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A Correlation Study of Facial Soft Tissue Proportions (Golden Sections) and Cephalometric Measurements of Golden Sections and the Eleven Factor Analysis

Russell Andrew Sutliff

Abstract

A CORRELATION STUDY OF FACIAL SOFT TISSUE PROPORTIONS (GOLDEN SECTIONS) AND CEPHALOMETRIC MEASUREMENTS OF GOLDEN SECTIONS AND THE ELEVEN FACTOR ANALYSIS

By Russell Andrew Sutliff

Frontal photographs on a total of one hundred and three individuals who had been treated by Dr. Ricketts, and had been involved in a prior study at Rocky Mountain Data Systems, were evaluated for facial proportions according to Ricketts application of Pythagoras' golden section. Seven facial proportions were analyzed from 1:1 retention phase frontal photographs. Forty individuals, made up of twenty-two females and eighteen males, 12.2 to 21.0 years of age, were selected and divided into two groups of twenty each, according to their soft tissue facial proportions. A range of acceptability for the facial proportions was derived. Proportions within this range were considered acceptable; whereas, those measurements outside the range were considered unacceptable.

Group one had five or more of the seven proportions within the acceptable range, while group two had two or less acceptable proportions. The golden section skeletal

analysis was applied to the retention phase lateral cephalometric radiographs for both groups. Facial patterns, as described by the Eleven Factor Analysis of the Modified Downs Analysis, were determined for the individuals of each group.

The results revealed a brachyfacial tendency in the "acceptable" soft tissue ratio group, while the "non-acceptable" soft tissue ratio group showed a mesofacial pattern. No statistically significant correlation was found between the soft tissue and the hard tissue proportion measurements and the Eleven Factor Analysis components.

LOMA LINDA UNIVERSITY

Graduate School

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By

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for the Degree Master of Science
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Each person whose signature appears below certifies that this manuscript in his opinion is adequate, in scope and quality, as a thesis for the degree Master of Science.

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Robert J. Schulhof, President, Rocky Mountain Data Systems

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INTRODUCTION

In the Pythagorean school (500 B.C.) mathematics and nature were studied for order and harmony. Huntley[1] states, according to the mathematician Kepler, that two great geometric treasures came from this school. "One is the theorem of Pythagoras; the other, the division of a line into extreme and mean ratio." Lucas Pacioli[2], a fifteenth century mathematician, defined this aesthetically satisfying ratio as the "divine proportion" in his work Divina Proportione. This ratio is also referred to as the "golden section" and the "golden proportion" in the literature.

The golden section is a naturally occurring ratio witnessed in the patterns of butterfly wings, structures of leaves, pine cones and the beautiful design of the logarithmic spiral of the chambered nautilus sea shell. Great paintings, such as George Seurnat's "La Parade" (1887) and Leonardo da Vinci's panel painting "Virgin and Child with St. Anne" (1500), have linear patterns based upon the principles of the golden section.[3,4] Architects have employed the golden section principle in buildings, the most famous being the Parthenon.[4]

The mathematical derivation[1,5] of the golden section is as follows: The division of a line such that the ratio of its parts is the same as the ratio of the larger part to the whole line establishes the golden section. Continued multiplication or division of the segments, while maintaining the same premise, will continue to exhibit the golden section. This ratio mathematically is equal to 1:1.618. This golden relation is called Phi and is assigned the Greek symbol O. Uniquely, its reciprocal, 0.618, is found by subtracting 1.00 from 1.618. This is the only positive number to exhibit such a nature.

Another well documented mathematical phenomenon, the Fibonacci series[5], is correlated with the golden section. Given any pair of numbers, a series can be generated by adding the pair with the sum becoming the third number of the series. Successively summing the last two numbers in the series, such a 2, 3, 5, 8, 13, ...55, 89, 144,.... establishes a Fibonacci series. The correlation is apparent in that, as the series continues, the ratio between any pair of successive numbers comes closer and closer to the golden section, 1:1.618. For example, 8/5=1.60 while 89/55=1.618 and 144/89=1.618.

When the golden section is applied to angular means, such as triangles and rectangles, curves and spirals can be formed.[1,6] These ratios can be found as examples in nature as well as examples constructed by man. Due to the natural occurrence of this ratio and its relevance to beauty and form, the golden section has been proposed as a guide for a proportional analysis of facial soft and hard tissues.[6]

With the golden section, esthetic goals could be derived from an evaluation of several components in the craniofacial complex. The subsequent blending of these components in the diagnosis and treatment planning could lead to a more functional result. It has been hypothesized by Ricketts[6] that the potential for dental relapse could be decreased when the patient is treated within their individual golden sections.

REVIEW OF THE LITERATURE

For hundreds of years, beauty and harmony have intrigued artists and philosophers. Artist contributions from the ancient Greek and Roman periods remain as standards for the comparison of present art forms.[8] Watson[9] states that Plato and Aristotle, through their studies of natural beauty, developed the concept of "aesthetics". The famous artist, engineer and anatomist, Leonardo da Vinci 1452-1519, devoted his life to the study of nature and the development of measures of excellence in nature and art. Through his studies of artistic and anatomic form, as reported by Berkman,[10] he graphically demonstrated his concept of the proportions of the normal face. To many artists, the identification and the study of the uncommon face or physical deformity leads to an understanding of beauty.[11]

Orthodontic efforts to improve facial esthetics have been greatly enhanced due to the advances and applications of cephalometrics. In 1931 Broadbent[12] introduced a radiographic method for the study of the human head and then in 1937[13] he illustrated the growth patterns of a normal child in serial radiographs. Brodie,[14] in 1941 published his serial study of the growth of the human head that occurs between the third month and the eighth year. In 1948 Downs[15] introduced an analysis using five skeletal and five dental criteria which could be evaluated as subsections of the whole for the balance and harmony of the individuals facial profile. Employing cephalometric values, discrepancies could be located in the skeletal framework. The main thrust of diagnosis had been in the dental malocclusion and the anterior-posterior dimensions. Few analyses dealt with the variations in the facial height and the vertical proportions.

