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Subjective and Objective Evaluation of the Symmetry of Maxillary Incisors among Residents of Southwest Poland

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Abstract: Dental aesthetics is an essential factor affecting people's psychosocial wellbeing. One of the most critical components of an aesthetic smile is symmetry within the dentition. Dentists and orthodontists, unlike laypersons, are critical in assessing dental aesthetics. This study aimed to evaluate the accuracy of patients' assessment of the symmetry of their maxillary incisors and some factors that influence it. The study was conducted on 83 participants aged from 11 to 39 years. First, the participants filled out a questionnaire to obtain patients' opinions of the symmetry of their upper incisors. This stage was followed by an intraoral examination, during which we used a digital caliper to measure the width of four maxillary incisors. The data were entered into STATISTICA v. 13.3. The following conclusions were drawn from the study. First, the respondents were generally able to determine the asymmetry of the incisors. Second, among the maxillary incisors, the participants defined the symmetry of maxillary central incisors more accurately than the maxillary lateral incisors. The cut-off value for incisor asymmetry noticeable to a layperson is 0.2 mm for maxillary medial incisors and 0.55 for maxillary lateral incisors. Third, we found no dependence of the accuracy of the assessment of incisor asymmetry on the age of the subjects; however, in our study group, the age range (spread) was not significant, so further studies are recommended. Finally, results concerning the relationship with gender showed that males assess the level of symmetry of their maxillary incisors more accurately than females.

Keywords: symmetry; orthodontics; upper incisors; smile esthetics; teeth symmetry; dental aesthetics; maxillary incisors

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1. Introduction

It is widely known that dental aesthetics is an important factor that affects quality of life and psychosocial wellbeing. It improves emotional stability, self-confidence, and life satisfaction. People commonly consider attractive people who are considered more intelligent and successful [1]. The main reason patients seek orthodontic treatment is to improve the aesthetics of their smile [2,3].

1.1. Macroaesthetics

The topic of an attractive smile has been studied by researchers for a long time and has become an increasingly popular topic over the last few years. While in prehistoric times facial features were rarely depicted on rock drawings or stone carvings [4], over time, the face and its proportions have become of greater interest to artists. The first notion of a golden division was defined by Euclid and referred to the way a straight line was divided. According to this proportion, the ratio of the whole line to the larger section is equal to the ratio of the larger to the smaller section. Luca Pacioli called this relation the

divine proportion. Fibonacci mathematically calculated the golden ratio as the ratio of 1.618 or 0.618, representing it with the symbol Φ [5]. In the 1970s, attempts were made to introduce the golden ratio into dentistry. In 1973, Lombardi [6] was the first to demonstrate a relationship between the golden ratio and teeth, but found it 'too strong for dental use'. Levin [7] proposed the relationship in dental aesthetics, where the width of the lateral incisor should be 0.618 of the central incisor and the width of the canine should be 0.618 of the lateral incisor, analyzing the arch from the perspective of the person looking straight ahead (Figure 1).

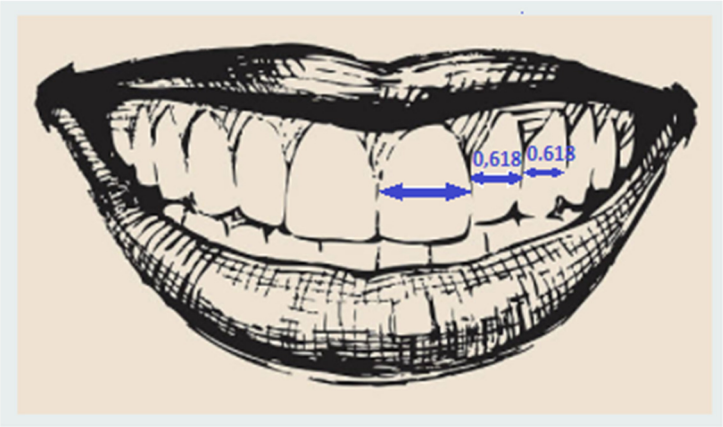

Figure 1. The dental aspect of golden proportion [7].

Snow [8], on the other hand, proposed measuring the width of the central incisor as a percentage of the total width between the canines. Additionally, dental aesthetics is considered in terms of the interproximal contact ratio. In a perfect smile, the contact point between the central incisors is 50% of their length, between the central and lateral it is 40% of their length, and between lateral incisors and canine it is 30% of their length [9].

