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Comparison of Maxillary Anterior Tooth Proportion Measurements Using Chu's Gauge and Digital Calipers in College Students

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Abstract: Smile aesthetics is closely related to the proportion of the maxillary anterior teeth, which plays an important role in aesthetic dentistry. Standard evaluation tools such as Chu's Esthetic Proportion Gauge, based on the Recurring Esthetic Dental (RED) proportion, are widely used to assess anterior tooth proportions. However, these standards were primarily developed from Caucasian populations and may not accurately represent dental characteristics in other populations. Considering the limited data on tooth proportion standards for the Indonesian population and the increasing demand for aesthetic dental treatment, evaluating the suitability of these tools in Indonesian individuals is important. This study aimed to assess the suitability of Chu's Esthetic Proportion Gauge in measuring maxillary anterior tooth proportions and to compare its measurements with those obtained using a digital caliper among PSPDG FKKGIK Universitas Prima Indonesia students from the 2022–2024 cohorts. This quantitative comparative study employed a cross-sectional design involving 68 respondents selected through purposive sampling. Measurements of the central incisors, lateral incisors, and canines were conducted using Chu's Gauge and a digital caliper. Data were analyzed using reliability testing, the Kolmogorov–Smirnov normality test, and the Mann–Whitney test. The results showed that both instruments demonstrated good reliability. However, significant differences were found between the measurements obtained using Chu's Gauge and the digital caliper for all maxillary anterior teeth ($p < 0.05$), with the digital caliper consistently producing higher values. The highest agreement with Chu's Gauge was observed in the central incisors, lower agreement in the lateral incisors, and no agreement in the canines. Gender-related differences in tooth proportions were also identified. These findings provide practical implications for aesthetic dental practice and contribute to the development of tooth proportion references for the Indonesian population. Future research should involve larger samples and explore advanced digital measurement methods to improve accuracy in assessing anterior tooth proportions.

Keywords: Anterior tooth proportion; Chu's gauge; Dental aesthetics; Digital caliper

Introduction

Teeth are a crucial component of the stomatognathic system, playing a role in mastication, phonation, and facial aesthetics. In the context of dental aesthetics, tooth size and proportion are key factors determining a harmonious smile. The development of aesthetic rehabilitation techniques in the field of dentistry has brought about a paradigm shift in the field of restoration and aesthetics (Hidajah et al., 2020). Properly aligned teeth that fit the jaw arch will improve speech and chewing function, as well as enhance a person's appearance (Khairunnisa et al., 2022). Some patients complain of gaps in the upper anterior teeth, the

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lower teeth appearing more forward, and feel that their smile looks less aesthetically pleasing (Andini & Anggani, 2020). One of the primary concerns of patients attending dental clinics for esthetic reasons is the creation of harmonious proportions between the widths of maxillary anterior teeth when restoring or replacing them (Agrawal et al., 2016; Azam et al., 2014).

Differences in tooth size are fundamentally influenced by various factors, particularly race and environment. Each race has unique morphological characteristics, resulting in variations in tooth size, which ultimately impacts the proportions of anterior teeth and overall dental aesthetics (Hafiza et al., 2015; Prastyo et al., 2023). Dental aesthetics is a crucial aspect of modern dental practice, particularly in the restorative and aesthetic fields (Alqahtani et al., 2021). Dental aesthetics not only contributes to overall facial appearance but is also gaining increasing attention with the development of social media, which shapes social perceptions of a person's smile (Sari et al., 2025; Tithphit et al., 2025). Harmonious facial aesthetics and optimal functional occlusion can be achieved through accurate diagnosis and treatment planning. In this process, there are several fundamental factors that need to be considered, including the condition of the space, the size and shape of the teeth and jaw, the presence of crowded teeth, the relationship between the bite distance, and discrepancies in the dental arch (Ramadhan et al., 2020).