In an attempt to define the architecture and balance of the head, Sassouni,[16] in 1955, described his archial analysis. Studying four cephalometric planes along with the anterior and posterior facial heights, a "well-proportioned face" could be described. The Sassouni Analysis was one of the first attempts to proportion the face in order to establish facial balance.

Coben,[17] in 1955, published a study designed to determine the variation of the relative size and growth of the cranial and facial structures along with their effects on the profile. Using the Frankfort horizontal plane as the coordinate, he appraised the face against a right angle coordinate system. Linear measurements parallel or perpendicular to the Frankfort horizontal plane were used as direct dimensions and as reference points, respectively. Vertical and depth relationships were related as proportions. Growth increments were quantitated by comparing serial radiographs taken at eight and sixteen years of age.

Ricketts,[18] in 1957, discussed the cephalometric procedure for predetermining individual growth and treatment behavior according to facial type. Using the Basion-Nasion plane as the plane of reference, the amount and direction of the mandibular growth could be predicted, along with the changes of the maxilla. Soft tissue components (lips, nose and chin) could also be predicted. The Ricketts Esthetic plane, drawn from the tip of the nose to the anterior contour of the chin, was also described.

A very comprehensive facial soft tissue, or integumental, profile analysis was introduced in 1958 by Burstone.[11] Ten profile components (line segments) were employed to evaluate the facial contour, while five contour angles evaluated the morphology of the profile. In 1980, Legan and Burstone[19] introduced the "Cephalometrics for Orthognathic Surgery" (COGS) appraisal system to evaluate the horizontal and vertical positions of the facial bones. This analysis is very similar to that published by Coben in 1955.

In an effort to determine the area of disproportion, a division of the face into its individual skeletal units has been advocated. Legan and Burstone[19] and Belinfante[20] suggested dividing the face into thirds while Worms et al.[21] suggested five divisions. Biggerstaff[22], Opdebeeck and Bell,[22] Nahoum[24] and Schendel et al.[25] evaluated vertical facial components as a ratio of the upper to the lower anterior facial heights. Although reported ratios for upper and lower anterior facial heights vary in numerical values (partially due to the application of different landmarks), they all express a larger lower facial height. The theory remains that a well balanced and proportioned face is necessary for facial beauty.[11]

Ricketts[26], in 1981, proposed the application of a proportional ratio, the "golden section", to the soft tissue and cephalometric analyses of the human head. Lombardi[27] and Levin[28] also relate the golden section to tooth selection and placement in denture construction.

The purpose of this study is to determine whether there is correlation between facial soft tissue proportions and cephalometric measurements of golden sections and the Eleven Factor Analysis.

MATERIAL AND METHODS

One hundred and three 1:1 retention phase frontal photographs were acquired from Rocky Mountain Data Systems (RMDS)*. These were records of patients of Dr. Robert Ricketts which had been collected for a previous study at RMDS. Corresponding retention phase lateral head films were also available.

Horizontal and vertical soft tissue measurements were recorded, as illustrated in Figure 1. Due to the difficulty in locating the landmark Trichion (the most superior point of the top wrinkle of a raised forehead) on the photographs, this point, together with the associated ratios, were not included in this study. The soft tissue measurements were recorded from the following landmarks:

A. Horizontal landmarks and measurements

1. Width of the cranium at the level of the eyebrows
2. Width of the eyes at the lateral canthus
3. Width of the nose at the level of the alar rims
4. Width of the mouth at the lip embrasure

*RMDS, Rocky Mountain Data Systems, 7900 Sepulveda Blvd., Van Nuys, California. 91403.