Many researchers have considered the arrangement of teeth according to these proportions to be a major factor in determining a harmonious and balanced smile. However, as has been shown in many subsequent studies, the arrangement of teeth according to golden percentage (GP) is not a prerequisite for an aesthetically pleasing smile; many beautiful smiles do not show overlapping proportions [10], and the relationships themselves were rarely reflected in natural smiles [11,12]. It is believed that the symmetrical arrangement of teeth in the arch and their alignment with the midline of the face constitutes the basic element of a harmonious and balanced smile. Smile asymmetries are one of the main reasons that orthodontic treatment is needed [13].

Symmetry is the mirror image or absence of major deviations from an imaginary axis of symmetry [14]. Apparently symmetrical faces show a certain level of variation [15]. Many studies have examined the effect of symmetry on facial attractiveness. In Zaidel's studies [16,17], participants rated natural faces as more attractive than artificially created perfectly symmetrical faces.

Different results were obtained by Bertamini [18]: in his study, perfectly symmetrical mirror images of faces were found to be more attractive to observers. These inconsistent results were probably due to the use of a different method of symmetry manipulation. Zheng [19], on the other hand, argues that the direct effect of symmetry on facial attractiveness is not significant, and it is the normality of the face rather than its symmetry that is the main factor affecting its attractiveness.

A small degree of facial asymmetry is a physiological feature, but once a certain limit is exceeded, the face is considered distorted [20]. In Chinese, African, and Peruvian art, the asymmetry of the characters' faces was supposed to indicate a negative character, signifying ugliness and even moral decay [21].

Asymmetries often affect tissues located further from the skull. Upperface and midface regions are affected, respectively, at 5% and 36%, and the highest prevalence occurs in the mandible, especially on the right side (74%) [22]. From the data above, asymmetries within the smile, especially in terms of incisor width, are relatively rare.

1.2. Miniesthetics

Occlusion features in the anterior part of the oral cavity have a key role in dental aesthetics [23]. The medial incisors and canines exert the greatest effect on the aesthetic smile [24,25]. Eye-tracking studies have confirmed that the first sight fixation when observing dentition is focused on the mesial incisors [26].

The results show that asymmetries within the maxillary central incisors are rare [27,28], indicating a 63% degree of perfect symmetry between them, with the largest difference in incisal width being 0.89 mm. In contrast, asymmetries occur much more frequently within the lateral incisors. The ideal proportion between the left and right sides is found in only 30% of individuals, with the maximum difference in lateral incisors width being 1.62 mm [29].

Central incisors' asymmetries rarely exceed 0.2 to 0.3 mm in one of the three dimensions (length, width, or thickness) [30]. The results of the study on the incisors' width were influenced by the subject's gender, the size of the face, and the method of measurement.

The objective of the present study was to investigate laypersons' perceptions regarding the width of their own teeth and some factors that influence it.

2. Materials and Methods

The study was approved by the Bioethics Committee at the Medical University of Wrocław, and the commission consent number was 942/2021. All participants and their parents (in the case of minors) gave written consent to participate in the study.

The sample consisted of 83 patients, who were youngsters and young adults of Caucasian race treated in the private office of Dr. Dent Paulina Chrapla. Participants fulfilled the following criteria: 1—no serious sight problems; 2—the presence of the entire upper anterior teeth with no missing teeth; 3—no veneered, crowned, fractured, or apparent tooth loss due to attrition; 4—no tooth rotation or malposition; 5—no interdental spacing or crowding; 6—no current treatment with fixed braces.

In the first part of the study, study participants were given a questionnaire to complete. This questionnaire was used to obtain sociodemographic data, information on past/current/planned orthodontic treatment, and patients' opinions on the symmetry of their upper dental arch. Responses were included on a 5-point Likert scale ranging from "strongly disagree" to "strongly agree". Survey questions were thoroughly reviewed by a panel consisting of three dentists to ensure readability and validity of the questions.