Many individuals seek dental care primarily due to concerns about the appearance of their teeth, particularly the maxillary anterior teeth, as these are the most visible components of the face during speaking and smiling. The demand for aesthetic dental treatment has increased significantly in recent years. Studies report that aesthetic concerns related to tooth color, alignment, and anterior tooth proportions are among the most common reasons patients visit dental clinics. Approximately 40–60% of patients seeking dental treatment report dissatisfaction with the appearance of their anterior teeth, highlighting the importance of proper aesthetic evaluation in dental practice. An ideal smile not only influences visual aesthetic perception but also contributes to self-confidence, self-image, and the quality of social interactions (Mayun, 2023). Therefore, the success of aesthetic dental treatment is not only assessed by masticatory function but also by the appropriate proportions and harmonious appearance of the anterior teeth. Maxillary anterior teeth play a crucial role in shaping facial aesthetics and creating an attractive smile. Loss of maxillary anterior teeth not only impacts facial appearance but also has the potential to have psychological impacts on the individual (Liao et al., 2019).

The aesthetic value of a smile is determined by the integration of several key components: gingival anatomy and contour, tooth morphology, and lip shape and position. These three components must have a harmonious proportional relationship to produce a balanced and attractive smile (Puspitasari et al., 2025). However, dental trauma to the maxillary incisors is a fairly common condition and requires careful treatment planning, taking into account the location of the fracture line, occlusion conditions, and treatment prognosis. In addition to functional aspects, trauma to the anterior teeth also has the potential to affect tooth dimensions and proportions. Mismatched proportions, particularly in the length and width of the maxillary anterior teeth, can create a less-than-ideal smile and impact overall aesthetic perception (Khairunnisa et al., 2022; Nugraheni et al., 2023).

In an effort to achieve ideal anterior tooth aesthetic proportions, various analytical concepts have been developed and widely used. Some of these include the Golden Proportion, Preston's Proportion, and the Recurring Esthetic Dental (RED) Proportion (Kalia, 2020). The Golden Proportion concept emphasizes certain mathematical relationships considered visually ideal and is widely adopted in dental aesthetic design (Mayun, 2023). The most important guideline for aesthetics is the Golden Proportion value. The optimal width-to-height ratio of maxillary central incisors varies between 66% and 85% (Aldegheishem et al., 2019). However, this concept is often considered too rigid because it does not always accommodate individual anatomical variations. Preston's Proportion was later developed as a modification of the Golden Proportion to be more flexible and adaptable to smile variations (Rabi, 2021). Chu's Esthetic Gauge is based on the concept of the Recurring Esthetic Dental (RED) proportion, which commonly applies a standardized value of approximately 78% for the proportional relationship among maxillary anterior teeth (Bardocz-veres et al., 2022). Chu's gauge digunakan untuk mengukur proporsi ideal gigi, gingival dan tulang alveolar (Indro & Nelwan, 2019). However, because this device was originally developed based on specific demographic data, its applicability and accuracy may vary across different populations and therefore require validation in diverse ethnic groups (Malli et al., 2023).

Based on the RED Proportion principle, a clinical tool known as the Chu's Esthetic Proportion Gauge was developed. This tool is designed to help dentists quickly and practically evaluate the length and width of anterior teeth in the treatment chair. The Chu's Gauge uses a fixed color and scale system that represents the ideal aesthetic proportion based on the RED 78% standard. The advantages of this tool lie in its ease of use and time efficiency, making it frequently used in daily clinical practice. However, the use of a fixed scale on the Chu's Gauge also presents limitations because it does not allow

for adjustments to individual tooth morphological variations or differences in population characteristics.

Several previous studies have reported that the accuracy and suitability of the Chu's Esthetic Proportion Gauge vary across populations. A study conducted by Wagh et al. (2020) in Central India compared measurements of maxillary anterior tooth proportions using the Chu's Esthetic Proportion Gauge and digital calipers. The results showed that the esthetic proportions determined by the Chu's Gauge did not reflect the natural tooth proportions in the Central Indian population. This confirms that the proportion standards used by the Chu's Gauge are not universally applicable to all population groups.