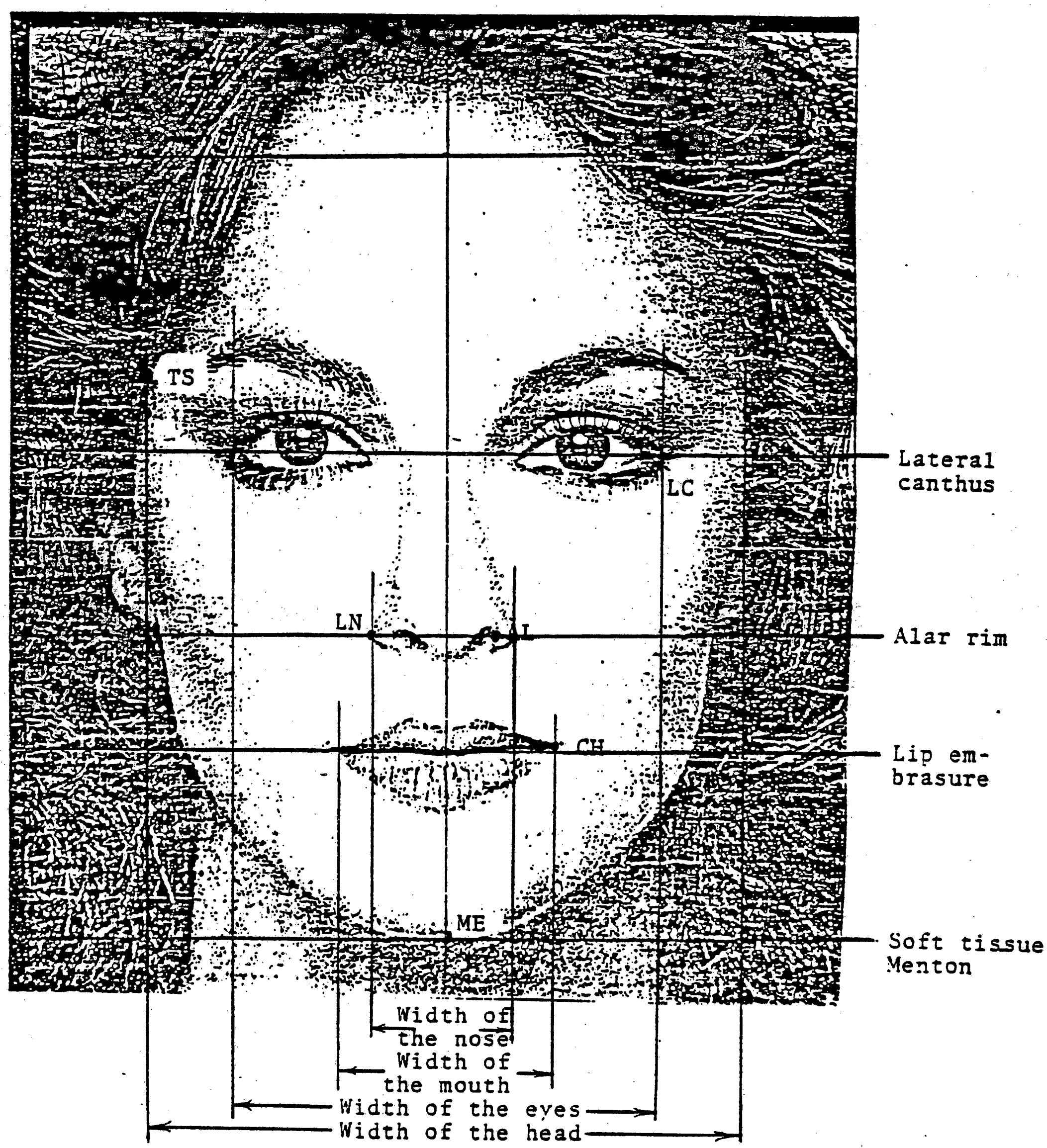


Figure 1. Soft tissue landmarks and horizontal measurements. (Copied from Reference 7)

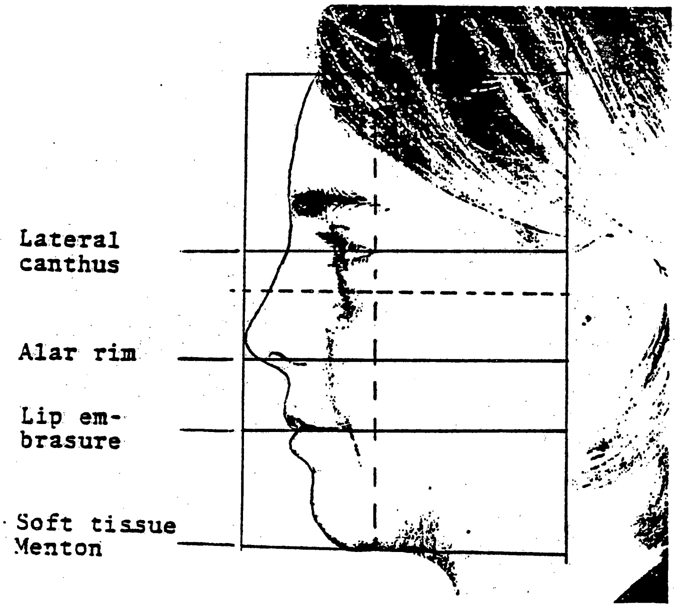


Figure 2. Lateral photographic golden section landmarks. (Copied from reference 29)

B. Vertical landmarks along the sagittal midline at the following levels:

1. Lateral canthus of the eyes
2. Curve of the ala of the nose
3. Lip Embrasure
4. Soft tissue Menton

The landmarks were traced on a sheet of tracing acetate overlaying the photographs. The distances were measured with a millimeter ruler and recorded on each individuals analysis sheet.

Seven ratios, three horizontal and four vertical, were computed to determine the soft tissue golden sections for each individual, as described by Ricketts.[26] These ratios were calculated by relating the following:

A Horizontal ratios

1. Forehead width : Eye width
2. Eye width : Mouth width
3. Mouth width : Nose width

B. Vertical ratios from measurements along the midline

1. Lateral canthus-lip embrasure : Lip embrasure-Menton
2. Ala of the nose-Menton : Lateral canthus-ala of the nose

3. Lateral canthus-ala of the nose : Ala of the nose-lip embrasure
4. Lip embrasure-Menton : Ala of the nose-lip embrasure.

For this study, the soft tissue golden section ratios were considered acceptable if falling within the range of 1.6180.122, a 7.50% variation. Based on the assumption by Ricketts[29] that beautiful faces exhibit soft tissue golden sections, two groups of twenty individuals each were formed. Of the seven ratios listed above, group one had five or more acceptable ratios, while group two had two or fewer acceptable ratios.

Hard tissue skeletal relationships for the individuals in both groups were evaluated from the corresponding retention phase lateral cephalometric radiographs. The Down's Analysis, as modified by Ricketts was used to analyze the radiographs. A computer composite of thirty adult Peruvian National males with full thirty-two tooth dentitions, as illustrated in Figure 3, was used to evaluate each individuals facial type. The analysis is composed of the various angular and linear measurements as follows:

1. Facial Axis: The angle between the Nasion Basion plane and the Facial Axis (Pterygoid point to Gnathion).

2. Facial Depth: The angle between the Facial Plane (Nasion to Pogonion) and the Frankfort Plane.

3. Mandibular Plane: The angle between the Frankfort Plane and the Mandibular Plane.

4. Lower Facial Height: The angle between a line from the Anterior Nasal Spine (ANS) to the geometric center of the ramus (Xi point) and Corpus Axis (Xi point Pm).

