

Association of Gonial Angle with Hand Grip Strength in Vertical, Horizontal and Average Growers: A Cross-sectional Study

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ABSTRACT

Introduction: The orthodontic treatment focuses on improving facial aesthetics and functional occlusion by improving the masticatory function, including masticatory chewing pattern, masticatory muscle activity, maximum occlusal force, and occlusal contact area. In orthodontics, every decision is based on the patient's growth pattern and muscle strength.

Aim: To evaluate the gonial angle, hand grip strength and association of the gonial angle with Hand Grip Strength (HGS) in vertical, horizontal and average growers.

Materials and Methods: This cross-sectional study was conducted from 24th June 2021 to 24th July 2022 in the Department of Orthodontics at Sharad Pawar Dental College and Hospital in Sawangi, Wardha District, Maharashtra, India on a total of 196 patients. Data were categorised according to the growth pattern. For the vertical growth pattern, 49 patients were selected, 49 for the horizontal growth pattern, and 98 for the average growth pattern. A Jamar hand dynamometer was used to measure HGS and gonial angle using a lateral cephalogram. Study compared the results using inferential and descriptive

statistics with a Analysis of Variance (ANOVA) (one-way) and multiple comparisons with the Tukey's test. Also, p-value <0.05 was considered as a level of significance.

Results: The data of total of 49 patients in vertical growth pattern, 49 for the horizontal growth pattern, and 98 for the average growth pattern was collected and analysed. Grip strength and gonial angle were compared between horizontal, average, and vertical growers. The gonial angle ranged from 101° to 124° in the average growth pattern, 81° to 99° in the horizontal growth pattern and 121° to 156° in the vertical growth pattern. The HGS in the horizontal growth pattern patients ranged from 27.2 kg to 57.5 kg. The HGS in the vertical growth pattern ranged from 14.7 kg to 37.7 kg. In the vertical growth pattern, the HGS was decreased compared to the horizontal growth pattern group. To determine the factor of HGS, gonial angle is the most prominent one. The assessment of growth patterns is vital in diagnosis and treatment planning.

Conclusion: The study concluded that, due to weak muscle strength, vertical group cases should be treated more carefully.

Keywords: Dentistry, Growth pattern, Lateral cephalogram, Orthodontic treatment

INTRODUCTION

The focus of orthodontic treatment is to improve facial aesthetics and functional occlusion by improving the masticatory function, that includes masticatory chewing pattern, masticatory muscle activity, maximum occlusal force, and occlusal contact area. In orthodontics, every treatment planning is based on the patient's growth pattern and muscle strength [1]. There is a difference in muscle activity of vertical, horizontal, and average grower's which ultimately affect the mandible angle during growth. Horizontal growers have forward growth direction, are counter-clockwise growers, have hypodivergent facial patterns, and have strong muscular strength. Vertical growers have downward growth direction, are clockwise growers, have hyperdivergent facial patterns, and have weak muscular strength [2].

A key parameter of the craniofacial complex for predicting growth patterns is the gonial angle [3]. A gonion is the point where the mandibular corpus meets the ascending ramus. Average mean value of gonial angle is 128±7°. Age assessments can also be made using the gonial angle. The position of attachment of muscle, muscular strength, and tonicity are the factors responsible for the variations in the form of mandibular growth and degree of gonial angle [1].

HGS is a convenient and useful method for measuring physical function that is combined with muscle strength [4]. Using a sealed hydraulic system, the Jamar and its variants can measure HGS and display grip forces up to 200 pounds or 90 kg in pounds and kilograms. Due to its high retest reliability and precision level, this

device is considered the gold standard by which other dynamometers are compared [5]. In studies conducted by Härkönen R et al., Mathiowetz V et al., Niebuhr BR et al., Mathiowetz V et al., Lusardi MM and Bohannon RW, Hamilton A et al., reliability and validity of Jamar Hand Dynamometer have been proven [6-11].