Similar results were also found in a study by Bardocz-veres et al. (2022) in Transylvania, which evaluated the accuracy of the Chu's Esthetic Proportion Gauge by comparing it to digital caliper measurements. The study reported that the average length and width of the maxillary anterior teeth measured using the Chu's Gauge tended to be higher than the RED standard of 78%, thus not corresponding to the actual tooth proportions in the Transylvanian population. Furthermore, Malli et al. (2023) in their study in South India found that only about 39% of central incisor dimensions matched the Chu's Gauge standard, while the correspondence rates for lateral incisors and canines were much lower, at 10% and 6.4%, respectively.

These findings suggest that the applicability of Chu's Esthetic Proportion Gauge may vary depending on racial and morphological characteristics. The gauge was originally developed based on tooth proportion standards derived mainly from Caucasian populations. In contrast, Mongoloid populations, including Indonesians, generally exhibit different dental morphological characteristics. Anthropometric studies report that individuals of Mongoloid descent tend to have anterior teeth with relatively wider mesiodistal dimensions and shorter inciso-gingival lengths compared to Caucasian populations. Such differences in tooth morphology may influence the accuracy of aesthetic proportion assessments when using tools developed based on different population standards.

Despite the growing interest in aesthetic dentistry in Indonesia, research examining the suitability of Chu's Esthetic Proportion Gauge for the Indonesian population remains limited. Most existing studies have been conducted in other countries and populations, leaving a gap in scientific evidence regarding whether the RED proportion–based Chu's Gauge can accurately represent the natural anterior tooth proportions of Indonesians. Understanding this suitability is essential for dentists in selecting appropriate measurement methods for aesthetic treatment planning. The use of measurement tools that do not align with the morphological characteristics of the population may lead to inaccurate proportion analysis and potentially affect clinical and aesthetic treatment outcomes.

This study was conducted on students of the Dental Professional Education Program (PSPDG) of the Faculty of Dentistry and Oral Health Sciences, Universitas Prima Indonesia, from the 2022–2024 cohorts. This population was selected because dental students generally have relatively good oral health conditions and minimal restorative alterations on anterior teeth, allowing more accurate evaluation of natural tooth proportions. In addition, selecting respondents within a relatively homogeneous age group helps minimize variations caused by age-related dental changes.

Therefore, this study aims to compare the proportions of maxillary anterior teeth measured using Chu's Esthetic Proportion Gauge and a digital caliper in an Indonesian Mongoloid population. Scientifically, this research is expected to contribute to the development of reference data regarding anterior tooth proportions in the Indonesian population and to evaluate the applicability of Chu's Gauge for this group. Clinically, the findings may assist dentists in selecting appropriate measurement tools and methods for aesthetic analysis, thereby supporting more accurate smile design and aesthetic dental treatment planning.

Method

This study employed a quantitative comparative design with a cross-sectional approach to compare the proportions of maxillary anterior teeth measured using Chu's Esthetic Gauge and a digital caliper. The research was conducted at Prima Dental and Oral Hospital over a two-month period, from September to October 2025. The study population consisted of 164 undergraduate dental students enrolled in the Dental Professional Education Program (PSPDG), Faculty of Dentistry, Faculty of Medicine and Health Sciences, Universitas Prima Indonesia, class cohorts of 2022–2024. Sample size estimation was performed using the Taro Yamane formula with a margin of error set at 10%, resulting in a minimum required sample of 62 participants. To anticipate potential dropouts, an additional 10% was added, yielding a final minimum sample size of 68 subjects. Participants were recruited using purposive sampling based on predefined inclusion and exclusion criteria to ensure homogeneity of dental and esthetic conditions.