5. Mandibular Arc: The angle between the Corpus Axis and the Condylar Axis (Xi point to DC point)

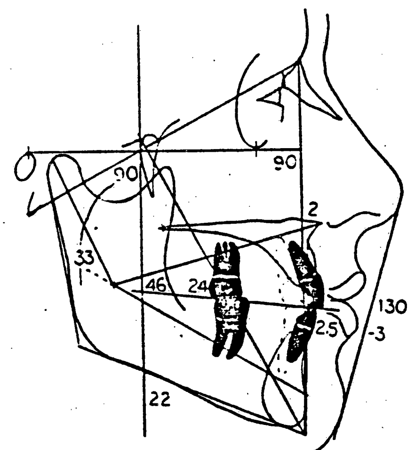
6. Convexity: The linear distance between A point (the point of greatest concavity of the anterior maxilla) and the Facial Plane.

7. $\overline{1}$ to APo: The linear distance between the incisal tip of the mandibular central incisor ($\overline{1}$) and the Apo plane (A point to Pogonian).

8. $\overline{1}$ to APo: The angle between the long axis of $\overline{1}$ and the APo plane.

9. $\underline{6}$ to PTV: The linear distance between the distal of the first maxillary molar ($\underline{6}$) and PTV (a line perpendicular to Frankfort and tangent to the distal wall of the pterygoid).

10. Lower Lip to E Plane: The distance between the anterior contour of the lower lip and the E Plane (a line from the tip of the nose to anterior contour to the chin).



N-30 ♂

PERUVIAN COMPOSITE

Factor	Means	Norms for 9 Yr Olds
F. Axis	90°±3	No change w age
F. Depth	86°±3	Increase 1°/3 yr
Md Plane	26°±6	Decrease 1°/3 yr
LFH	47°±4	No change w age
Md arc	26°±4	Increase .5°/3yr
1 to APo	+1mm±2mm	No change w age
1 to APo	22°+4	No change w age
6 to PTV	Age+3mm+2	Increase 1mm / yr
Lip-E plane	2mm+2	Less Protrusive w growth
Inter Inc Angl	130+6	No change w age

Figure 3. Ricketts Eleven Factor Analysis. Listed are the factors, means for a 9 year old and adjustment increments for growth. (Copied from references 26 and 30.

11. Interincisal Angle: The angle formed by the intersection of the long axis of the upper and lower central incisors.

While the listed norms represent means for a 9 year old individual, several factors increase or decrease with normal skeletal growth. The direction and amount of change with growth for those factors are also listed in Figure 3. Using these norms and adjustments for growth, each individuals eleven factors were calculated in terms of standard deviations and recorded.

Facial typing describes an individuals general growth pattern. Three basic facial patterns, illustrated in Figure 4 are referred to as:

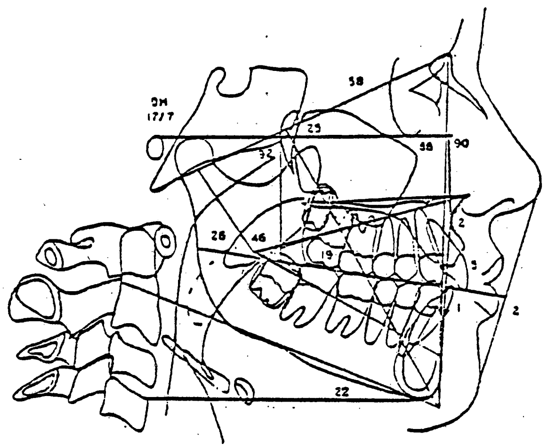
1. Brachyfacial - Displaying a horizontal growth pattern.

2. Mesofacial - Displaying a normal growth pattern.

3. Dolichofacial - Displaying a vertical growth pattern.

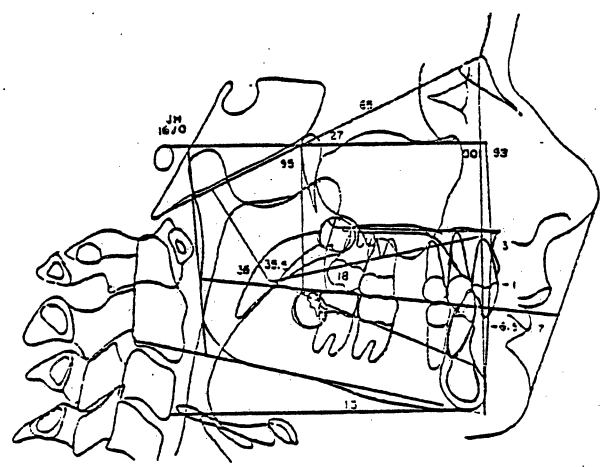
The hard tissue golden section ratios, as described by Ricketts[26] are shown in Figures 5 and 6. The prescribed distances were measured with a millimeter ruler and recorded for each tracing. The golden section ratios were computed from the following relationships:

1. S-Na : S-Ba



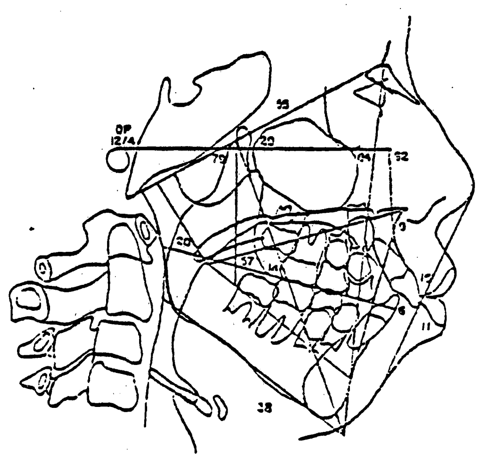
1. MESOFACIAL

Most of the 5 measurements are within one clinical deviation of the mean.



