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Comparative Study of Smile Analysis by Subjective and Computerized Methods

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Clinical Relevance

In order to define the esthetic rehabilitation of the smile, smile analysis must be assessed in association with the face, taking into consideration the following factors: midline of the smile, labial line, smile line, the line between commissures and the golden proportion.

SUMMARY

Purpose: This study compared: 1) the subjective analyses of a smile done by specialists with advanced training and by general dentists; 2) the subjective analysis of a smile, or that associated with the face, by specialists with advanced training and general dentists; 3) subjective analysis using a computerized analysis of the smile by specialists with advanced training, verifying the midline, labial line, smile line, the line between commissures and the golden proportion. Methods: The sample consisted of 100 adults with natural dentition; 200 photographs were taken (100 of the smile and 100 of the entire face). Computerized analysis using AutoCAD software was performed, together with the subjective analyses of 2 groups of professionals (3 general dentists and 3 specialists with advanced training), using the following assessment factors: the midline, labial line, smile line, line between the commissures and the golden proportion. The smile itself and the smile associated with the entire face were recorded as being agreeable or not agreeable by the professionals. Results: The McNemar test showed a highly significant difference (p=0.0000) among the subjective analyses performed by specialists compared to general dentists. Between the 2 groups of dental professionals, there were highly significant differences (p=0.0000) found between the subjective analyses of the smile and that of the face. The McNemar test showed statistical differences in all factors assessed, with the exception of the midline (p=0.1951), when the computerized analysis and subjective analysis of the specialists were compared. In order to establish harmony of the smile, it was not possible to establish a greater or lesser relevance among the factors analyzed.

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INTRODUCTION

Esthetic appearance is extremely subjective and relates to beauty and harmony. Esthetic appearance is also subject to social and cultural factors and age, making

this concept vary from individual to individual. Alterations in esthetic appearance may have psychological implications that range from a simple manner of disguising a problem to total introversion, completely damaging the individual's self-confidence. In the specific case of teeth, there is a marked psychological effect, because the face is always uncovered, people show their teeth when they speak or smile and this in an inopportune moment to be thinking of dissimulating some defect that is on display.[1]

As beauty is subjective, an attempt is made to adopt some criteria to analyze it by means of established comparative measures, such as proportions. In an attempt to establish proportions, the Golden Number, Aurea Section, Aurea Proportion or Divine Proportion, which is called "phi," was arrived at and has a value equal to 1,618.[1] Another progression that closely approximates the Aurea Section in whole numbers is the Fibonacci series: 1, 1, 2, 3, 5, 8, 13, 21 and so on. Each term is the sum of the 2 previous terms and the proportion between the 2 terms is the difference between the consecutive terms of an arithmetic progression that tends to approximate the Aurea Section as the series moves toward the infinite.[2] This progression is more agreeable to the senses and provides a unique relationship.[3] The smile presents an esthetic sense, and the rehabilitation of a smile must comply with certain rules, including the golden proportion, which is well defined for the various teeth.[1]

The golden proportion is also noted in various relationships of the face. In fact, Ricketts[3] affirmed that a confusion of perfect relationships is observed on the beautiful face, and people who do not have these proportions are not considered as beautiful as those who have the "divine" values.

With the increased use of cosmetic dentistry, the need arose for a better understanding of esthetic principles.[4] Some authors reported the importance of applying the golden proportion to dental components in order to analyze the smile. Also, there is the need to assess the midline, labial line, smile line and line between commissures, in addition to the principles of tooth shades, outline and gingival health, among others.[1,3-15] According to Goldstein[1] and Rufenacht,[11] the midline is one of the most important aspects to be considered in the smile, as it determines the symmetry of the arch. However, in the majority of cases, this analysis is verified in a subjective manner; in addition, it is difficult to communicate to the patient when esthetic rehabilitation is being planned, and there may also be divergences among different professionals in the area of dentistry due to different criteria for defining the esthetic appearance most suited to patients.

The lack of objective criteria for performing these analyses is widely observed in the literature. Moskowitz and Nayyar[16] mentioned the importance of a harmonious relationship among facial components in order to provide aesthetic balance, and, it is therefore necessary to analyze the smile in conjunction with the face. Only Levin[7] developed a compass for the direct application of the golden proportion, also used by Ricketts.[3] Ward[14] suggested the use of photographs and molds for taking measurements, and Naylor[17] recommended the use of a tracing system called Grade. Such analyses could allow for greater safety and objectivity.