Eligible participants were those presenting with healthy maxillary anterior teeth, without crowding, diastema, fractures, missing teeth, orthodontic appliances, or non-carious lesions such as attrition, erosion, abrasion, or abfraction. Subjects with a history of orthodontic treatment were included only if no

interproximal reduction had been performed. Only individuals of Mongoloid race were included. Exclusion criteria comprised participants under 18 years of age, those using dental prostheses, individuals who had undergone gingivectomy or crown lengthening procedures, and subjects presenting with a high smile line exposing more than 2 mm of gingiva. The independent variable in this study was the measurement instrument used to determine the proportion of maxillary anterior teeth, namely Chu's Esthetic Gauge and a digital caliper. The dependent variable was the proportion of maxillary anterior teeth, specifically the clinical crown dimensions of the central incisors, lateral incisors, and canines on both the left and right sides. Operational definitions of all variables are provided in the supplementary materials.

Data collection involved both clinical and laboratory procedures. Initially, participants completed a demographic questionnaire to confirm eligibility. All subjects received a detailed explanation of the study objectives and procedures and provided written informed consent prior to participation. Visual assessment and standardized frontal photographs of the smile and maxillary anterior teeth were obtained using a DSLR camera under consistent lighting conditions. Three dental specialists (Periodontics, Prosthodontics, and Orthodontics) independently evaluated the photographs to validate subject selection.

Participants who met all criteria underwent clinical evaluation using Chu's Esthetic Gauge while seated in a dental unit with the head positioned in the Frankfort horizontal plane. Prior to examination, subjects rinsed with chlorhexidine solution for 30 seconds, and cheek retractors were placed to optimize visibility. The maxillary anterior teeth (teeth 11–13 and 21–23) were visually assessed using the color-coded reference lines of Chu's Gauge corresponding to central incisors, lateral incisors, and canines. Subsequently, maxillary impressions were taken using alginate impression material. The impressions were rinsed under running water, disinfected with 5.25% sodium hypochlorite solution, and poured with type III dental stone to obtain study models. The accuracy of Chu's Gauge measurements was verified on the models prior to digital measurement. Actual clinical crown width and height were then measured on the study models using a digital caliper.

Data obtained from Chu's Esthetic Gauge were compared with measurements acquired using the digital caliper to assess the accuracy of Chu's Gauge in determining maxillary anterior tooth proportions. Statistical analysis was performed using appropriate software. Reliability testing was conducted to assess measurement consistency. Data normality was evaluated using the Kolmogorov–Smirnov test. For comparative analysis, an independent t-test was applied when data were normally distributed, while the Mann–Whitney U test was used for non-normally distributed data. Statistical significance was set at $p < 0.05$.

Result and Discussion

Result

Distribution of Research Sample by Gender

The distribution of the research sample by gender is presented to illustrate the characteristics of the respondents involved in this study. The sample consisted of students from the Dentistry Education Program (PSPDG FKKGIK) of the Faculty of Medicine, Dentistry, and Health Sciences (Faculty of Medicine, Dentistry, and Health Sciences) at Prima Indonesia University, graduating in the 2022–2024 intake. The population of PSPDG FKKGIK students at Prima Indonesia University, graduating in the 2022–2024 intake, consisted of 164 students, consisting of 133 female students (81.1%) and 31 male students (18.9%).

Table 1. Sample Characteristics Based on Gender

Gender	n	Percentage (%)
Male	13	19.1
Female	55	80.9
Total	68	100

A total of 68 students met the inclusion criteria as research subjects, with 55 female subjects (80.9%) and 13 male subjects (19.1%).

The Accuracy Level of Chu's Gauge on the Tooth Morphology of PSPDG FKKGIK Students, Prima Indonesia University, Class of 2022-2024

The assessment of dental morphology, particularly of the maxillary anterior teeth, is an important aspect of dental treatment planning related to both function and aesthetics. Accuracy in determining tooth size and proportions serves as a fundamental basis for achieving optimal treatment outcomes, whether in restorative, rehabilitative, or aesthetic procedures. One of the instruments widely used in evaluating the proportions of anterior teeth is Chu's Gauge, which is designed to provide quick and practical measurements based on the principles of ideal proportions. Therefore, a study is required to examine the level of accuracy of Chu's Gauge in representing actual tooth morphology, particularly in the population of PSPDG FKKGIK Universitas Prima Indonesia students from the 2022–2024 cohorts.