2. BRACHYFACIAL

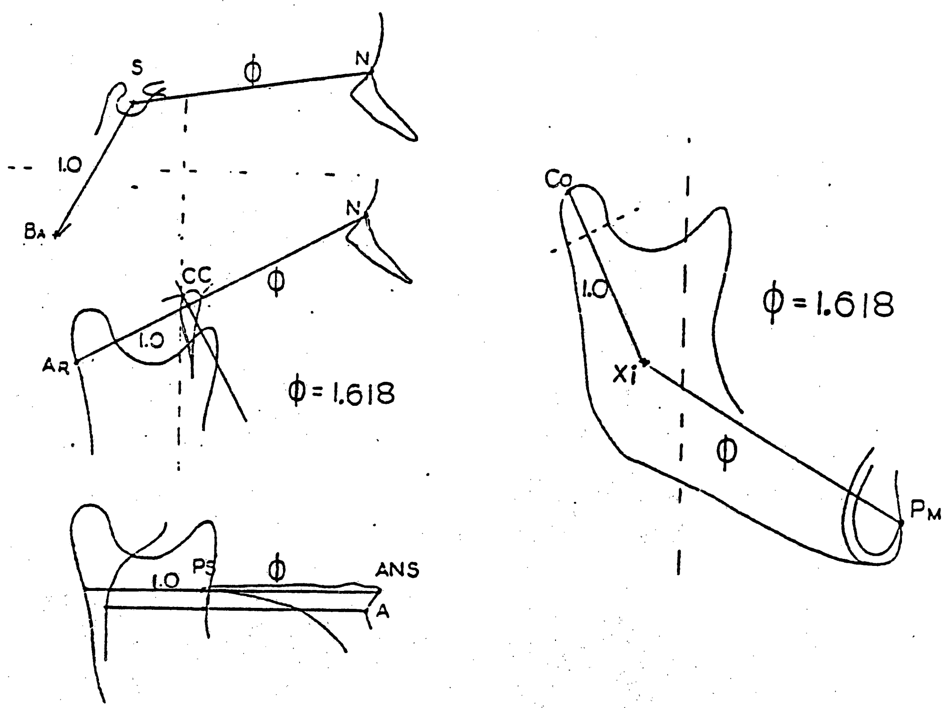
Mand. Arc	+ 1 C.D.
Lower Face Ht.	- 1 C.D.
Mand. Plane	- 1 C.D.
Post. Face Ht.	+ 1 C.D.
Facial Axis	+ 1 C.D.



3. DOLICHOFACIAL

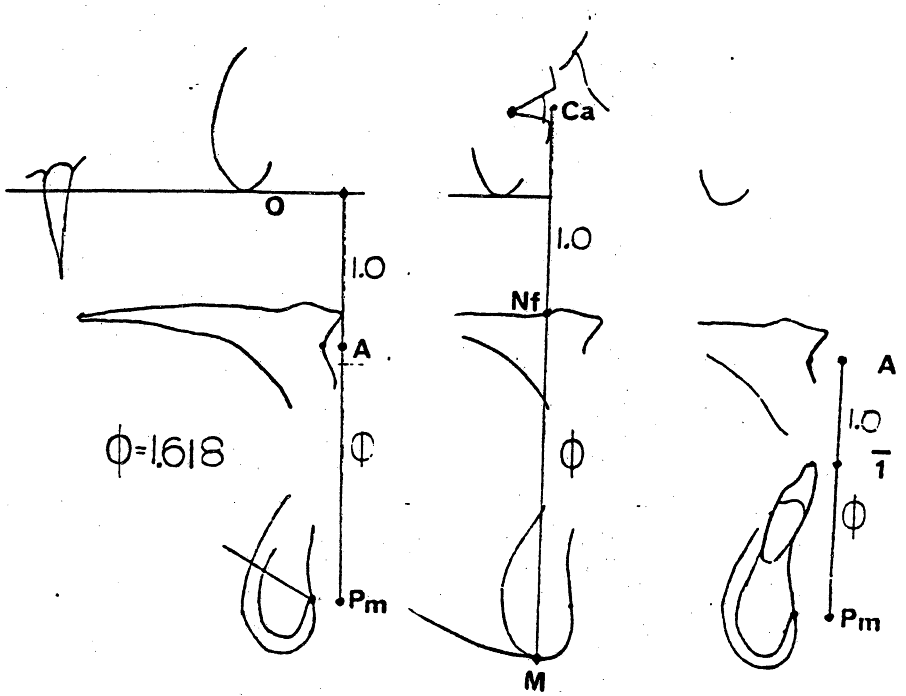
Mand. Arc	- 1 C.D.
Lower Face Ht.	+ 1 C.D.
Mand. Plane	+ 1 C.D.
Post. Face Ht.	- 1 C.D.
Facial Axis	- 1 C.D.

Figure 4. Examples of the three basic facial patterns. (Copied from reference 30)



Xi = Geographic center of the ramus
Cd = Condylion or superior posterior aspect of the condyle
Pm = Anterior border of the symphysis at the transition from convex to concave
S = Sella
Na = Nasion
Ba = Basion
Ar = Articular, the point of intersection of the Na-Ba line and the distal of the condylar neck
ANS = Anterior Nasal Spine
PNS = Posterior Nasal Spine
A pt = A point, most medial point of the anterior maxilla

Figure 5. Hard tissue landmarks and Golden Section relationships. (Copied from reference 26)



Me = Menton
1 = Incisal tip of the lower incisor
FH = Frankfort Horizontal
Ramus base of the condylois process on the extended ANS-PNS line
Soft tissue wall of the posterior pharynx
Nasal floor
Canthus of the eye

Figure 6. Hard tissue landmarks and Golden Section relationships. (Copied from reference 26.)