In next step, measurements of the width of the four maxillary incisors were performed. The maximum mesiodistal width of individual teeth was recorded between contact points mesially and distally, perpendicular to the tooth's long axis. The measurements for all the teeth were performed three times, and the average of the three measurements was considered the final reading. All measurements were recorded on the labial surface of the teeth in millimeters (mm). These measurements were performed using a sharp-edged digital caliper (Electronic Digital Caliper, measuring range 1 to 100 mm, graduation 0.01 mm, accuracy +/− 0.02 mm). During intraoral examinations, the participant was positioned in a horizontal position under 5000 lux illumination. All the measurements were performed by the same operator (P.C).

Data were recorded on a data-collection sheet and then transferred to a spreadsheet (Excel 365, Microsoft).

The sample size was established assuming the significance level alpha = 0.05 and the minimum power of the test: 1 − beta = 0.70. The enrollment of further patients in the studies was completed when both conditions were met.

The data analysis was conducted using the program STATISTICA v. 13.3 (TIBCO Software Inc., Palo Alto, CA, USA). In order to select the methods of hypothesis testing and data description, the distribution of the analyzed sample was checked with the Shapiro–Wilk test. As there were no grounds to reject the hypothesis of the normality of the distribution of the studied data, standard parametric methods were used in the analysis:

- Analysis of variance with post hoc tests to find significant differences between groups;
- Student's *t*-test to assess the significance of differences between the measurements in two groups;
- ROC curve analysis to determine threshold values for continuous variables

During the study, the authors posed 5 hypotheses for verification:

1. Subjective assessment of the width of the upper incisors by patients coincides with the actual width of the incisors.
2. Patients define the symmetry of maxillary central incisors more accurately than maxillary lateral incisors.
3. Patients are able to notice only a large disproportion in the width of the upper incisors (e.g., over 1 mm).
4. Younger people more accurately assess the symmetry of the upper incisors.
5. Women more accurately assess the symmetry of the upper incisors.

3. Results

The study enrolled 83 patients, including 49 women (59.0%), aged from 11 to 39 years (mean M = 20.5; standard deviation SD = 5.3). The list of patients includes 5 (6.0%) patients screened in preparation for orthodontic treatment, 72 (86.7%) patients currently undergoing orthodontic treatment with removable braces or aligners, and 6 (7.2%) patients who finished their orthodontic treatment within the past 5 years. The general characteristics of the study subjects are shown in Table 1.

Table 1. General characteristics of the studied patients.

Variable	Statistics
Sex:	
F, n (%)	49 (59.0)
M, n (%)	34 (41.0)
Age (years), M ± SD:	20.5 ± 5.3
Age from 11 to 18 years, n (%)	30 (34.9)
Age from 19 to 23 years, n (%)	27 (31.4)
Age from 24 to 39 years, n (%)	26 (30.2)
Place of residence:	
Village	38 (45.8)
A city with up to 50,000 inhabitants, n (%)	28 (33.7)
A city with 50,000 to 100,000 inhabitants, n (%)	10 (12.1)
A city with a population of 100,000 and more, n (%)	7 (8.4)
Education:	
Student, n (%)	35 (42.2)
Basic, n (%)	7 (8)
Professional, n (%)	4 (4.8)
Secondary, n (%)	18 (21.47)
Higher, n (%)	19 (22.9)

Patients were given a self-administered questionnaire to complete. The questions in the questionnaire and the numbers (proportions) of answers to each item of the questionnaire are presented in Table 2.

Table 2. Number (proportions) of patients in subgroups differing in their responses to survey questions.

The Questions of the Original Questionnaire	*N*	(%)
1. The upper arch of my teeth is symmetrical		
Strongly disagree	9	10.8
Disagree	14	16.9
Neither agree nor disagree	16	19.3
Agree	33	39.8
Strongly agree	11	13.2
2. My maxillary central incisors are the same width		
Strongly disagree	2	2.4
Disagree	3	3.6
Neither agree nor disagree	7	8.4
Agree	59	71.1
Strongly agree	12	14.5
3. My maxillary lateral incisors are both the same width		
Strongly disagree	2	2.4
Disagree	6	7.2
Neither agree nor disagree	18	21.7
Agree	47	56.6
Strongly agree	10	12.1

Verification of Hypotheses

1. Subjective assessment of the width of the upper incisors by patients coincides with the actual width of the incisors.

The first null hypothesis verified was the following statement: The subjective assessment of the width of the upper incisors does not coincide with the actual width of the incisors.

