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To Determine The Maximum Bite Force In Different Skeletal Growth Patterns

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ABSTRACT
Bite force serves as an indicator of masticatory efficiency and is influenced by multiple factors including age, occlusion, growth pattern, periodontal health, and temporomandibular joint function. This study aimed to assess and compare maximum bite force among individuals with different skeletal growth patterns—vertical, horizontal, and average. A total of 270 subjects aged 18–40 years were selected and categorized according to growth pattern determined through lateral cephalometric analysis. Bite force measurements were obtained in the first molar region using a calibrated strain-gauge transducer, and the mean values were statistically analyzed using ANOVA with significance assessed through p-values. Results indicated that individuals with an horizontal growth pattern exhibited the highest bite force, whereas vertical and average growth patterns demonstrated relatively lower, non-significant differences. The greater bite force observed in horizontal growers is likely attributable to balanced craniofacial morphology and optimal muscle orientation, enhancing masticatory performance. Variations due to measurement technique and individual anatomical differences were also considered. In conclusion, individuals with an horizontal growth pattern demonstrate superior bite force and masticatory efficiency compared to vertical or average growers. Relevant literature on bite force, craniofacial structure, and measurement methodology was reviewed to support the findings.

Keywords: *maximum bite force; skeletal growth pattern; horizontal growers.*

1. INTRODUCTION

The force generated between maxillary and mandibular teeth by an act of the jaw elevator muscles is known as bite force(1). The assessment of maximum bite force has long been recognized as an important clinical indicator of the functional state of the masticatory system(2). Bite force not only reflects the efficiency of mastication but also provides valuable insights into the anatomical, neuromuscular, and occlusal characteristics of individuals. It is influenced by several factors, including age, occlusal morphology, craniofacial growth patterns, periodontal support, and temporomandibular joint function(3,4). Among these, occlusal classification and growth patterns have been shown to play a critical role in determining the magnitude and distribution of bite forces.

Skeletal growth patterns, categorized as vertical, horizontal, or average, have a significant impact on the magnitude and direction of bite force. Individuals with a horizontal growth pattern generally exhibit greater masticatory efficiency and higher bite force due to favorable jaw mechanics and muscle orientation. In contrast, vertical growth patterns are often associated with reduced bite force, reflecting altered muscle leverage and less efficient load distribution across the jaws. These variations highlight the close interrelationship between craniofacial morphology, muscle function, and occlusal performance, underscoring the importance of skeletal growth pattern assessment in evaluating functional adaptations of the

masticatory system.

Understanding bite force in the context of growth types is clinically significant for orthodontic diagnosis, treatment planning, and predicting stability of treatment outcomes. A comprehensive evaluation of these parameters can provide a clearer understanding of the functional adaptations in different skeletal and dental relationships.

The present study aims to determine and compare the maximum bite force in different growth pattern. A total of 270 subjects were included in all skeleton growth pattern, with 90 samples representing each growth pattern, in the age group of 18 to 40 years. This investigation seeks to establish the relationship between growth patterns and bite force, thereby contributing to the broader understanding of occlusal bite force function in clinical practice

2. MATERIALS AND METHODOLOGY

The aim of the study is to evaluate the maximum bite force in individuals with various growth patterns. The objectives are to determine the maximum bite force in vertical, horizontal, and average growth patterns and to compare the bite force among these three groups to identify any significant differences related to growth pattern characteristics.

This retrospective observational study was carried out in the Department of Orthodontics and Dentofacial Orthopedics at Saraswati Dental College, Lucknow. Participants were selected based on specific inclusion and exclusion criteria. Subjects included were between 18 to 40 years of age, with no history of temporomandibular disorders, craniofacial trauma, or prior orthodontic treatment, and exhibited good periodontal health. Individuals with systemic conditions affecting muscle function, cleft palate, dental implants, or pregnancy were excluded from the study.

To conduct the study, a standardized set of materials and instruments were used, including digital lateral cephalometric radiographs (8x10 inches), 0.003-inch acetate matte tracing sheets, X-ray view boxes, masking tape, 4H pencils with fine tips, geometry sets, pens, and data recording sheets. Bite force was measured using a strain gauge-based transducer—a device that employs elastic elements and resistance strain gauges to convert mechanical strain into changes in electrical resistance. This change is proportional to the applied force, allowing for accurate and sensitive bite force measurements. The strain gauge transducer used in this study featured a compact design, high sensitivity, and reliability, making it suitable for clinical research environments(5).