2. CC-Na : CC-Ar
3. ANS-PNS : PNS-Ramus base of the condyloid process
4. A pt-PNS : PNS-Soft tissue wall posterior pharynx
5. A pt-Pm : Apt-FH
6. Me-Nasal floor : Nasal floor-Canthus of the eye
7. Lower incisor-Pm : Lower incisor-A pt
8. Xi-Pm : Xi-Cd

Two additional cephalometric measurements were recorded: Upper lip length, measured from ANS to the lip embrasure; and Lip embrasure to Occlusal plane.[30]

METHOD OF DATA ANALYSIS

The ratios for the soft tissue relationships, the ratios for the hard tissue relationships and the standard deviations of the Eleven Factor Analysis and the lip relationship (a total of twenty-seven factors) were analyzed by Rocky Mountain Data Systems. Using the means, the correlation coefficient test were completed for the two groups utilizing all twenty-seven factors. The two groups Eleven Factor Analysis values were compared for statistically significant differences by student t-tests. A discriminant analysis was computed to determine which elements of the Eleven Factor Analysis could be combined to determine the most accurate method of predicting a particular individuals group.

DATA AND TEST RESULTS

For identification purposes, the group with five or more acceptable soft tissue sections will be referred to as the golden group while the group with two or fewer golden sections will be the non-golden group.

The golden group consisted of sixteen females and four males with a mean age of 14.7 years (12.2-19.6 years). This group had a mean of 5.3 acceptable soft tissue golden sections.

Table I tabulates the mean values for the soft tissue golden sections recorded with the value of 1.0 being given for an acceptable ratio and a value of 2.0 being given for a non-acceptable ratio.

The Eleven Factor values in both groups were computed and recorded in terms of standard deviations derived from the given norms in Figure 3. The mean values and standard deviations for both groups, tabulated in Table II, are based on standard deviations from the given set of norms. The norm values were adjusted for age when applicable as indicated in Figure 3.

The mean values and the standard deviations for the upper lip lengths and lip embrasure to occlusal plane measurements are summarized in Table III.

Employing the mean values of the vertical components of the Eleven Factor Analysis (facial axis, facial depth, mandibular plane, lower facial height and mandibular arc), directional tendencies away from the norms were calculated for each group. The golden group had a deviation from the norm of +0.30 standard deviations while the non-golden group had a -0.05 standard deviation from the norm. These values showed the golden group to be of a brachyfacial pattern tendency; whereas, the non-golden group was more mesofacial.

The hard tissue golden section ratio mean values and standard deviations are tabulated in Table IV.

Correlation coefficients were computed correlating each of the Eleven Factor Analysis to each of the soft tissue golden section values and to each of the hard tissue golden section values. The results showed no correlation above a coefficient of absolute value of 0.5. The highest correlation coefficient, in relationship to the soft tissue golden section, was 0.44; whereas, the highest value for the hard tissue golden sections was 0.38. Both values are too low to be statistically significant.

Listed in Table V are the Student t-test results which evaluated the two groups Eleven Factor Analysis. The results reveal a statistically significant difference in the lower facial height and the lower lip to E-plane values.

The discriminant analysis revealed that the lower facial height, mandibular arc and facial axis values were the most likely to determine an individuals group. The success rate, when using these factors, was shown to be 77.5% (31 of 40 were correctly catagorized).

DISCUSSION

Evaluating an individual in a clinical setting would facilitate more accurate measurements of several soft tissue landmarks. Trichion point could not be used in this study due to the difficulty in determining its location. The location of the sides of the head, for example, was at times an estimation in some subjects due to the individuals hair style. In such cases, three measurements were taken and the mean value used.

The examination of the soft tissue ratios reveals that 50% of the golden group had unacceptable values for the width of the mouth to the width of the nose; whereas, 100% of the non-golden group were unacceptable. It should be noted that the faces were passive and displayed flat affects in the photographs. The mouths were flaccid and expressionless. The slightest expression widens the commissures of the lips which would change this ratio.

The Eleven Factor Analysis describes the basic facial and skeletal structures in relationship to the chin, the mandible, the maxilla, the teeth and the cranial structures, together with a soft tissue evaluation. The standards and norm values have been established by Ricketts for classifying individuals according to facial patterns. In comparing the subjects in the two groups, tendencies in facial patterns can be demonstrated.

1. The golden group tended to be a more brachyfacial population. This tendency was revealed in the lower facial height ($\overline{X}$ = -0.86 S.D.) and interincisal angle ($\overline{X}$ = -0.69 S.D.).
2. The non-golden group tended to have means closer to the norms, indicating a mesofacial pattern. One indicator of a slight brachyfacial tendency was the mandibular arc ($\overline{X}$ = 0.41 S.D.). This group also exhibited more protrusive features revealed in convexity ($\overline{X}$ = 0.60 S.D.) and the lower lip to the E plane ($\overline{X}$ = 0.98 S.D.).
3. Both groups showed a high $\overline{1}$ Inclination value ($\overline{X}$ = 1.27 S.D. and 1.35 S.D.). This high value is assumed to be a result of Dr. Ricketts desire not to extract in orthodontic treatment; therefore, tending to leave the lower incisor more protrusive.
4. An evaluation of the composite lateral cephalometric tracing that Ricketts uses to illustrate the hard tissue golden sections, shown in Figure 3, reveals a brachyfacial tendency. This tendency is indicated by the values for the

mandibular arc ($\overline{X}$ = -0.63 S.D.), the lower facial height)$\overline{X}$ = -0.25 S.D.) and the mandibular plane ($\overline{X}$ = -0.50 S.D.).