To verify this hypothesis about the lack of a relationship between the self-assessment of the symmetry of the width of the maxillary upper incisors and the results of measurements made by the doctor, the answers to questions 2 and 3 of the questionnaire and the results of measurements of the absolute difference between the width of the right and left maxillary central and lateral incisors were used. The dependence of the difference value |TW11-TW21| and |TW12-TW22| was assessed using the Student's *t*-test between the "yes" and "no" groups. Figure 2 represents the perception of the mean difference between the upper incisors of the left and right sides.

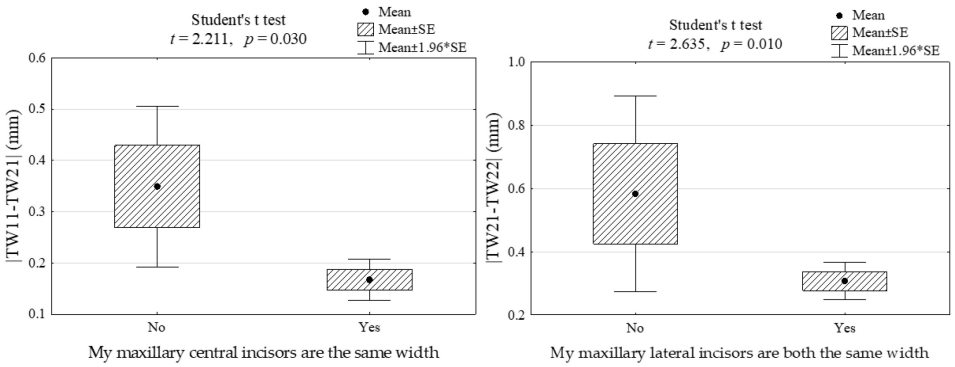

Figure 2. Absolute differences in the width of the upper incisors on the right and left in groups of patients differing in self-assessment of tooth-width symmetry and significance tests.

The mean difference between the incisors among those who answered 'no' is much greater than that among those who found their incisors to be the same width for both central and lateral incisors (p = 0.030 and p = 0.010, respectively; Figure 2).

On this basis, it can be concluded that the respondents are able to make an accurate self-assessment of the asymmetry of the incisors.

2. Patients define the symmetry of maxillary central incisors more accurately than that of maxillary lateral incisors.

The threshold values for the absolute value of the difference in the widths of maxillary central incisors and maxillary lateral incisors were established based on the analysis of the ROC curves.

In the case of maxillary central incisors, due to the immediate vicinity, the border difference is smaller—|TW11-TW21| = 0.20 mm (Figure 3a)—and for maxillary lateral incisors, it is greater—|TW12-TW22| = 0.55 mm (Figure 3b). There is a statistically significant relationship between the objective assessment of the asymmetry of maxillary central incisors and the subjective assessment (Table 3). For maxillary lateral incisors with the same threshold value (0.20 mm), there is no correlation between subjective and objective assessments (p = 0.477). Additionally, when the optimal cut-off point (0.55 mm) is assumed for maxillary lateral incisors, the correlation between the subjective and objective assessments is at the borderline of significance (p = 0.041).

