $\pm$  1.22, which indicates a decrease in the length of the orbit to the jaw distance caused by tooth intrusion due to tooth extraction premolars.

The results of facial balance showed that the face angle value decreased by  $-0.32 \pm 6.48$  meaning that there were retraction and intrusion and the lips became competent. The value of G' - A' decreases by  $-0.06 \pm 1.01$  and G' - Pog' decreases by  $-0.21 \pm 1.34$  indicating that the face is getting shorter.

Group	Vertical dimension and Harmony Value	Difference X±SD	P-value	
	Intramandibular relation			
Non-extraction	M41 Dee'	0.05±0.64		
Extraction		-0.01 ±0.67	= 0.824	
Non-extraction	LLA Dog'	0.17±0.68		
Extraction	LLA-Fog	-0.03±0.87	= 0.499	
Non-extraction	B' D'	0.08±0.61		
Extraction	B -Pog	-0.07±0.70	= 0.373	
Non-extraction	NTP Pog'	-0.05±5.84		
Extraction	NIT-Fog	0.60±3.59	= 0.658	
	Inter Jaw Relation			
Non-extraction	Sal Deal	0.05±0.94		
Extraction	311-P 0g	-0.17±0.87	= 0.342	
Non-extraction	AL DI	0.04±0.66		
Extraction	— A-B	-0.23±0.66	= 0.107	
Non-extraction		0.03±0.60		
Extraction		-0.14±0.65	= 0.505	
	Orbita to Jaw	Orbita to Jaw		
Non-extraction		0.12±0.97		
Extraction	Or'-A'	-0.15±0.90	= 0.897	
Non-extraction		0.33±1.67		
Extraction	Or-Pog	-0.01±1.22	= 0.376	
	Facial Balance			
Non-extraction	Sudut Wajah	0.61±2.99		
Extraction		-0.32±6.48	= 0.477	
Non-extraction	G'-A'	0.12±0.90		
Extraction		-0.06±1.01	0.785	
Non-extraction		0.17±1.60	0.025	
Extraction	G-Pog	-0.21±1.34	= 0.925	

**Table 5.** Differences in the effect of verticaldimension and facial harmony values betweenthe depilation and non-extraction sample groups.

The results of the treatment show that there is an effect of changes in vertical

Volume · 16 · Number · 2 · 2023

dimension to the value of facial harmony (intramandibular relations, relations between the jaws, orbit to the jaw and facial balance), where there is a reduction in vertical dimension followed by a reduction in the value of facial harmony in cases with extractions, but this effect has a value not significant with an overall p value of >0.05.

In table 5, this study also conducted the Pearson correlation test to see the correlation of changes in facial harmony values before and after orthodontic treatment that occurred between the extraction group and the nonextraction group. The results showed that there were no significant differences between the two study sample groups, both in intramandibular relations, inter-jaw relations, orbit to jaw and facial balance with an overall p value >0.05.

## Discussion

Based on table 3 above, it can be seen that in the group without extraction, after orthodontic treatment there was an increase in the vertical dimension of the face (MP-SN) of  $0.11 \pm 4.18$ . This result is in line with the study of Chua et al that there was an increase in lower anterior facial height in the non-extraction group.<sup>31</sup> In the group with extraction (table 4), there was a decrease in the vertical dimension after treatment of  $-1.63 \pm 6.24$ . This decrease in vertical dimension occurs because the extraction of the premolars will make the molars move forward and up, counterclockwise rotation of the mandible occurs so that the patient's facial height is reduced.<sup>19,32</sup>

These results indicate that the extraction of premolars does not always have an adverse effect on facial esthetics. These results are the same as the study of Benedito et al who tested the hypothesis of the difference between changes in cephalometric measurements during orthodontic treatment between the group without premolar extraction and the group with premolar extraction in Class I malocclusions that there is no significant relationship to changes in soft tissue profile. Aksakalli and Demir A also stated that there were no differences in facial profile that occurred before and after orthodontic treatment in Class I malocclusions.33 Some researchers reported that the extraction of premolars did not cause a change or increase in facial profile, but some other researchers stated

that the extraction of premolars could cause changes in facial profile.<sup>34</sup>

Premolars are the most commonly extracted teeth for orthodontic treatment due to their close position to the anterior segment making it easier to retract and correct crowding so that the extraction scars can be closed easily.<sup>31,35</sup> Premolar extraction is generally performed in cases of severe crowding and bimaxillary protrusion to correct the discrepancy between tooth size and arch length and reduce protrusion. However, the removal of these premolars is still controversial due to the impact it has on the vertical dimension.<sup>36,37</sup>

The clinical significance of the results of this study suggests that the presence or absence of premolar extraction is not the main determinant of the effect on the facial profile. Diagnosis, choice of treatment and correct mechanism are the things that directly affect the end result of a face that is considered satisfactory.<sup>33</sup>

# Conclusions

The following conclusions are drawn from the study:

1. The effect of changes in the vertical dimension of the face on the total value of facial harmony in Class I malocclusion without removal of the maxillary first premolar is not significant with an overall value of p>0.05.

2. The effect of changes in the vertical dimension of the face on the total value of facial harmony in Class I malocclusion of the maxillary first premolar extraction was not significant with an overall value of p>0.05.

3. There was no significant difference in the effect of the vertical dimension of the face on the value of facial harmony between the extraction groups without removal of the maxillary first premolar in skeletal Class I malocclusion before and after orthodontic treatment, with an overall value of p>0.05

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#### **Declaration of Interest**

The authors declare no conflict of interest, financial or otherwise.

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Volume · 16 · Number · 2 · 2023

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