The lack of a significant statistical correlation between the hard and soft tissue golden sections and the Eleven Factor Analysis is determined by having no correlation coefficients above the 0.5 level. Several factors may be affecting this outcome:

1. The sample is mixed, female and male, at various stages of development.
2. The population, of which the sample groups were chosen, did not include individuals with severe facial deviations. This is evident in that the sample groups chosen had slight brachyfacial tendencies. Dolichofacial patterns were not observed. A study of individuals displaying vertical excesses, or mandibular deficiencies, would result in higher statistical significance levels.
3. There is a tendency towards a brachyfacial pattern in the hard tissue golden section sample which, with growth, could become statistically significant.

Evaluating the mean values and standard deviations for the hard tissue golden sections, tabulated in Table IV, reveals the following:

1. Both groups had high values for the ratio of the horizontal distances from point A-PNS to PNS-posterior pharynx (both groups $\overline{X}$ = 1.88). In comparison, the ratios for the ANS-PNS to PNS-distal border of the condyle for both groups were acceptable ($\overline{X}$ = 1.65 for the golden group and $\overline{X}$ = 1.63 for the non-golden group). It may be concluded that the horizontal ratio involving the posterior wall of the pharynx is not as strong of an indicator as the ratio involving the hard tissue radiographic ratios.
2. The ratios for $\overline{1}$-Pm to $\overline{1}$-A point for both groups were low ($\overline{X}$ = 1.51 for the golden group and $\overline{X}$ = 1.45 for the non-golden group). This indicates that both groups represented individuals not having excessive lower facial heights. This characteristic is common in the brachyfacial pattern.

As indicated by the t-test and the discriminant analysis, important indicators of the groups characteristics are lower facial height, facial axis and mandibular arc. These three factors are strong determinants of facial patterns in the Eleven Factor Analysis. As shown in the results, these factors reveal a brachyfacial tendency in the golden group while the non-golden groups is closer to the means of a mesofacial pattern.

Several conclusions may be drawn from the data collected.

1. While employing the Eleven Factor Analysis to identify the characteristics of the individual groups, the golden section ratios are possibly evaluating something independent of the Eleven Factor Analysis. Frontal dimensions such as those measuring the soft tissue are not evaluated by the Eleven Factor Analysis.
2. Since there are no statistically significant correlations found between the golden sections and the Eleven Factor Analysis for this sample of normal individuals (lateral cephalometric $\bar{X}$ within 1.00 S.D. of the norms), it could be concluded that the average person does not have soft tissue golden sections.

Further research studying more extreme diviations of facial patterns would be recommended by the author. A study with the sample selection based upon the individuals cephalometric analysis would insure representative facial types.

A comparison of pre-surgical golden sections and post-surgical golden sections of successful orthognathic surgery cases would contribute to the validity of the golden section parameters in treatment planning of orthognathic surgery cases.

A study of the golden sections proportions of a sample selected by a mixed group of judges (ie. laymen, students, dentists) would provide an index to the public opinion of facial esthetics and the golden sections.

SUMMARY

In the treatment of dentofacial abnormalities, the clinician deals with the facial complex. Cephalometric linear and angular measurements do not, in and of themselves measure, or assess, the proportionality and balance of the face. Whereas, a proportional analysis may not be sensitive to the coexisting dysplasia, a linear analysis, when compared to selected norms, could detect significant deviations. A combined analysis of skeletal components, and their proportions to the total complex, would more likely contribute to a well-proportioned, balanced result.

Presented here is a study of forty individuals facial soft tissue proportions, hard tissue (cephalometric) proportions and cephalometric analyses. The proportions are made in the horizontal and vertical dimensions. The facial pattern tendencies for the subject groups are reported.

TABLE I

Mean values for the soft tissue golden sections.

Ratios	Golden Group	Non-Golden Group
$\frac{TS-TS}{LC-LC}$	1.00	1.20
$\frac{LC-LC}{CH-CH}$	1.30	1.80
$\frac{CH-CH}{LN-LN}$	1.50	2.00
$\frac{LC-CH}{CH-ME}$	1.15	1.90
$\frac{AL-ME}{LC-AL}$	1.15	1.95
$\frac{LC-AL}{AL-CH}$	1.25	1.75
$\frac{CH-ME}{AL-CH}$	1.35	1.65

TABLE II

Eleven Factor mean and standard deviations for the golden and non-golden groups.

Factor	Golden Group $\bar{X}$	Golden Group S.D.	Non-Golden Group $\bar{X}$	Non-Golden Group S.D.
Facial Axis	0.20	1.06	-0.33	1.70
Facial Depth	0.30	1.00	-0.21	1.04
Mandibular Plane	-0.25	1.17	-0.14	1.31
Lower Face Height	-0.86	0.99	0.26	1.23
Mandibular Arc	0.19	1.11	0.42	1.05
Convexity	0.34	0.86	0.61	1.22
$\overline{1}$ to Apo (mm.)	0.26	0.82	0.23	0.67
$\overline{1}$ to Apo (°)	1.27	1.43	1.14	1.14
6 to PTV	0.28	1.04	0.31	1.20
Lower Lip to E Plane	-0.10	1.27	0.98	1.23
Interincisal Angle	-0.69	1.66	-0.34	1.40

TABLE III

Mean and standard deviations for Upper Lip Length and Lip Embrasure to the Occlusal Plane.