Prior research has been done mostly to assess gonial angles in vertical, horizontal, and average growers [2]. Studies on relationship between growth pattern and HGS are limited. The present study aims to determine, if the gonial angle and hand grip strength are associated with patients undergoing orthodontic treatment. The research protocol of the present study has already been published [1].

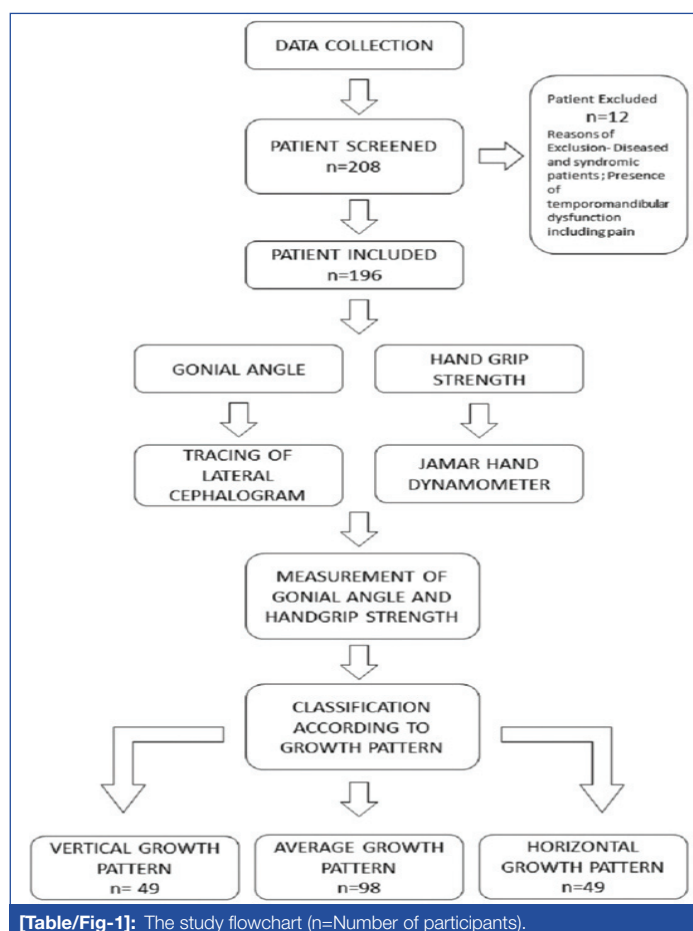
MATERIALS AND METHODS

This cross-sectional study was conducted from 24th June 2021 to 24th July 2022 at the Department of Orthodontics, Sharad Pawar Dental College and Hospital in Sawangi (Meghe), Wardha District, Maharashtra, India, on patients undergoing orthodontics treatment having vertical, horizontal, and average growth patterns. The study was conducted after approval from the Institutional Ethics Committee of Datta Meghe Institute of Medical Sciences, Deemed to be University, with Ethical Clearance number: DMIMS(DU)/IEC/2022/884.

Inclusion criteria: Patients both female and male, 18 years and above age group, people of vertical/horizontal or average growth pattern, presence of malocclusion (Angle's Class I, II and III), complete absence of syndrome involving abnormality of muscular or maxillofacial morphology such as cleft lip and/or cleft palate,

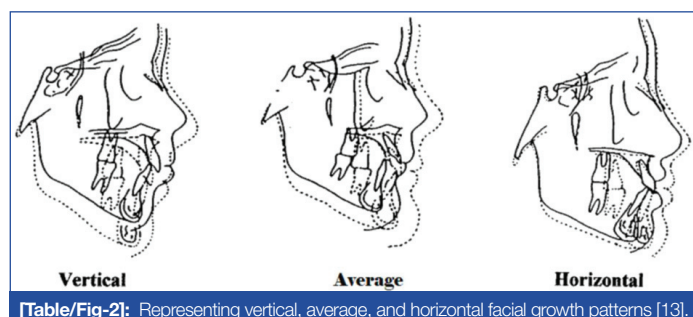
absence of injuries to the upper limbs, complete availability of required data were included in the present study.