Table 2. Accuracy Level of Chu's Gauge Against Dental Aesthetic Standards Based on the Morphological Characteristics of the Teeth of PSPDG FKKGIK Universitas Prima Indonesia Students, Class of 2022-2024

Dental Elements	Appropriate		Not appropriate		Total	
	n	%	n	%	n	(%)
Central Incisor (I1)	66	48.5	70	51.5	136	100
Lateral Incisor (I2)	53	39	83	61	136	100
Canine (C)	0	0	136	100	136	100

The accuracy level of Chu's Gauge against dental aesthetic standards showed variations in suitability for each type of maxillary anterior teeth (central incisors, lateral incisors, and canines) in PSPDG FKKGIK Universitas Prima Indonesia students' class of 2022–2024. For central incisors (I1), 66 teeth (48.5%) were declared suitable, while 70 teeth (51.5%) were not suitable. For lateral incisors (I2), the suitability level was lower, namely 53 teeth (39%) were suitable and 83 teeth (61%) were not suitable. These results indicate that the level of suitability of measurements using Chu's Gauge is better for central incisors than for lateral incisors. All canines (C) evaluated, namely 136 teeth (100%), were declared not to comply with Chu's Gauge aesthetic standards. Overall, the highest level of suitability was found in central incisors, decreased in lateral incisors, and was not found at all in canines.

Ideal Anterior Maxillary Proportion Standards for PSPDG FKKGIK Students at Prima Indonesia University

Determining the ideal standard for maxillary anterior tooth proportions is a crucial component in aesthetic and rehabilitation dentistry, as proper proportions contribute to a harmonious smile, facial balance, and support phonation and mastication. Anterior tooth proportions, particularly the ratio of crown length to crown width, are often used as a parameter for assessing optimal dental aesthetics. However, these ideal proportions can vary between individuals and populations, influenced by race, gender, and tooth morphology. Therefore, a study is needed to determine the ideal standard for maxillary anterior tooth proportions in students of the Dental Dentistry Program (PSPDG) Faculty of Dentistry and Dental Surgery (FKKGIK) at Prima Indonesia University as a reference for clinical evaluation, treatment planning, and the development of knowledge in dentistry.

Table 3 shows the average results of measurements of the proportions of the maxillary anterior teeth based on measurements and gender, indicating variations in values for each tooth, both in mesiodistal (M-D) and cervico-incisal (C-I) measurements. Mesiodistal (M-D) measurements show that male subjects have average width values (teeth 11, 12, and 13) of 8.3 mm, 6.7 mm, and 7.4 mm. On the left side, the average values (teeth 21, 22, and 23) are 8.2 mm, 6.8 mm, and 7.1 mm, respectively. In female subjects, the average mesiodistal values (teeth 11, 12, and 13) are 8.1 mm, 6.4 mm, and 7.2 mm, respectively. And on the left side, the average values for teeth 21, 22, and 23 were 8.2 mm, 6.6 mm, and 7.3 mm, respectively.

Table 3. Results of Measurement of the Dimensions of the Upper Anterior Teeth Based on Gender

Gender	Tooth Measurement Dimensions	Average Tooth Size (mm)					
		13	12	11	21	22	23
Male	Tooth Width (M-D)	7.4	6.7	8.3	8.2	6.8	7.1
	Tooth Length (C-I)	8.3	7.9	9.3	9.6	7.1	8.4
Female	Tooth Width (M-D)	7.2	6.4	8.1	8.2	6.6	7.3
	Tooth Length (C-I)	8.1	7.4	8.7	8.9	7.6	8.4