Factor	Golden Group $\bar{X}$	Golden Group S.D.	Non-Golden Group $\bar{X}$	Non-Golden Group S.D.
Upper Lip Length	-0.74	0.97	-0.15	1.28
Lip Embrasure to Occlusal Plane	-0.23	0.82	-0.86	1.11

TABLE IV

Hard tissue golden section ratio means and standard deviations.

Factor	Golden Group		Non-Golden Group	
Na-S / S-Ba	1.63	0.13	1.57	0.15
Na-CC / CC-Ar	1.68	0.15	1.66	0.14
ANS-PNS / PNS-D of Condyle	1.63	8.17	1.65	0.16
pt A-PNS / PNS-Post Phar	1.88	0.25	1.88	0.30
pt A-Pm / pt A-Frankfort	1.51	0.24	1.69	0.24
Nasal Fl-Me / Ca of eye-N Fl	1.62	0.16	1.76	0.14
Pm-$\overline{1}$ / 1-pt A	1.51	0.23	1.45	0.12
Xi-Pm / Co-Xi	1.61	0.09	1.56	0.08

TABLE V

Student t-test results for the Eleven Factor Analysis

1.	Facial Axis	1.17	---
2.	Facial Depth	0.71	---
3.	Mandibular Plane	-0.28	---
4.	Lower Face Height	-3.17	.01
5.	Mandibular Arc	-0.67	---
6.	Convexity	-0.79	---
7.	Lower Incisor Protrusion	0.11	---
8.	Lower Incisor Inclination	0.30	---
9.	Upper Molar to PTV	-0.08	---
10.	Lower Lip to E Plane	-2.75	.01
11.	Interincisal Angle	-0.72	---

LITERATURE CITED

1. Huntley, H. E.: The Divina Proportione, ed. 1, New York, 1970, Dover Publications.

2. Pacioli, L.: Divina Proportione. Wien Graser, 1896, C. Winterberg.

3. Benton, W. B.: Art of painting. Encyclopedia Britannica. 13: 874, 1974.

4. Reichardt, J. A.: Art at large. New Scientist. 56:601, 1972.

5. Cundy, H. M. and Rollett, A. P.: Mathematical Models, ed. 2, New York, 1945, McGraw-Hill Book Company.

6. Thompson, D. W.: On Growth and Form, ed. 1, Oxford, 1952, Cambridge University Press.

7. Manuscript received from Rocky Mountain Data Systems for a book by R. M. Ricketts scheduled for publication in 1982.

8. Lines, P. A., Lines, R. R. and Lines, C. A.: Profilemetrics and facial esthetics, AM. J. Orthod. 73: 648-657, 1978.

9. Watson, W. G.: Art in orthodontics, Am. J. Orthod. 78: 571-573, 1980.

10. Berkman, M. D.: Evaluation-Diagnosis-Planning. The challenge in the correction of dentofacial deformities, Alpha Omega. 23: 18-26, 1978.

11. Burstone, C. J.: The integumental profile, Am. J. Orthod. 44: 1-25, 1958.

12. Broadbent, B. J.: A new x-ray technique and its application to orthodontia, Angle Orthod. 1: 45-66. 1931.

13. Broadbent, B. H.: The face of the normal child, Angle Orthod. 7: 183-208, 1937.

14. Brodie, A. G.: On the growth pattern of the human head from the third month to the eighth year of life, Am. J. Anat. 68: 209-261, 1941.

15. Downs, W. G.: Variations in facial relationships: Their significance in treatment and prognosis, Am. J. Orthod. 34: 812-840, 1948.

16. Sussouni, V.: A roetgenographic cephalometric analysis of cephalo-facial-dental relationships, Am. J. Orthod. 41: 735-764, 1955.

17. Coben, S. E.: The integration of facial skeletal variants, Am. J. Orthod. 41: 407-434, 1955.

18. Ricketts, R. M.: Planning treatment on the basis of the facial pattern and an estimate of its growth. Angle Orthod. 27: 14-32, 1957.

19. Legan, H. L. and Burstone, C. J.: Soft tissue cephalometric analysis for orthognathic surgery, J. Oral Surg. 38: 744-751, 1980.

20 Belinfante, L. S.: Total treatment planning for esthetic problems of the face: a team approach. J. Oral Surg. 37: 178-186, 1981.

21. Worms, F. W., Isaacson, R. J. and Speidel, T. M.: Sugical orthodontic treatment planning: Profile analysis and mandibular surgery. Angle Orthod 46: 1-25, 1976.

22. Biggerstaff, R. H.: A vertical cephalometric analysis of the human craniofacial complex. Am. J. Orthod. 72: 397-405, 1977.

23. Opdebeeck, H. and Bell, W. H.: The short face syndrome. Am. J. Orthod. 73: 499-511, 1978.

24. Nahoum, H. A.: Vertical proportions: A guide for prognosis and treatment in anterior open bite. Am. J. Orthod. 72: 128-139, 1977.

25. Schendel, S. A., Eisenfeld, J., Bell, W. H., Epker, B. N. and Mishelevich, D. J.: The long face syndrome: Vertical maxillary excess. Am. J. Orthod. 70: 398-408, 1976.

26. Ricketts, R. M.: Perspectives in the clinical application of cephalometrics. Angle Orthod. 51: 115-150, 1981.

27. Lombardi, R. E.: The principles of visual perception and their clinical application to denture esthetics. J. Prosthet. Dent. 29: 358-382, 1977.

28. Levin, E. I.: Dental Esthetics and the golden proportion, J. Prosthet. Dent. 40: 244-252, 1978.

29. Ricketts, R. M.: The golden divider, J. Clin.Orthod. 15: 752-758, 1981.

30. University manual published by Rocky Mountain Data Systems.