Exclusion criteria: Included diseased and syndromic patients, presence of symptoms of temporomandibular dysfunction, including pain. The exclusion criteria included diseased and syndromic patients, Presence of symptoms of temporomandibular dysfunction, including pain [Table/Fig-1].



[Table/Fig-1]: The study flowchart (n=Number of participants).

Sample size calculation: Using an Open Epi, version 3.0, using the mean difference from the parent article [12]. The calculated sample size of the study was 196 under the criteria, 49 for horizontal, 49 for vertical, and 98 for the average growth pattern [Table/Fig-2] [13]. By comparing the value, the clinicians can determine, whether the data matches female and male norms appropriately.



[Table/Fig-2]: Representing vertical, average, and horizontal facial growth patterns [13].

Measuring Gonial Angle

The lateral cephalogram of the ongoing patients was evaluated for the gonial angle measurement in vertical, average, and horizontal growth patterns [14]. The gonial angle was measured in the lateral cephalograms at the point of intersection of the plane tangential to the lower border of the mandible and another line tangent to the distal border of the ascending ramus and the condyle. The gonial angle at the intersection of these planes was measured [Table/Fig-3] [15]. The subject was categorised by the value of each cephalogram value into three groups.



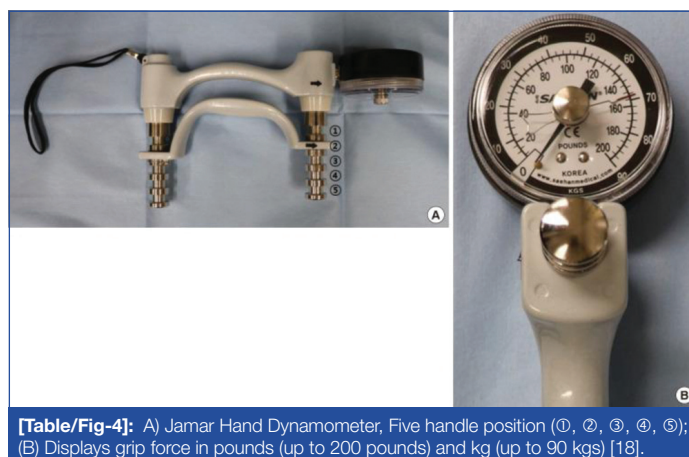
[Table/Fig-3]: Gonial angle construction on a lateral cephalogram.

Cephalometric Tracing

On an acetate tracing paper, the radiographs of the lateral cephalograms were manually traced with a sharp 3H (Hard) pencil using a transilluminated light source. The gonial angle was measured using a mathematical protractor [Table/Fig-3] [16].

Measuring Hand Grip Strength (HGS)

HGS was calculated as a measure of muscle strength and was measured using a hand grip Dynamometer. The HGS with one hand on either side was measured twice seated; the average value was taken into account in the analysis. Measurements were made using the Jamar Hand Dynamometer. Invented in 1954, the Jamar dynamometer can record grip strength values with five different handle positions [17]. There are two handles, and one handle is curved for a comfortable grip. From 1-3/8 to 3-3/8 inches, there are five handle positions for different handle sizes in half inch increments. In general, the third or second handle provides the strongest HGS, and it is the standard position recommended by the American Society of Hand Therapists (ASHT) [Table/Fig-4] [18].



[Table/Fig-4]: A) Jamar Hand Dynamometer, Five handle position (①, ②, ③, ④, ⑤); (B) Displays grip force in pounds (up to 200 pounds) and kg (up to 90 kgs) [18].

STATISTICAL ANALYSIS

Using inferential and descriptive statistics, the statistical analysis was done using one-way Analysis of Variance (ANOVA) and multiple comparisons. Tukey's test software used in the study was Statistical

Package for Social Sciences (SPSS) 27.0 version (Released 2020; Statistics for Windows, Armonk, New York: International Business Management (IBM) Corp.). A p-value <0.05 was considered as the level of significance.

