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Analysis of the Anterior Maxillary Zone: Evaluation of Chu's Gauge Proportion Instrument in a Transylvanian Population

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ABSTRACT

Background: The esthetic proportion gauge developed by Chu is using a 78% recurring esthetic dental (RED) proportion and it is based on evaluating the size and proportion of frontal teeth chairside. The **aim** of the present study was to evaluate the validity of Chu's device and to measure the correlation between the width and length of the frontal teeth, attempting to identify the application of the proportion gauge in Mureș county. **Materials and methods:** From the 142 selected patients, 73 fulfilled the inclusion criteria. The height and width values of the participants' teeth were measured with a digital caliper and evaluated with Chu's esthetic proportion gauge. The measurements were then compared statistically. **Results:** The values obtained from the digital caliper measurements did not correlate with Chu's proportion scale, and the results showed no significant differences between the two sides (p >0.05). **Conclusions:** In conclusion, the measured teeth ratios did not show a similarity with the predetermined esthetic proportion scale suggested by Chu.

Keywords: proportion scale, esthetic dental proportion, width/height ratio, anterior maxillary arch

INTRODUCTION

In the last decade, the desire for natural, beautiful smile has resulted in a new specialty in dentistry, esthetic dentistry. The main purpose of this field is to analyze, design, and implement the 'perfect smile'. The new esthetic requirements have led to the improvement of techniques and tools in order to accomplish perfection and symmetry in dental rehabilitations. From an esthetic point of view, the maxillary anterior region is the most visible and crucial component of a smile, and the arrangement of teeth in this region is important in establishing harmony and symmetry.

Macroesthetics, such as the size, shape, form, and proportion of the tooth, and microesthetics, such as shade, color, texture, and translucency, are co-dependent, and we have to keep them in a delicate balance. The crucial factors to creating an esthetic smile are the size, shape, and arrangement of the anterior teeth, more precisely the maxillary central and lateral incisors, and canines.[1] Over the years, several proportions have been described in the literature, and many variations of these proportion were reported in relation to the various ethnic characteristics specific to the population studied.[2]

The importance of dental distribution was first described by Lombardi, who studied dental morphology and noticed a constant mathematical relation between the teeth; he called it the 'golden ratio'. He considered that from the frontal view, the mesiodistal diameter of the maxillary incisors, lateral incisors, and canines have a constantly decreasing value. Over the years, this theory was refuted, and researchers established that the majority of teeth proportions do not correlate with this formula. The new concepts suggest clinicians to use a formula that remains consistent and in proportion with the facial morphology and also takes in consideration certain subjective factors.[3,4]

The recurring esthetic dental (RED) proportion is defined as the ratio between the height and length of teeth and states that this ratio should remain constant in distal direction. The proportion provides some flexibility, with a range from 62% to 80%.[5] Based on these, a tool was designed for 78% of the RED proportion, by Chu, a renowned specialist in the field of dental cosmetics. He determined the average width of the anterior teeth, demonstrating that it corresponds to a percentage of only 34% of the population for maxillary teeth and 42% for mandibular teeth. The tool, named Chu's esthetic proportion gauge, was designed to help clinicians evaluate tooth size and proportion chairside.[6]

In our study, we focused on an easily accessible evaluation of tooth proportion, using Chu's tool and a digital caliper in a limited group of patients in Mureș County, Transylvania. We intended to evaluate the efficacy of Chu's esthetic proportion gauge in the maxillary anterior region, to evaluate and compare the dimensions of the maxillary central incisors, lateral incisors, and canines.

MATERIALS AND METHODS

Our study was conducted between July 2019 and January 2022, on patients who presented for esthetic or prosthetic treatments in a private dental clinic in Târgu Mureș, Romania. Out of 150 participants evaluated, 73 met the inclusion criteria. The selected patients, aged between 20 and 48 years, were informed and a consent was obtained from each of them. Inclusion criteria were: intact maxillary arches, anterior teeth well aligned in the curvature of the arch, without restoration, fracture or orthodontic treatment, and periodontally healthy.

An examiner took photos in frontal view, displaying the anterior teeth, gingival tissues, and lips. Each examination was conducted in the same dental chair, the patients being seated parallel with Frankfurt's plane. For better visualization and accessibility, a cheek retractor was used (Cheek Retractors; Directa AB, Upplands Vasby, Sweden). Every photo was taken from a 1.5 m distance by the same person, in the same location, and in standard brightness and focal length conditions for better data standardization. The digital equipment used was a DSLR camera (Nikon D7200) equipped with a Sigma 105 mm macro lens. The photos were analyzed on a personal laptop (Dell Inspiron, Dell Inc.).

FIGURE 1. Chu's instrument with T-bar tip

TABLE 1. Average range values for length and width on Chu's T-bar gauge

Color codes on the instrument	Significance (average values in mm)	
RED	Central incisor	L = 9.5–11 W = 7.5–8.5
BLUE	Lateral incisor	L = 7–8.5 W = 5.5–6.5
YELLOW	Canine	L = 8.5–9.5 W = 8.5–9.5

We used Chu's device with the T bar tip, which has red, blue, and yellow lines on the vertical and horizontal bar with preset corresponding height/width ratios. These color-coded lines are at a distance of 1 mm from each other. The purpose of the tool is to eliminate subjective dentogingival esthetic appreciation, by favoring visual appreciation of the dental esthetic proportions of the frontal area. Measurements with this instrument were made directly on the teeth. We evaluated one tooth at a time using the predetermined color-coded markings from the incisal edge: red for the central incisor, blue for the lateral incisor, and yellow for the canine (Figure 1). The obtained proportions were then arranged in Microsoft Excel tables.