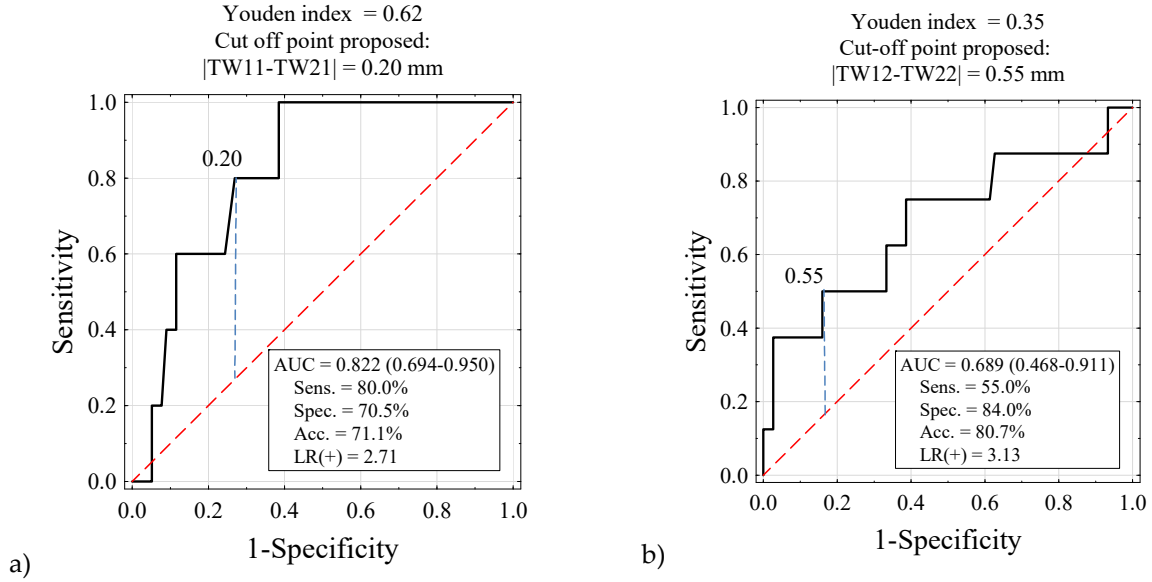

Figure 3. ROC curves to predict the subjective assessment of the asymmetry of the width of the maxillary central (**a**) and lateral (**b**) incisors from the absolute difference between right and left teeth, area under the curve (AUC), and sensitivity, specificity, accuracy, and positive probability proposed cut-off value for |TW11-TW21| and |TW12-TW22|.

Table 3. The number (percentage) of patients in the groups differing in the objective and subjective assessment of the width of the incisors and the result of the independence test.

Objective Assessment of the Asymmetry of the Width of the Tooth	My Maxillary Incisors Are the Same Width				p	Sens.	Spec.	OR (95% CI)
	"Definitely Not" or "Rather Not"		"Definitely Yes", "Rather Yes" or "Hard to Say"					
$\Delta W1 \geq 0.20$ mm	4	80.0%	22	28.2%	0.032	80.0%	71.3%	10.2 (1.08–96.2)
$\Delta W1 < 0.20$ mm	1	20.0%	56	71.8%				
$\Delta W2 \geq 0.20$ mm	6	75.0%	45	60.0%	0.477	80.0%	71.3%	2.00 (0.38–10.6)
$\Delta W2 < 0.20$ mm	2	25.0%	30	40.0%				
$\Delta W2 \geq 0.55$ mm	6	75.0%	29	38.7%	0.038	80.0%	71.3%	5.42 (1.19–24.7)
$\Delta W2 < 0.55$ mm	2	25.0%	46	61.3%				

where $\Delta W1$ = |TW11-TW21|, $\Delta W2$ = |TW12-TW22|.

The results of the analysis confirm the ability to recognize the differences more accurately in the case of maxillary central incisors than in the case of maxillary lateral incisors.

3. Patients are able to notice only a large disproportion in the width of the upper incisors (e.g., over 1 mm).

The ROC curve was used as before to determine the optimal threshold value for the test result. The difference of 0.2 mm was shown to make patients think that the widths of the maxillary central incisors were not the same. For this cut-off value, the sensitivity is 80%, the specificity is 70.5%, the accuracy of the test is 71.1%, and the positive likelihood ratio LR (+) is 2.71. The LR (+) value determines the degree to which the result of the examination $|TW11\text{-}TW21| = 0.20$ mm alters the suspicion of incisor-width asymmetry.

The evaluation of the relationship between the actual result of the difference in the width of maxillary incisors and the subjective evaluation (significance level p of Fisher's exact test) and the values of the odds ratio are presented in Table 3.

In summary, in the group of patients with a difference of 0.2 mm or more between the widths of the maxillary central incisors, the chance of an affirmative answer to question 2 of the questionnaire about asymmetry is ten times higher than in patients with a width difference of less than 0.2 mm. Patients noticed asymmetry in the upper lateral incisors' widths only when it exceeded 0.55 mm.

4. Younger people more accurately assess the symmetry of the upper incisors.

The number (percentage) of patients in groups differing in age, the accuracy of the assessment of the asymmetry of the width of the incisors, the results of the independence test, and the odds ratio are presented in Table 4. Age groups were established on the basis of the tercyl values (33.3% and 66.7%).

Table 4. The number (percentage) of patients in groups differing in age and the accuracy of the assessment of symmetry of the upper incisors and the results of independence tests.

