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Correlations between morphologic palatal dimensions and the cranio-facial balance

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1. INTRODUCTION

The relationship between occlusion and cranio-facial morphology represents an often-discussed argument in orthodontics. Attempts have been made to correlate the shape and dimension of the dental arches with different facial patterns.
The researcher's goal is to evaluate the reciprocal relationships of the two dental arches and the cranial base, pointing out the influence of oro-facial muscles in the development of normal dental arches and malocclusions.

There have been a number of papers published on this subject. Considering the oral cavity as a complete and complex organ for different vital functions, the roof of this cavity represents a connection between occlusion and craniofacial morphology in an individual. Our research aims to evaluate palatal morphology not as a single value, but as a sum of different elements (skeletal, muscular and functional) essential for harmonic development of the lower 2/3rds of the face.

2. THE MORPHOLOGIC RESEARCH ON THE PALATAL ROOF

Previous studies, especially longitudinal ones, have evaluated growth and osseous remodelling.
With the purpose of evaluating modification during growth, Lebret (1971) conducted a longitudinal study of 30 subjects comparing the cephalometric tracings at 5 years of age and one at 18 years. The growth in the intermediate ages was so gradual so that the internal range variations

are not evident. Lebret wrote, " the palatal growth is in the same amount during the mixed dentition (6-12 years old) and after the second molar eruption (from 12 to 18)". Knott et. Johnson (1970) conducted an investigation on female subjects aged 5 to 17 years. The results showed that the average increase in palatal height per year from 12 to 15 is less than the one from 5 to 9. From 15 to 17 the measurements do not change and the dento-alveolar remodelling seems to stop its activity.

Howell made the latest study in 1981. He used a palatal index (P.I) as a numerical expression of the palatal height. This is calculated by dividing the height by the length in the premolar and molar areas, in the deciduous, mixed, and permanent dentition.

In this study, the palatal index increased from deciduous to permanent dentition but the most statistically significant increase occurred in the first molar area. This method is able to describe the palatal size but not the shape, since a V-shaped palate could have the same index of a more rounded palate. Literature on maxillary morphology became poor when we searched for palatal shape and malocclusions.

The available articles are hardly comparable since the points considered for measurement change with authors and with malocclusions. Klami and Horowitz (1979) presented a study with subjects aged 11 to 16 years with crossbite, Class I, Class II malocclusions compared with a control group.

Palatal height was measured on 3 levels of latero-posterior sector: between the first and second premolar, between the second premolar and the first molar and between the first and second molars. For each level, 5 measurements were made: one on the median raphe and four lateral to it symmetrically distanced 2 mm from the center and between them. The bilateral crossbite patients had the same morphology as the control group. The unilateral crossbite patients showed a vertical asymmetry with a greater palatal height on the pathological side, while no statistically significant differences were found in the control group.

Branislav (1971) was the first author to propose the combination of cephalometric data and palatal morphology. His conclusion was that individual facial angle variation (FH/N-Pg) or the sphenoidal angle (NSBa) does not influence the development of the palatal roof and it is not correlated with facial height, with piriform orifice and choana. Furthermore he concluded that there are no differences in males and females, and that the vertical palatal size does not change after 12 years of age.

3. MATERIALS AND METHODS

This study involves 136 subjects, 68 female and 68 male, aged between 7 and 18 years, selected from the patients of the Orthodontic Department of the University of Florence. The subjects had different types and severity of malocclusions. The selection criteria are as follows::

- - no previous orthodontic treatment
- - total eruption of upper and lower first molar
- - absence of patology such as cleft palate or genetic syndromes
- - presence of clinical documentation (panoramic and cephalometric radiographs, study models with good details including palatal plica and median raphe

  The total group was divided into homogeneous subgroups for numbers; facial divergency (normal, hypodivergent, hyperdivergent) and malocclusion type (Class I, II and III).

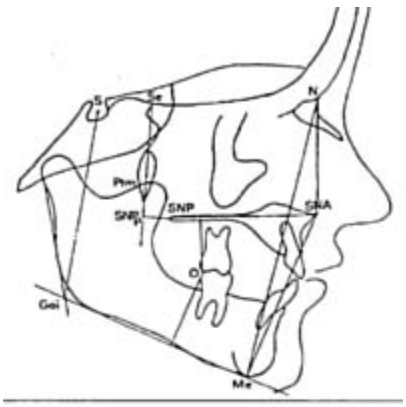
  The details were:

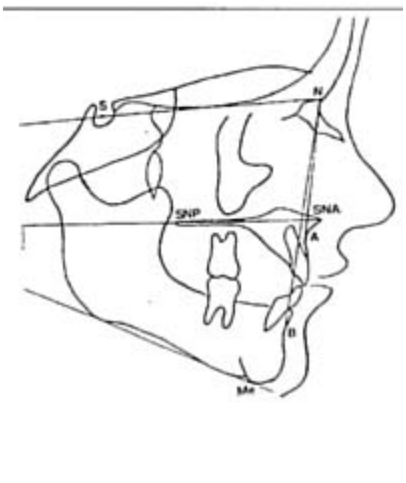
Class I	female	male
Normal	7	9
Hypodivergent	9	7
Hyperdivergent	7	7
Total 46		
Class II		
Normal	8	8
Hypodivergent	8	8
Hyperdivergent	9	9
Total 50		

Class III		
Normal	8	7
Hypodivergent	4	6
Hyperdivergent	8	7
Total 40		

For each subject a cephalometric analysis was done. We considered the different authors' suggestions, with linear and angular measurements. In our opinion the sagittal and vertical balance of the examined subjects is important (figg. 1-2).