Goldstein[1] affirms the importance of using computerized analyses, enabling the professional to study and discuss the patient's expectations with the dental professional, since there are no analyses or studies showing what should be applied in clinical practice. Therefore, this study proposed to compare: 1) the subjective analyses of a smile done by specialists with advanced training and general dentists; 2) the subjective analysis of a smile alone or, in conjunction with the face, by specialists with advanced training and general dentists; 3) subjective analysis with a computerized analysis by specialists with advanced training, verifying the midline, labial line, smile line, line between commissures and the golden proportion.

METHODS AND MATERIALS

a) Sample Selection

This study was conducted after project approval by the Ethical Committee on Research. The sample consisted of 100 randomly chosen Caucasian adults (65 women and 36 men) over 20 years of age with natural dentition and without the use of total or partial removable, maxillary and/or mandibular dentures.

b) Obtaining the Photographs

Two-hundred (200) photographs were taken, 100 of the smile only and 100 of the individual's entire face. The photographs were denominated "smile 1" and "face 1," respectively, from 1 to 100. The camera that was used was a digital Canon Power Shot G3 with Circular Flash Canon MR-14EX in ETTL mode, using the automatic mode with macro, without zoom for the photos of the face and with zoom at 4x for the smile photos. All the photos were taken indoors with artificial fluorescent lighting, with the individuals seated in an upright position.

c) Selection of the Examiners

Six examiners were selected (3 specialists with advanced training and 3 general dentists). The specialists had a minimum of 10 years of professional experience in the clinical area, with graduate studies in the areas of prosthesis and/or restorative dentistry. The clinicians had a minimum of 2 years of professional experience in the clinical area.

d) Comparative Analysis Between the Smile and the Face

In order to prevent an influence of opinion, each professional individually analyzed the study participants on different days. The 100 photographs of smiles were analyzed, with each professional classifying the smiles as either being esthetically agreeable or not. One week later, the same professionals assessed the 100 photographs of the corresponding faces, also to classify the smiles either as esthetically agreeable or not. This phase was performed with the intention of verifying the influence of the other facial components on the esthetics of the smile.

e) Analysis of the Smile

After 1 more week, using computerized analysis, only the specialists with advanced training performed a subjective assessment of all the smiles individually and in association with the faces for later comparison. The smiles were defined as either esthetically *agreeable* or *not agreeable* in accordance with the following factors under study: midline, labial line, smile line, line between commissures and golden proportion.

1) Midline or Median Facial Line: for analysis, this method used 3 anatomic points: naso, naso-labial sulcus and mento. A line was traced to join these 3 points, thus locating the median facial line. All the smiles in which the median facial line did not coincide with the median dental line between the central maxillary incisors were considered to be not agreeable.

2) Labial Line or Lip Line: the classification used for the analysis relates the top lip, gingival tissue and antero-maxillary teeth in the following manner:

- Low Lip Line or Low Smile—shows less than 3/4 of the maxillary teeth.

- Median Lip Line or Medium Smile—shows a large portion of or complete maxillary teeth and tip of the interdental papilla.

- High Lip Line or High Smile—shows the total height of the maxillary teeth and a strip of gingival tissue.

The ideal lip line would appear to be the one obtained when the top lip reaches the interdental gingival margin of the maxillary incisors during the smile; this line is common in a large number of people.[11] Therefore, the "medium smile" was considered to be esthetically agreeable.

3) Smile Line or Incisal Curvature: defined as an imaginary curve line that accompanies the trajectory of the edges of the 4 antero-maxillary teeth and the tips of the maxillary canine cusps. Generically, it is accepted that, in a harmonious dental composition, the bottom lip accompanies the curvature of the maxillary teeth. When an incisal plane is traced, and it is perpendicular to the median facial line, one would have an esthetically agreeable relation.[18] It is defined in 3 stages:

- Positive: when the incisal edges of the central maxillary incisors are below the canine cusps, one would have a convex curve, which may approximate and harmonize with the bottom lip line.

- Neutral: when the incisal edges of the central maxillary incisors coincide with the tips of the canine cusps.