Age (Years)	Incisor Symmetry Assessment				p	OR (95% CI)
	Accurate		Inaccurate			
From 11 to 18	14	31.1	16	42.1	0.358	0.46 (0.16–1.37)
From 19 to 23	14	31.1	13	34.2		0.57 (0.19–1.72)
From 24 to 39	17	37.8	9	23.7		1.00 (ref.)

There was no statistically significant relationship between age and the accuracy in assessing of the symmetry of the upper incisors' widths ($p = 0.358$). The hypothesis that younger people more accurately assess the symmetry of the upper incisors has not been confirmed.

5. Women more accurately assess the symmetry of their upper incisors.

The accuracy of the subjective assessment of symmetry was defined as the correspondence of the answers to the questions about the symmetry of the widths of maxillary central incisors and maxillary lateral incisors with the objectively determined difference in width (measured by the doctor). The results of the analysis of the relationship between gender and the validity of assessing the symmetry of the upper incisors' width are presented in Table 5.

Contrary to the null hypothesis, men assessed the symmetry of their incisors significantly more accurately ($p = 0.047$).

Table 5. The number (percentage) of patients in groups differing in gender and the accuracy of the assessment of symmetry of the upper incisors and the results of independence tests.

Gender	Incisor Symmetry Assessment				*p*	OR (95% CI)
	Accurate		Inaccurate			
Men	23	51.1	11	28.9	0.047	2.57 (1.03–6.39)
Women	22	48.9	27	71.1		1.00 (ref.)

4. Discussion

The face is a region of the body that plays a major role in a person's physical attractiveness. The teeth area, just behind the eyes, is the main part of the face responsible for its attractiveness [31–34]. Most articles investigating smile aesthetics focus on the perception of computer-altered images [35–37]. Knowing that dental aesthetics influences patients' quality of life [38] and cooperation during treatment [13,39], the authors of the present study decided to evaluate the patients perception on the symmetry of the smile as one of the factors that could be noticed by the individuals. This article's purpose was to investigate how important patients perceive their smile, how much precision they have in guessing the width of their own incisors, and what factors determine it.

Many authors agree that the upper central incisors, in particular, are key determinants in assessing the aesthetics of anterior teeth [6,40,41]. The presented research also confirmed this point and suggests that these teeth probably play a subconscious key role in people's judgements about dental aesthetics. This is exemplified by the fact that patients are more tolerant of dental wear on the lateral incisal crowns (1 mm) than on the medial incisal teeth (0.5 mm) [42]. A study by Wolfart et al. [43] analyzed laypersons' perceptions of altered angulation of mesial and lateral incisal teeth. Even small changes in the mesial incisal teeth's angulation (symmetric or asymmetric) were perceived by patients as unattractive. In contrast, even significant changes in the angulation (10°) of the lateral incisal teeth did not reduce the smile's attractiveness. These results were confirmed in a study by Thomas et al. [44]. Additionally, crowding in the mesial incisor teeth affects the perception of smile aesthetics greater than crowding in the upper lateral incisors [45]. These results support the conclusion that people are less aware of aesthetic deviations further from the midline. The authors of this study focused on patients' perceptions of the proportions of the maxillary incisor teeth. They did not analyze factors such as tooth attrition or abnormal eruption. The authors made the null hypothesis stating that patients are more accurate in determining the asymmetry of their own upper central incisors than of their upper lateral incisors. This statement was confirmed: a statistically significant relationship was observed between the subjective and objective evaluation of the asymmetry of maxillary central incisors (Table 3). For the upper lateral incisors at the same threshold value (0.20 mm), the correlation between subjective and objective assessment does not occur ($p = 0.477$). It seems that the factor influencing the more accurate recognition of symmetry in terms of upper central incisors is their central location in the smile but also their immediate proximity, which facilitates comparison of their width and assessment.