Cervico-incisal (C–I) measurements showed that male subjects had average heights for teeth 11, 12, and 13 of 9.3 mm, 7.9 mm, and 8.3 mm. On the left side (teeth 21, 22, and 23) they were 9.6 mm, 7.1 mm, and 8.4 mm, respectively. Female subjects had average cervico-incisal values for teeth 11, 12, and 13 of 8.7 mm, 7.4 mm, and 8.1 mm. On the left side, the average values for teeth 21, 22, and 23 were 8.9 mm, 7.6 mm, and 8.4 mm. In general, the results of cervico-incisal measurements show that the height of the maxillary anterior teeth in male subjects tends to be greater than in female subjects.

Table 4. Average Proportion of Tooth Width to Length

Gender	Amount	Percentage (%)	Proportion of Tooth Width to Tooth Length (Mean±SD mm)					
			13	12	11	21	22	23
Male	13	19.1	0.913 ± 0.233	0.856 ± 0.125	0.911 ± 0.142	0.856 ± 0.073	0.968 ± 0.207	0.863 ± 0.159
Female	55	80.9	0.900 ± 0.124	0.874 ± 0.127	0.882 ± 0.139	0.930 ± 0.114	0.873 ± 0.108	0.874 ± 0.126

Table 4 shows the difference in values between male and female subjects based on each type of tooth, namely central incisor, lateral incisor, and canine both right and left. Male subjects with an average value of the proportion of width to length of the right central incisor (11) is 0.911±0.142, right lateral incisor (12) 0.856±0.125, and right canine (13) 0.913±0.233. The left side obtained an average value of the proportion of the central incisor (21) of 0.856±0.073, lateral incisor (22) 0.968±0.207, and canine (23) 0.863±0.159. Female subjects with an average value of the proportion of width to length of the right central incisor (11) of 0.882 ± 0.139, right lateral incisor (12) 0.874 ± 0.127, and right canine (13) 0.900 ± 0.124. On the left side, the central incisor (21) had an average value of 0.930 ± 0.114, lateral incisor (22) 0.873 ± 0.108, and canine (23) 0.874 ± 0.126.

Reliability Test Results

Reliability test results for the research instruments showed that the Chu's Gauge had a Cronbach's Alpha value of 0.779, while the digital caliper had a Cronbach's Alpha value of 0.776. The Cronbach's Alpha values for both instruments were above the minimum threshold of 0.70, thus they were deemed reliable (Table 5).

Table 5. Reliability Test Results

Research Instruments	Cronbach's Alph	Category
Chu's Gauge	0.77	Reliable
Digital Caliper	0.77	Reliable

These results indicate that the Chu's Gauge and digital caliper have good internal consistency in measuring the proportions of maxillary anterior teeth, so they can be used consistently and reliably for repeated measurements. Therefore, both instruments are suitable for use as measuring tools in a comparative study of maxillary anterior tooth proportions in PSPDG FKKGIK Universitas Prima Indonesia students.

Differences Between the Results of Measuring the Proportions of the Upper Anterior Teeth Using a Chu's Gauge and a Digital Caliper in PSPDG FKKGIK Students of Prima Indonesia University, Class of 2022-2024

To determine the differences in the results of measurements of the proportions of the maxillary anterior teeth using the Chu's Gauge and digital calipers in PSPDG FKKGIK Universitas Prima Indonesia students of 2022-2024, a normality test was first performed using the Kolmogorov-Smirnov Test (Table 6). The Chu's Gauge normality test showed that the data on the proportions of the central, lateral, and canine teeth had a significance value (p-value) less than 0.05. In measurements using the digital caliper, the p-value for the central incisor was 0.002, while the p-value for the lateral incisor and canine were 0.000 each. These significance values indicate that the data were not normally distributed, both in measurements using the digital caliper and the Chu's Gauge. Further statistical analysis to compare the results of measurements of the proportions of the maxillary anterior teeth between the Chu's Gauge and the digital caliper was performed using a non-parametric statistical test, namely the Mann-Whitney test.