RESULTS

The participants' mean age was 49±38.11 years, and their range of age was 21 to 65. The study population had a significant majority of females (Male=89) (Female=107) (1:1.20). The study population's socio-demographic details are shown in the table [Table/Fig-5].

In the current study, the authors compared the gonial angle of horizontal, average, and vertical growers. The mean value was 113.10°, 90.44° and 138.84° for average, horizontal, and vertical

Variable	Number of participants (n)	Percentage (%)
Age category (years)		
18-25	83	42.34
26-35	91	46.42
36-45	12	6.1
>45	10	5.1
Total	196	100
Gender		
Male	89	45.40
Female	107	54.59
Total	196	100

[Table/Fig-5]: Socio-demographic details of the study population.

Gonial angle	n	Mean	Std. Deviation	Std. Error	95% Confidence interval for mean		Minimum	Maximum
					Lower bound	Upper bound		
Average	98	113.10	6.44	0.65	111.81	114.39	101.00	124.00
Horizontal	49	90.44	5.86	0.83	88.76	92.13	81.00	99.00
Vertical	49	138.85	10.16	1.45	135.93	141.77	121.00	156.00

[Table/Fig-6]: Comparison of gonial angle at average, horizontal and vertical growth pattern: Descriptive Statistics.

Source of variation	Sum of squares	df	Mean square	F	p-value
Between groups	57529.95	2	28764.98	522.109	0.0001
Within groups	10633.10	193	55.09		
Total	68163.06	195			

[Table/Fig-7]: Comparison of gonial angle at average, horizontal and vertical growth pattern. One-way ANOVA. p-values are significant

Gonial angle		Mean difference (I-J)	Std. Error	p-value	95% Confidence interval	
					Lower bound	Upper bound
Average	Horizontal	22.65	1.29	0.0001	19.58	25.72
	Vertical	-25.75	1.29	0.0001	-28.82	-22.68
Horizontal	Vertical	-48.40	1.49	0.0001	-51.95	-44.86

[Table/Fig-8]: Comparison of gonial angle at average, horizontal and vertical growth patterns. Multiple comparison: Tukey's Test. p-values are significant

Hand Grip Strength (HGS)	N	Mean	Std. Deviation	Std. Error	95% Confidence interval for mean		Minimum	Maximum
					Lower bound	Upper bound		
Average	98	41.58	9.53	0.96	39.66	43.49	21.30	57.50
Horizontal	49	45.01	9.12	1.30	42.39	47.63	27.20	57.50
Vertical	49	27.10	7.57	1.08	24.93	29.28	14.70	37.70

[Table/Fig-9]: Comparison of HGS at average, horizontal and vertical growth pattern. Descriptive Statistics.

Source of variation	Sum of squares	df	Mean square	F	p-value
Between groups	9350.47	2	4675.23	57.96	0.0001
Within groups	15567.66	193	80.66		
Total	24918.13	195			

[Table/Fig-10]: Comparison of HGS at average, horizontal and vertical growth pattern. One-way ANOVA. p-values are significant

growth patterns with 95% Confidence Intervals (CI) [Table/Fig-6]. There was significant difference between the groups for gonial angle with p-value of 0.0001. ([Table/Fig-7]. On pair-wise comparison, significant difference was seen among all the groups [Table/Fig-8].

In the present study, HGS ranged from 14.7 kg to 57.50 kg. the mean HGS in average, horizontal, and vertical growth patterns groups were 41.58 kg, 45.01 kg and 27.10 kg, respectively [Table/Fig-9]. Vertical growers showed significantly less strength when compared to average and horizontal growers. [Table/Fig-10,11]. On comparing the data tabulated in [Table/Fig-6-9], the authors found that, in group with large gonial angle, HGS was inferior, as compared to the group with a small gonial angle.

DISCUSSION

Orthodontic treatment improves facial aesthetics and functional occlusion. In orthodontics, every treatment planning is based on the patient's muscle strength and growth pattern [1].