- Negative: when the incisal edges of the central maxillary incisors are above the canine cusps, creating a convex and esthetically disagreeable line. A reverse incisal line (inverted smile) or an abnormal posture of the bottom lip has a profound effect on the degree of attraction of a smile.[11] This condition of the analysis does not harmonize with the other facial characteristics and may also be associated with occlusal malfunction or loss of vertical dimension. The smile that presented with a positive or neutral smile line was considered to be an esthetically agreeable smile.

4) Line Between Commissures: when the patient's mouth is in the position of a wide smile, one is able to draw an imaginary line that passes through the 2 commissures. Whether a smile is younger or older can be assessed from the number of maxillary teeth exhibited under this imaginary line.[1,11] Generally, younger patients exhibit 75% to 100% of the maxillary teeth below the line. The relation of contact between the bottom lip and the incisal edge of anterior maxillary teeth is also important in esthetic assessment. The smile that presented with exposure of more than 75% of the maxillary teeth below the line between the commissures was considered to be an esthetically agreeable smile.

5) Golden Proportion: golden proportion is not a real measurement but an apparent one that is the mirrored region of the central and lateral incisors and the maxillary canines, which is the region that reflects light directly. When the shape of the tooth is altered, the light that falls on it is altered as well. Flatter and smoother surfaces reflect more light; therefore, they appear to be wider and closer. The mirrored zone of the lateral maxillary incisor must be equivalent to 60% of that of the central incisor, and the mirrored zone of the canine must be 60% of the lateral incisor. Thus, aesthetics considers the appearance and not the real measurement.[1,11] The smile with teeth within the range of 51.1% to 69.9% was considered to be an esthetically agreeable smile, due to the great variation in percentage. Therefore, the proportion between the right maxillary canine (13), right lateral maxillary canine (12), right central canine (11), left central canine (21), left lateral maxillary canine (22) and left maxillary canine (23) was used.

Table 1 shows a summary of the criteria used by the specialists to assess the photograph of the "smile" and

Table 1: *Criteria adopted for the analysis of photographs of the "smile" by specialists and by the computerized program, in accordance with the factors under study.*

Factors Under Study	Classification Criteria
Midline	Agreeable: coincident with the facial midline Not agreeable: not coincident with the facial midline
Labial line	Agreeable: classified as median Not agreeable: classified as high or low
Smile line	Agreeable: classified as positive or neutral Not agreeable: classified as negative
Line between the commissures	Agreeable: exposure of more than 75% of the teeth below the line between commissures Not agreeable: exposure of less than 75% of the teeth below the line between commissures
Golden proportion	Agreeable: proportion between the teeth was in the range between 51.1 to 69.9% Not agreeable: proportion between the teeth was higher or lower than the range between 51.1 to 69.9%

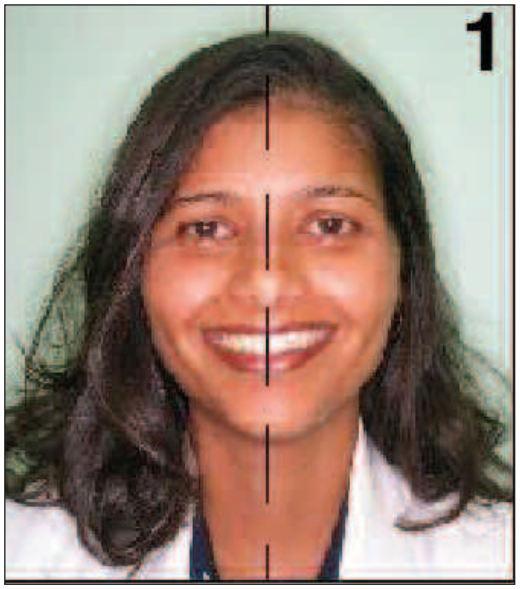


Figure 1: *Photograph of the "face," showing the midline tracing. Shade of the maxillary right and left central incisors at 1.5 years post-bleaching: B3 and B4, respectively, F= Shade of the maxillary right and left central incisors 4.5 years post-bleaching: A6.*