In this study, the categorization of individuals into horizontal, vertical, and average growth patterns was determined using lateral cephalometric analysis, incorporating Tweed's FMA angle, Steiner's Go-Gn to SN plane angle, and Downs' Go-Me to FH plane angle as diagnostic parameters (6,7).

The main objective was to assess the maximum voluntary bite force in individuals with different craniofacial growth patterns. A total of 270 participants were selected based on clinical and cephalometric assessments. Bite force data were recorded using a strain gauge bite force transducer(Fig:3) comprising a metallic biting fork covered with acrylic resin(Fig:1) to ensure safety and comfort (5). The device was calibrated with standard weights before use to ensure accuracy.

During the recording process, each participant was seated upright with the head in a natural position. The biting fork was positioned alternately in the right and left first molar regions, covered with a disposable plastic sleeve(Fig:2) for infection control(8). Participants were instructed to bite maximally and sustain the force for 3–5 seconds. Three measurements were taken on each side with a two-minute rest period between trials to avoid muscle fatigue. The highest value recorded was considered the individual's maximum bite force. All readings, recorded in Newtons, were documented, and the mean and standard deviation were calculated. These values were then statistically analyzed to compare bite force across vertical, horizontal, and average craniofacial growth patterns.

Ethical approval for the study was obtained from the institutional review board the portfolio number of which is #FM20R07062025R, and written informed consent was secured from all participants.

Fig:1 A metallic biting fork covered with

Fig:2 Disposable plastic sleeve acrylic resin

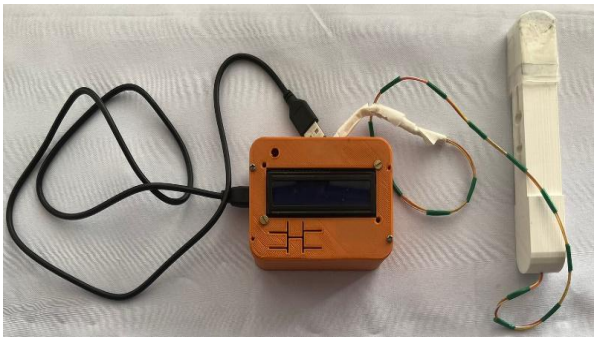

Fig:3 Strain gauge bite force transducer

The statistical analysis for this study was conducted using Python (version 3.12) with the pandas (2.x) and scipy (1.11) libraries for data handling and statistical testing, respectively, while visualizations were created using matplotlib (3.8) and seaborn (0.13); the primary statistical method applied was a one-way ANOVA to compare bite force values among the three skeletal growth patterns (Vertical, Horizontal, and Average), and post hoc pairwise comparisons were performed using paired t-tests, with statistical significance set at $\alpha = 0.05$ ($p < 0.05$), and interactive or editable 3D visualizations, where required, were exported using Plotly.js (2.27).

Statical analysis

Table : Comparative evaluation of Bite force between vertical, horizontal & Average growth patterns.

Comparison	Test Type	Test Statistic	P-value	Significance (α=0.05)
Vertical vs Horizontal	Paired t-test	t = -5.513	0.000000	*** (significant)
Vertical vs Average	Paired t-test	t = -1.240	0.218221	ns (not significant)
Horizontal vs Average	Paired t-test	t = 4.833	0.000006	*** (significant)
All three (ANOVA: between groups)	One-Way ANOVA	F = 16.46	0.000000	*** (significant)

Fig : Comparative evaluation of Bite force between vertical, horizontal & Average growth patterns.

3. RESULT

The statistical analysis comparing maximum bite force across Vertical, Horizontal, and Average skeletal growth patterns

(n=90 each) shows that the Horizontal group has the highest bite force and the Vertical group the lowest, with ANOVA revealing a highly significant difference between the groups ($F = 16.46$, $p < 0.001$); post hoc results demonstrate that the Horizontal group's bite force is significantly greater than both Vertical and Average ($p < 0.001$), while there is no significant difference between the Vertical and Average groups, confirming that skeletal growth pattern is a strong predictor of bite force capacity.

4. DISSCUSSION

The purpose of this study was to assess how people with various skeletal growth patterns differed in their maximal bite force. The goal was to ascertain whether there is a meaningful correlation between the masticatory system's functional ability and vertical skeletal relationships. Skeletal growth patterns as an independent predictor of biting force have received relatively little attention in prior research, which has mostly focused on occlusal traits and malocclusion categories. To the best of our knowledge, no study has been published in the current population that specifically focuses on how skeletal divergence affects maximum bite force.