In the second part of the study, we used a digital caliper to record the height and width of teeth in millimeters. All measurements were taken twice for each tooth, and the average value was noted. Every measurement was recorded by the same examiner in order to eliminate errors. We compared the resulting proportions from the two devices. Table 1 shows the values of the proportions of different teeth on Chu's T-bar gauge.[6] The height/width ratio of the maxillary anterior teeth has been considered an important factor for dental esthetics. Therefore, the results were categorized into two groups: Group 1, the esthetic group, which comprised measurements in the average range of values, and Group 2, the non-esthetic group.

The collected data were centralized in a Microsoft Excel spreadsheet and then exported to SPSS. Outliers were excluded and the distribution of data was checked. Intergroup comparisons between Chu's tool and the digital caliper, as well as comparisons between the left and right sides were done using Chi-squared and Mann-Whitney U tests. The level of significance was set at 0.05.

RESULTS

The mean values obtained from our digital caliper measurements were 82.31% for the central incisors, 81.10% for the lateral incisors, and 79.26% for the canines, which did not correlate with the proportions determined by Chu (RED 78%).

The length/width proportions of central incisors, lateral incisors, and canines were significantly higher than the average range values indicated by Chu ($p < 0.001$). Table 2 shows the categorization into proportionate (Group 1) and disproportionate (Group 2) ratios, as well as the p values after the intergroup comparisons between Chu's tool and the digital caliper.

Our results showed no significant differences between the right and left side proportion percentage values of the central incisors, lateral incisors, and canines (Table 3).

TABLE 2. Comparisons by measurement type: Chu's tool and digital caliper

	Tooth	Measurement technique	Group 1 (n)	Group 2 (n)	p value
Right	CI	Chu's tool	46	27	<0.001
		Caliper	13	60	
Left	CI	Chu's tool	51	22	<0.001
		Caliper	13	60	
Right	LI	Chu's tool	42	31	<0.001
		Caliper	12	61	
Left	LI	Chu's tool	43	30	<0.001
		Caliper	12	61	
Right	C	Chu's tool	44	29	<0.001
		Caliper	17	56	
Left	C	Chu's tool	42	31	<0.001
		Caliper	17	56	

CI – central incisor; LI – lateral incisor; C = canine

DISCUSSION

For an esthetic appearance, the maxillary anterior region must be in proportion to the facial morphology. In order to fulfill the patient's esthetic requirements, dental practitioners need to take into consideration and meet esthetic principles that were designed for the clinical chairside application. In our study, direct chairside measurements

TABLE 3. Comparison of height/length ratio between the right and left side

Tooth	Right side	Left side	Mann-Whitney test (p value)
Central incisor	82.61 ± 7.35	82.05 ± 7.03	0.97
Lateral incisor	81.32 ± 7.41	80.88 ± 7.22	0.73
Canine	79.13 ± 8.20	79.31 ± 8.03	0.82

were done using simple tools such as Chu's esthetic proportion gauge and a digital caliper.

Similar results to ours were obtained in a US study that used digital programs and found no correlation between the RED proportion and tooth arrangements of natural, pleasant smiles.[7]

Sandeep *et al.* found a correlation between the maxillary anterior teeth and the golden proportion but no correlation with the RED proportion.[8]

Our results support the earlier international literature and are in concordance with numerous studies which found that there is no mathematical applicability of the RED proportion in the natural dentition. The mean values obtained from our measurements were 82.31 ± 7.35 for the central incisors, 81.10 ± 7.11 for the lateral incisors, and 79.26 ± 8.01 for the canines, which did not correlate with Chu's proportion scale.[9–14]

For maxillary anterior teeth, the length/width ratio is considered to be the most reliable reference because it has minimum variation among teeth and between genders. In a study, dental students preferred a ratio of 75%; another study asserted that maxillary teeth should have a ratio of approximately 80%; other authors found very significant variations in the ratios of different ethnic groups (74–124%).[15–18]

A study conducted by Orozco-Varo *et al.* measured the clinical crown of teeth, concerning width, height, and their ratio. Their results were similar to ours, and they also found no correlation with the predetermined proportions in the study sample.[19] There is also recent research by Mootha *et al.*, which compared different devices, such as DSD software and Chu's proportion gauge, to evaluate tooth proportions and concluded that their population was within the range of 78% recurrent esthetic proportions scale and DSD.[20]

CONCLUSION

Within the limitations of the study, we can conclude that the average dimensions of natural teeth did not replicate the 78% RED proportion applied by the tool proposed by Chu in the investigated population. The anterior teeth of the maxillary arch did not show a similarity with Chu's esthetic proportion scale in this small Transylvanian population. We consider that the proportions and the tools need to be modified by taking into account the diversity of the population. Therefore, in the future, a larger study with an ethnically and culturally varied sample size is recommended.

CONFLICT OF INTEREST

The authors declare no competing interests.

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