In the present population, the gonial angle ranges from 81° to 156°. In the given population, the gonial angles went from 81° to 99° in the horizontal growth pattern, 101° to 124° in the average growth pattern and from 121° to 156° in the vertical growth pattern. Bajracharya M et al., researched to determine the gonial angles in various growth patterns. They concluded that a mean gonial angle of 119.9° was found in the horizontal growth pattern, 124.0° in the average growth pattern, and 132.8° in the vertical growth pattern [16]. Bhullar M et al., determined the efficacy of lateral Cephalogram for calculating gonial angle and compared

Hand Grip Strength (HGS)		Mean difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Average	Horizontal	-3.43	1.57	0.076	-7.14	0.27
	Vertical	14.47	1.57	0.0001	10.76	18.18
Horizontal	Vertical	17.90*	1.81	0.0001	13.62	22.19

[Table/Fig-11]: Comparison of HGS at average, horizontal and vertical growth patterns. Multiple comparison: Tukey's Test. p-values are significant

it with the Orthopantomogram (OPG) values. They concluded that, there is no significant difference in the angles obtained by both methods. Although, using OPG for determining the gonial angle would be easier because of less superimposition in the OPG, there is no difference in the calculation accuracy in both techniques [19].

Alabdullah M et al. conducted a study to find the correlation between growth pattern and muscle activity. The study concluded that the Electromyography (EMG) value of Buccinator and anterior digastric muscle. They also concluded that, the EMG of the masseter, anterior digastric muscles and orbicularis oris was significantly higher in the vertical growth pattern group. They also determined that the lowest EMG value of the masseter muscle was seen in the horizontal growth pattern [20]. A similar study was conducted by Ueda HM et al., they did not find any correlation between the EMG values of temporalis and the growth pattern but also found that the EMG values of masseter are the lowest in the horizontal growth pattern [21].

Hogrel JY, conducted a study to determine the reliability of the Myogrip Dynamometer. He also compared the data from the Myogrip dynamometer with the data obtained by Jamar Dynamometer. In the study, he determined the normative data for HGS in people, age ranging from 5 to 80 years. He determined that for the age group of 20-30, the mean HGS of the right hand was found to be 29.2 kg, and for the age 15-20 years, it was 27.9 kg. The study also found that the myogrip for determining HGS is a reliable tool. The HGS of the age group 15-20 years using the Jamar Dynamometer was 31.1 kg, whereas for the age group 20-30 years was 34.1 Kg [22].

In the current study, HGS ranges from 14.7 kg to 57.50 kg. The mean HGS was found in the horizontal growth pattern, with a mean HGS of 45.01 kg. The minimum HGS was found in vertical growth pattern patients, with a mean HGS of 27.1. Nakagawa S et al., conducted a similar study to compare the HGS in hyperdivergent and hypodivergent patients and got identical results. Although the HGS determined in the Japanese women by the authors, was significantly lower, the relation between the gonial angle and HGS was the same. The mean HGS in low gonial angle cases was 223.9 N (22.83 kg), whereas for the high gonial angle patients were 197.6 N (20.14 kg). The study also concluded that, the gonial angle is the largest factor determining HGS. Sex, height and weight did not affect HGS as much as the gonial angle [12]. This study could not differentiate between the role of the gonial angle or the malocclusion in a change in HGS. Thus, the present study included patients with similar malocclusion (Angle's Class I, II and III malocclusions), to solely determine, the role of gonial angle and, in turn, the role of muscles of mastication.

Limitation(s)

Insufficient sample size, age specific considerations and non consideration of Angle's subdivision classification were the limitations of the present study.

CONCLUSION(S)

Using a cephalometric radiograph, the authors evaluated HGS on patients with small and large gonial angle groups. A value of 81°

was the lowest gonial angle (Horizontal growers), and 156° was the highest (Vertical grower). A value of 14.7 kg was the minimum hand strength (Vertical growers), and 57.5 kg was the maximum hand strength (Horizontal growers). Due to weak muscle strength, vertical group cases should be treated more carefully.

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Declaration: The research protocol for the present study has already been published in Journal of Pharmaceutical Research International [1].

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