Table 6. Normality Test Results

Teeth	P-Value	
	Digital Caliper	Chu's Gauge
Central Incisor	0.002	0.000
Lateral Incisor	0.000	0.000
Canine	0.000	0.000

The Mann–Whitney test results showed a statistically significant difference between the results of measurements of the proportions of the maxillary anterior teeth using Chu's Gauge and digital calipers for all types of teeth studied, namely central incisors, lateral incisors, and canines on both the right and left sides. This is indicated by a significance value (p-value) of 0.000 for all tooth groups ($p < 0.05$) (Table 7).

In central incisors, the mean proportion of the measurement results using a digital caliper was 0.925±0.127, higher than the Chu's Gauge 0.800 0.096. In lateral incisors, the digital caliper showed a mean proportion of 0.879±0.131, while the Chu's Gauge was 0.812±0.100. In canines, the mean proportion using a digital caliper was 0.893±0.141, higher than the Chu's Gauge at 0.843±0.112. Overall, the results of the Mann–Whitney test showed a significant difference between the results of measurements of the proportions of the maxillary anterior teeth using the Chu's Gauge and the digital caliper, with the digital caliper measurement values tending to be higher in all anterior teeth studied.

Table 7. Differences in the Measurement Results of the Proportions of the Upper Anterior Teeth Using the Chu's Gauge and Digital Caliper (Mann–Whitney Test)

Teeth	N	Mean ± SD (mm)		P-Value
		Digital Caliper	Chu's Gauge	
Central Incisor	136	0.925 ± 0.1267	0.867 ± 0.092	0.000*
Lateral Incisor	136	0.880 ± 0.130	0.800 ± 0.096	0.000*
Canine	136	0.893 ± 0.141	0.843 ± 0.111	0.000*

Discussion

The results of the study showed that the level of conformity of the evaluation results of the proportion of maxillary anterior teeth using Chu's Gauge in PSPDG FKKGIK Universitas Prima Indonesia students of 2022–2024 varied for each tooth type. The highest conformity was found in central incisors, lower in lateral incisors, and no conformity was found in canines at all. These findings indicate that Chu's Gauge does not have the same level of conformity for all anterior teeth. These results are in line with previous research conducted by Malli et al. (2023) in South India, which evaluated the proportion of maxillary anterior teeth based on the Recurring Esthetic Dental (RED) proportion standard of 78% using Chu's Esthetic Proportion Gauge and caliper measurements. The study showed that only about 39% of central incisors conformed to the Chu's gauge standard, while the conformity levels for lateral incisors and canines were much lower, only 10% and 6.4%, respectively. This finding strengthens the results of this study that the level of conformity of Chu's Gauge tends to decrease from the central incisor to the lateral incisor, and is very low in the canine.

The high level of conformity of the Chu's Gauge to central incisors can be explained by the morphology of these teeth. Central incisors have a relatively symmetrical crown shape, a clear flat plane, and a more consistent width-to-height ratio across individuals (Song et al., 2017). These characteristics align with the basic principles of the Chu's Gauge, which is designed based on maxillary proportion standards, which include proportional evaluation of the central incisors, lateral incisors, and canines. However, the level of morphological consistency in central incisors allows this instrument to provide measurement results closer to the standard than those for other anterior teeth. Conversely, the Chu's Gauge's conformity to dental aesthetic standards was found to be lower for lateral incisors. This may be due to the greater morphological variation of lateral incisors compared to central incisors. Lateral incisors often exhibit variations in crown shape, smaller size, and differences in incisal edge angle and contour. This morphological variation causes the width and height proportions of the lateral incisors to not always conform to the standard measurements set by the Chu's Gauge, resulting in a lower level of accuracy for these teeth (Kondo et al., 2014). The most striking result of this study was the failure to meet the Chu's gauge aesthetic standards for canines. Canines have very different morphological characteristics than incisors, namely a longer crown, a more convex labial surface, and sharp cusps (Ash, 2010). These anatomical characteristics cause the width-to-height ratio of canines to vary greatly and are difficult to align with the Chu's Gauge aesthetic proportion standards. This indicates that the Chu's Gauge has limitations in evaluating the aesthetic proportions of canines, especially in the student population of the PSPDG FKKGIK Universitas Prima Indonesia.