"face." These aspects were also assessed in photographs of the "smile" and "face" by means of tracings performed by the AutoCAD computer program. The software is manufactured by the Autodesk Company and is used for various projects—from buildings to industrial parts—and is frequently found in engineering and architectural offices. The photos of the smiles and faces were inserted into the program, and the tracings were made in accordance with the factors under study, individually, within each photo (Figures 1-5). The dimensions required for assessing the golden proportion were automatically obtained using a resource of the program. Using tracings of the computerized analysis, Figures 1 through 5 are photographs of the patient's "face" and "smile," intended for assessment by the specialists and clinicians.

f) Statistical Analysis

Specialists and general clinicians conducted a subjective analysis of patients whose "smile" was associated with the "face" and patients whose "smile" was analyzed in the study. A comparative analysis was also performed by specialists between the results obtained by computerized analyses of the "smile" with subjective analyses of the different levels of factors of the "smile" under study. The McNemar test was used for to compare the results (α=1%).

RESULTS

Using individual analysis of the "smile," specialists considered 40% of the smiles as *agreeable* and 60% as *not being agreeable*. In the analysis of the "smile" in association with the "face," the specialists considered 55% of the smiles as being *agreeable* and 45% as *not being agreeable* (Table 2).

In the analysis of the photos of the "smile," the clinicians considered 49% of the smiles as being *agreeable* and 51% as *not being agreeable*; whereas, in the analysis of the "smile" in conjunction with the face, the clinicians considered 64% of the smiles as being *agreeable* and 36% as *not being agreeable* (Table 2).

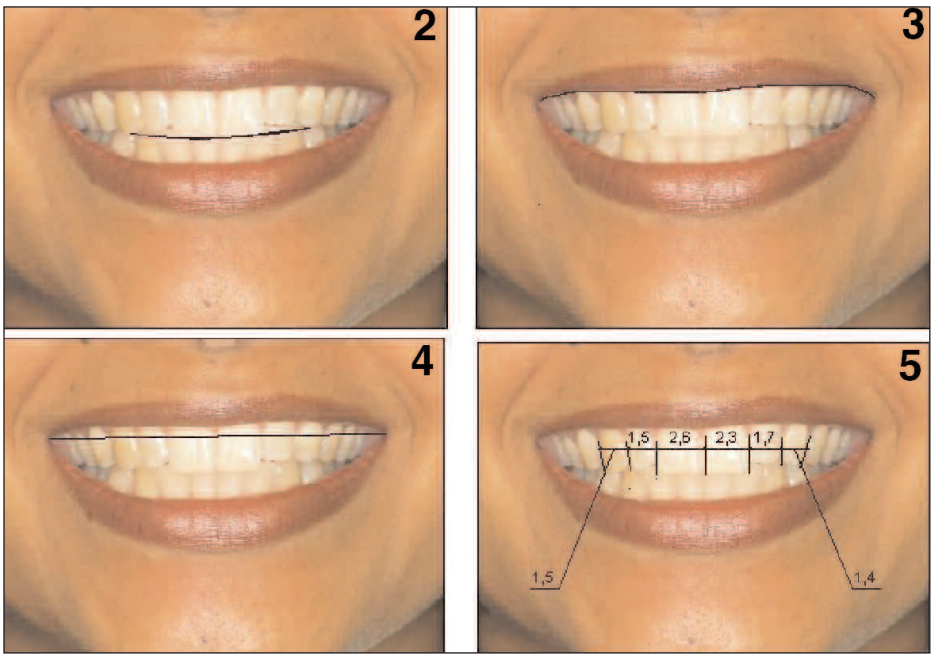
The McNemar test showed that more aesthetically agreeable smiles were observed in association with faces analyzed by the specialists (p=0.0000) and general dentists.

Tables 3 and 4 compared the answers of the specialists and general dentists.

The results of the McNemar test for analysis of the smile, individually, in relation to the type of professional is highly significant (p=0.0000). More aesthetically agreeable smiles were observed by the general dentists.

The results of the McNemar test for analysis of the smile associated with the "face" in relation to the type of professional is highly significant (p=0.0000). More esthetically agreeable smiles were observed by general dentists when observing the "smile" with the entire face.