Another hypothesis tested stated that patients are only able to notice a large disproportion in the width of the upper central incisors (e.g., more than 1 mm). Many articles have been written on the fact that dentists/orthodontists are more critical in evaluating the component parameters of smiles than laypersons are [46–50]. Asymmetries of the gingival margin of maxillary central incisors affected laypersons' perception when it exceeded 2 mm, whereas for orthodontists and prosthodontists, this threshold was 0.5 mm. Nonprofessionals did not notice the midline shift of the upper dental arch, even if it exceeded 4 mm [51]. In contrast, the asymmetry in the length of the incisal edge of the upper central incisor was noticed and considered less attractive by patients at as little as 0.5 mm, whereas this value was 1 mm for the upper lateral incisor [42]. In another study, laypersons evaluated a given face with asymmetrical upper central incisors on video recordings. The value that was noticeable and posed a "threat" to aesthetics was 1 mm or higher [52]. In this experiment,

the authors assumed as a hypothesis that the asymmetry in the width of the patients' upper incisors must be large for it to be noticed. The authors took 1 mm as the cut-off value. However, the authors found that even a difference of 0.2 mm leads patients to believe that the widths of the upper central incisors are not equal. In the group of patients with a difference of 0.2 mm or more between the widths of the upper central incisors, the chance of an affirmative answer to question 2 of the questionnaire about asymmetry was almost ten times higher than in patients with a difference of less than 0.2 mm. Asymmetry in the width of the upper lateral incisors was observed by patients when it exceeded 0.55 mm.

Many studies indicate that the age of the evaluators affects the perception of smile components. In the study by Sriphadungporn C et al. [53], younger subjects preferred gingival exposure of 0–2 mm when smiling, while older subjects were much less critical and positively evaluated gingival exposure ranging from −4 to +2 mm. The older age group also showed greater tolerance for the presence of a black triangle between the upper central incisors. On the other hand, no differences in the preference for the length of the upper central incisors were noted, indicating the symmetrical nature of the changes as the likely cause. Additionally, other authors observed less-critical evaluation of smile parameters such as the size of cheek corridors, differences in both SI (smile index—width/height of smile) and IEP (Incisal Edge Position), and missing teeth in the aesthetic zone [54–56]. The study by Santos et al. [57] analyzed the perceptions by patients of different ages of the difference in the height of the incisal edges of the mesial and lateral incisors as an expression of central-incisor wear. Younger subjects preferred longer incisors and steepness of 1.5 mm, while older subjects preferred a smaller steepness because they have more worn mesial incisors and smaller steepness. Pithon, M et al. [58], who also studied the perception of black triangles by laypeople of different ages, pointed out that the aesthetic perception of the smile decreases with age, and the critical sense of aesthetics is most evident in younger people. The fact that the older age group does not perceive asymmetry may suggest that advanced age leads to reduced perception of the details of smile aesthetics, which means that subtle changes are unnoticeable. In this study, the authors hypothesized that younger subjects were more accurate in assessing the symmetry of upper incisors' width. There was no statistically significant relationship between age and the accuracy of the assessment of upper incisors' widths ($p > 0.05$). The hypothesis that younger subjects are more accurate in assessing upper incisors symmetry was not confirmed. A possible factor is the small age discrepancy of the subjects covered by our study. Further studies that also include patients in the older age group (>60 years) are required.

One of the factors influencing the perception of smile attractiveness is gender. The appearance of teeth has been shown to be of greater importance to women than to men [59]. Women are also more critical of various components of smiles [60,61]. One could conclude that women are also more perceptive and better able to recognize nuances about dentition. Wolfart et al. [62] studied the relationship between patients' subjective assessment of dentition and objective measurements of maxillary incisors. A statistically significant correlation between objective and subjective assessment was found only for men but not for women. The present study confirms these results. In the study group of patients, the authors compared patients' subjective assessment of the width symmetry of upper central and lateral incisors, comparing it with the objective assessment. Males were significantly more likely to accurately assess the symmetry of their incisors. These results may suggest that perception may differ between men and women, with men appearing to be more rational and women more emotional and intuitive [63].

5. Conclusions

Respondents can make an accurate self-assessment of their upper incisors; therefore, the assessment of the symmetry of the upper incisors should constitute part of the dental diagnostics of the patient during orthodontic treatment and restoration of anterior teeth. Due to the fact that people more accurately assess the asymmetries within the central incisors, the clinician should pay more attention to restoring the correct symmetry within

these teeth, with the possibility of greater tolerance for leaving slight asymmetries within the lateral incisors. Due to the fact that more people pay attention to aesthetics in general, patients search for more aesthetic outcomes—not only in dentistry, but in medicine in general. Nevertheless, we propose to discuss with the patient the results of the upper incisal symmetry measurement to assess whether it constitutes an aesthetic defect for the patient.

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