In addition to variations in the level of descriptive agreement, the results of statistical tests also showed a statistically significant difference between the results of measurements of the proportions of the maxillary anterior teeth using the Chu's Gauge and digital calipers, with a significance value of $p < 0.05$ for all types of anterior teeth studied, including central incisors, lateral incisors, and canines. This finding indicates that the two instruments produce consistently different measurement values. These results are in line with a study conducted by Bardocz-Veres et al. (2022) in Transylvania, which evaluated the accuracy of the Chu's Esthetic Proportion Gauge compared to digital calipers. The study showed that the proportions of the length and width of the maxillary anterior teeth in the Transylvanian population did not conform to the proportion standards set by the Chu's Gauge, with measurement values tending to be higher than the RED proportion standard of 78%. These similar findings indicate that differences in results between the Chu's Gauge and digital calipers occur not only in the Indonesian population but also in other populations with different morphological characteristics.

In addition to tooth morphology, individual variation and biological factors also influence the suitability of the Chu's Gauge. The Chu's Gauge was developed based on tooth proportions in Caucasian populations. Therefore, its application to non-Caucasian populations, including Indonesian students, does not always reflect the morphological characteristics of the teeth studied. This is evident from the results of the study, which show that the suitability of the Chu's Gauge is not uniform across all types of anterior teeth. Based on these findings, the Chu's Gauge is more appropriate for use as an aesthetic evaluation tool, particularly for central incisors, rather than as the sole measuring tool for assessing anterior tooth proportions comprehensively. This study is the first study in an Indonesian student population to evaluate the suitability of the Chu's Esthetic Proportion Gauge for the morphological characteristics of maxillary anterior teeth and compare it with measurements using digital calipers. This study used primary data obtained from direct measurements of maxillary anterior tooth proportions in students of the PSPDG FKKGIK Universitas Prima Indonesia. The results of this study are expected to serve as baseline data and references for further research related to the application of anterior tooth aesthetic proportion standards in the Indonesian population. This study has limitations in the form of an unbalanced distribution of samples by gender and

limited photographic documentation due to the lack of a macro lens and the lack of standardized shooting distances and angles, which can affect visualization accuracy and measurement accuracy. Future research is recommended to use more standardized documentation and a more balanced sample distribution.

Conclusion

Based on the results of this study, there is a significant difference between the measurement of maxillary anterior tooth proportions using Chu's Gauge and digital calipers in PSPDG FKKGIK Universitas Prima Indonesia students from the 2022–2024 cohorts, where the digital caliper consistently produces higher measurement values than Chu's Gauge. The level of conformity of Chu's Gauge varies among tooth types, with the highest conformity in central incisors, lower conformity in lateral incisors, and no conformity in canines. Differences in tooth proportions were also observed between male and female subjects. Although both instruments demonstrated good reliability, Chu's Gauge is more suitable as an auxiliary aesthetic evaluation tool rather than as the sole reference for determining anterior tooth proportions. Clinically, the differences in measurement results indicate that dentists should combine visual assessment tools such as Chu's Gauge with more precise instruments like digital calipers when planning aesthetic dental treatments to achieve more accurate evaluation of anterior tooth proportions. This study also has limitations, including a relatively small sample size and respondents drawn from a single institution, which may limit the generalizability of the findings. Nevertheless, the results contribute to the development of reference data for evaluating anterior tooth proportions in the Indonesian population. Future studies are recommended to involve larger and more diverse populations and to explore additional measurement methods, such as digital imaging or three-dimensional scanning, to obtain more comprehensive results.

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Author Contributions
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