Table 5 shows a comparison of the results found by computer analysis to the analysis by specialists. With



Figures 2-5: *Photograph of the "smile," showing the tracings of the smile line (2), labial line (3), line between commissures (4) and the golden proportion (5).*

Table 2: *Frequency of Answers by the Specialists and General Dentists as Regards the Analysis of the Smile and Associated With the Face*

SPECIALIST	Agreeable Smile	Not Agreeable Smile	TOTAL
Agreeable Face	106	51	157
Not Agreeable Face	15	128	143
TOTAL	121	179	300
GENERAL DENTIST	**Agreeable Smile**	**Not Agreeable Smile**	**TOTAL**
Agreeable Face	139	52	191
Not Agreeable Face	12	97	109
TOTAL	151	149	300

Table 3: *Frequency of Answers to the Analysis of the "Smile" in Relation to the Type of Professional*

SMILE	Agreeable General Dentist	Not Agreeable General Dentist	TOTAL
Agreeable Specialist	109	12	121
Not Agreeable Specialist	42	137	179
TOTAL	151	149	300

Table 4: *Frequency of Answers to Analysis of the "Smile" Associated with the "Face" in Relation to the Type of Professional*

FACE	Agreeable General Dentist	Not Agreeable General Dentist	TOTAL
Agreeable Specialist	141	16	157
Not Agreeable Specialist	50	93	143
TOTAL	191	109	300

regard to the midline, the results of the McNemar test are not significant (p=0.1951), showing that there is no difference between the computerized assessment and that performed by the specialist. For the labial line, the results of the McNemar test are significant (p=0.0122) in that they show that there is a difference between the computerized assessment and the one performed by specialists.

With regard to the smile line, the results of the McNemar test are highly significant (p<0.0001), showing that there is a difference between the computerized assessment and that performed by specialists. For the line between the commissures, the results of the McNemar test are highly significant (p<0.0001), showing that there is a difference between the computerized assessment and the assessment performed by specialists.

With regard to the golden proportion, the results of the McNemar test are significant (p=0.0170), showing that there is difference between the computerized assessment and that performed by specialists.

DISCUSSION

Basic knowledge of the aesthetic aspects of natural dentition may contribute in a simple, yet, efficient manner toward reducing difficulties in the dentist versus patient relationship with regard to the patient's smile, aesthetic appearance and psychosocial integration. However, aesthetics is not absolute; it is extremely subjective.[1] According to Tjan and others,[19] beauty is generally dictated by ethnic and cultural factors and individual preference. In regard to dental professionals, Moore[20] emphasized the divergence among dentists in their concepts of facial esthetics, while Cvaillon[21] believes that each dentist has his/her own canons for defining a patient's esthetic appearance.

Table 5: *Comparison Between the Computerized Analysis and the Subjective Analysis by the Specialists in Relation to the Midline, Labial Line, Smile Line, Line Between Commissures and Golden Proportion*

Midline (Frequency)	**Agreeable**	**Not Agreeable**	**TOTAL**
Computer	46	54	100
Specialist	68	32	100
TOTAL	**114**	**86**	**200**
Labial Line (Frequency)	**Agreeable**	**Not Agreeable**	**TOTAL**
Computer	65	35	100
Specialist	59	41	100
TOTAL	**124**	**76**	**200**
Smile Line (Frequency)	**Agreeable**	**Not Agreeable**	**TOTAL**
Computer	81	19	100
Specialist	59	41	100
TOTAL	**140**	**60**	**200**
Line Between the Commissures (Frequency)	**Agreeable**	**Not Agreeable**	**TOTAL**
Computer	88	12	100
Specialist	80	20	100
TOTAL	**168**	**32**	**200**
Golden Proportion (Frequency)	**Agreeable**	**Not Agreeable**	**TOTAL**
Computer	19	81	100
Specialist	53	47	100
TOTAL	**72**	**128**	**200**

The golden proportion and analysis of the smile are related in a subjective manner, using neither clear nor objective analyses. Few articles relate to their clinical use[14,16-17] or conduct studies with larger samplings.[15,19,22-23] Thus, some of the esthetic principles were applied using an objective analysis in a sample of 100 patients to verify their applicability.