The measurement device's position (frontal, unilateral, or bilateral), size, material, elasticity, and accuracy, the patient's fear of pain or tooth breakage, and the sensitivity of the mandibular joint, muscles, and teeth all affect the maximal biting force (9). Shinogaya T. et al. (10) state that the molar region distributes 80% of the occlusal force. Because of this, we placed the sensor in the vicinity of the first permanent molars in our investigation.

Occlusal forces are associated with face shape (11). The masticatory muscles have a better mechanical advantage if the mandibular ramus is straighter and the gonial angle is comparatively smaller. The occlusal force may represent the link between form and function because as the gonial angle increases, the muscles' mechanical advantages diminish and their corresponding force results in a lesser force in occlusion (12).

Some data show that the bite force varies depending on the vertical facial morphology and individuals with hypodivergent type have higher values of the force compared to hyperdivergent (13, 14). Other studies do not find difference in maximum masticatory force in between hypodivergent and normodivergent individuals both on the left and on the right side. Bogdanov, V (2022) (15).

The results of our investigation showed that the highest biting force was demonstrated by individuals with an horizontal (hypodivergent) growth pattern, and this difference was statistically significant ($p < 0.001$). This result implies that the masticatory system's functional ability is significantly impacted by the face growth pattern. Horizontal growers may have a stronger bite force because of a good balance between mandibular biomechanics, occlusal contact area, and muscle orientation, which may maximize force production efficiency. On the other hand, bite force capacity may be impacted by anatomical or functional restrictions in individuals who grow horizontally or vertically (Edmonds, H. M., & Glowacka, H. 2020)(16).

Among students aged 20 to 23 with hypo-, normo-, and hyperdivergent face types, Abu Alhaija E.S. et al. (11) report a mean maximum bite force score of 573.42 ± 140.18 N. People with short faces had the greatest scores, according to the authors, while people with long faces had the lowest values. These findings align with those published by Kiliaridis S. et al. (17) and Sasaki K. et al. (18). Our findings indicate that the horizontal growth pattern (hypodivergent) type is statistically more significant than the vertical (hyperdivergent) and average (normodivergent) types. Interocclusal distance, the meter's position on the dentition, and the head's position during measurement are all factors associated with methodological variations (11). It has also been documented that those with and without parafunctional behaviours do not differ in their biting strength (19).

Although biting force rises with age, height, and body weight, according to Shiau Y. and Wang J. (20) Braun S. et al. (21) discover little relationship between bite strength and anthropometric measures. There is considerable uncertainty in the statistics about gender differences. Males have higher values than females, according to some writers (22, 23). The magnitude of bite force may be influenced or modified by various dental, anatomical, and functional factors. the presence of decayed or restored teeth can affect the efficiency and strength of biting (24,25), missing teeth result in reduced occlusal contact area (26), presence of prosthesis (27), the use of prosthetic appliances may alter natural occlusal dynamics and thereby influence bite force (27,28)), individual chewing or masticatory patterns contribute significantly to variations in bite force (29), differences in the extent of muscular involvement during measurement may lead to fluctuations in recorded values (Neumann, 1950)(30), the nature of occlusal relationships among teeth determines how effectively bite force is transmitted (Klaffenbach, 1936)(31), functional attributes of the masticatory muscles, periodontal ligament, jawbone health, and temporomandibular joint characteristics collectively affect bite force (Neumann, 1950)(30), anatomical variations such as root length, number of roots, and their angulation also play a role in modifying bite force (Dempster et al., 1964)(32).

5. CONCLUSION

The present investigation sought to elucidate the relationship between facial growth patterns and maximum bite force. Upon detailed statistical evaluation, individuals with an horizontal growth pattern demonstrated a distinctly higher bite force, with a statistically significant p-value when compared to both average and vertical growers. This remarkable finding points toward the inherent biomechanical advantage of balanced craniofacial proportions, where optimal skeletal alignment and efficient

muscular synergy culminate in superior masticatory strength. In contrast, the disproportionate leverage seen in average and vertical patterns may limit effective muscle output. Hence, the study accentuates that the harmony between form and function rather than extremity of growth pattern emerges as the defining factor for maximal bite force generation.

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