The results of this study show that there were statistical differences in comparisons made between analysis of the smile and the "face." In the group of specialists, a greater number of smiles were considered *agreeable* (55%) when the smile was assessed in conjunction with the face. It was also possible to observe a similar result for the general dentists, among whom 64% of aesthetically *agreeable* smiles were observed in the analysis associated with the face and 49% in the individual analysis. These data suggest that the other facial components influence analysis of the smile. Therefore, it is believed that the application of smile analysis should be done in conjunction with the face in regard to the classification of agreeable or not agreeable, since it is not possible to dissociate the smile from the patient's other facial components. Individual analysis of the smile will be more strongly indicated in terms of specific assessments among other factors analyzed (smile line, labial line, line between commissures and golden proportion), when seeking esthetic excellence of the smile, irrespective of the smile being classified as agreeable or not. Thus, the influence of other components of a beautiful face will be avoided when analyzing the individual components of the smile.

In the analysis conducted by the groups of professionals involved (specialists and general dentists), statistically significant differences could be observed in the analyses they performed. It was possible to note a greater number of smiles considered as being agreeable by the general dentists, both in the individual assessment of the smile and in conjunction with the face. It is suggested that the knowledge acquired by specialists, both in studies and their clinical experience, make them more demanding and qualified to assess the esthetics of the smile. Understanding the esthetic criteria of the smile is of fundamental importance to the present day dentist, considering the growing demand for aesthetic treatments.[4]

Among the factors used by specialists and computerized analysis used to analyze the smile—the midline, labial line, smile line and the line between the commissures—diverse results were observed among the groups of agreeable and not agreeable smiles. In the computerized analysis, a high index of agreeable smile line was observed (81%) and agreeable line between commissures (88%) was found in the agreeable smiles. In regard to the smile line, Rufenacht[11] affirmed that this is one of the most important factors that contributes to the connotation of an agreeable smile. Tjan and others[19] determined that the mean of smiles they studied had the incisal curvature of the maxillary teeth parallel to the curvature of the bottom lip (agreeable smile line).

A greater occurrence was also noted with an agreeable midline (46%) and agreeable labial line (65%) found in aesthetically agreeable smiles. The relation of the midline of the central maxillary incisors must, whenever possible, coincide with the median facial line.[1,11] If this coincidence does not occur, the 2 lines must be at least parallel to each other.[24-25]

The golden proportion was classified as agreeable in 19% of the smiles analyzed by the computer. Preston[8] related that the golden proportion was found in only 17% of the groups of patients studied. Mahshid and others[15] did not find the golden proportion among individuals who had an aesthetically pleasing smile.

AutoCAD software is widely used in a wide variety of projects—from buildings to industrial parts—its major application, however, is among professional engineers and architects, and it is not possible to observe any dental work in which it has been used. The significant variation in measurements, when it involves insignificant changes in the position of the points of reference, result in a limitation of this software in the field of dentistry.

With specialists analyzing the criterion of the golden proportion, it was possible to observe that a large majority of the smiles classified as not agreeable via computerized analysis presented proportions in excess of 69.9%, which makes one consider the proposition of Ward,[14] who recommends a continuous proportion of 70%, instead of the golden proportion, which should be changed to suit the patient's face, bone structure or general physical type. Ahmad[26] and Phillips[12] related that geometric laws must not be seen as immutable; instead, they should be viewed as very useful guides in the sequence and crafting of restorations. Touati and Etienne[13] believed that, although they serve as a basis for seeking aesthetic success, the values of golden proportion cannot alter the fact that the dental anatomy is 3-dimensional and the morphology cannot be reduced to an equation related to height and width.

When comparing the analyses done by the computerized system to that done by the specialists, only the criterion midline did not obtain a statistical difference. This result suggests the importance of performing computerized analysis, even for professionals with experience in dental esthetics. The visualization of tracings greatly facilitates analysis when compared with analysis using imaginary lines. To this point, it is important to emphasize the use of digital photographs for facial analyses, as suggested by Sarver and Ackerman.[27] Ward[14] mentions that photographs allow one to have unlimited time and the ability to measure the dimensions and proportions of the teeth. Ward also makes use of AutoCAD software valid, although use of the software does demand training and specific knowledge, which does not make it practical for the clinic, without further knowledge of computer technology.

CONCLUSIONS

The smile analysis must be assessed in association with the face in order to define the aesthetic rehabilitation of the smile, since it was not possible to establish greater or lesser relevance among the factors analyzed to establish harmony of the smile.

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