Linear parameters:





- SNA-Me: represent the anterior facial height.
- S-Go: represent the posterior facial height.
- N-Me: it represents the total anterior facial height.
- S-Go/N-Me: it is the ratio of the posterior and the anterior facial height.
- SNA-Me/N-Me: it is the ratio of the anterior lower facial height and the total anterior facial height.
- SNA-SNP: the lenght of the palatal plane.
- O-Pal. Plane: the line between O (occlusal point: the contact point inferior and posterior on the superior molar in occlusion) and the perpendicular line starting from palatal plane; it represents the superior alveolar posterior height.
- O-Mand. Plane: the line between the O point and the perpendicular line starting from O to mandibular plane; it represents the inferior alveolar posterior height
- N-SNA: represents the anterior facial superior height.
- Se-SNPp: represents the upper posterior facial height (distance between the spheno-ethmoidal suture and the projection of the posterior nasal spine on the line from Se and ptherigomascellar fissure)
- OVJ (Overjet): the distance in mm between the buccal surface of the lower central incisor on the antero-posterior plane.
- OVB (Overbite): the distance between the upper and lower central incisors on a vertical plane.

Angular parameters:

- S-N-A: the sagittal position of the maxilla

- S-N-B: the sagittal position of mandible
- A-N-B: the difference between the above values as defined by Ballard
- SN-Pal. plane: the inclination of palatal plane
- Pal.plane-Mand.plane: the intermaxillary divergency index

STUDY MODELS ANALYSIS

The upper model for each subject was frontally cut at two levels:

1. - at the mesial surface of the first deciduous molars or of the first premolars (the distal surface of the cuspid when the others were missing).

2. - at the distal surface of the first molars. The section was made with a gypsum dry cutter; and the sections were black painted, pointing out the mediam raphe and the gingival borders. A photocopy was made and was then scanned. The measurements on the palatal profile were made with CAD software called CadKey. All the technological equipment was made available by Leone S.p.A.

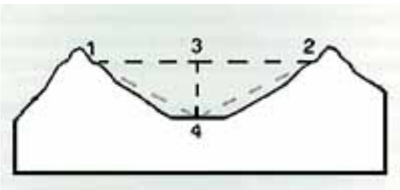


Fig. 4

Point and measurements:

for the anterior section:
- the more lingual point of the gingival border of the first deciduous molar or of the first bicuspid (points 1 e 2, fig. 3)
- the median raphe point (central point 4, fig. 3)

for the posterior section:
- the more lingual point of the gingival border of the right and left first molar (points 1 e 2, fig. 3)
- the median raphe point (central point 4, fig. 3)

Starting from these points, in both sections, the following segments have been drawn (figg. 3-4):
- the conjunction segment of the gingival points (1-2)
- the perpendicular segment to the median raphe (3-4)
- the right and left diagonals from the median raphe to the gingival points (1-4 e 2-4)

Model measurements

The following measurements were made:

- A segment (distance 1-3, the right half palatal measure)
- B segment (distance 2-3, the left half palatal measure)
- A segment + B segment (distance 1-2, total width)
- C segment: from the median raphe point to 1-2 segment (distance 3-4, palatal height)
- the angle between 1-2 segment and 1-4 diagonal, represents the left palatal process inclination
- the angle between 1-2 segment and 2-4 diagonal, represents the right palatal process inclination
- palatal section area: delimited surface from 1-2 segment and palatal border.

STATISTICAL METHODS

A statistical analysis was performed on all the parameters from subjects with malocclusions to evaluate the variability of one value in relation with another one. In other words to test the association force between the variables, data was considered in pairs. The correlation coefficient of Pearson was used with pairs of variables. The significance level (p) of each correlation coefficient (called "r" and between -1 and 1). The closer "r" is to 1, the stronger the association between two variables. Conversely, the closer "r" is to 0, the weaker the association between the two variables. The positive or negative sign before the "r" value indicates direct or inverse correlation respectively (Glantz 1988). According to Solow (1966), performing cephalometric correlations is necessary to distinguish between topographic and non-topographic variables. Inside a correlation matrix a topographic variable is defined by two cephalometric measurements (angular or linear) that present a common point or line, and they are situated on the same reference anatomical structure. According to Solow, the topographical variables that have a common point or line have an intrinsic basic correlation.

The non-topographical variable correlation assumes the meaning of a "biologic coordination" between the variables. In the analysis of the correlation matrix of the cephalometric and model measurements we considered only non-topographical correlations that could express significant associations under a biological aspect.

4. RESULTS

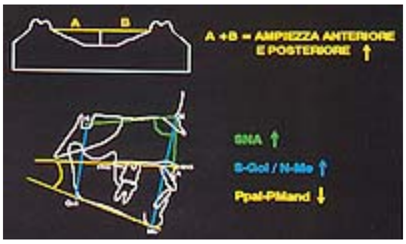
The most significant results, considering not-topographic correlations are:

Anterior widths (anterior A and B.)

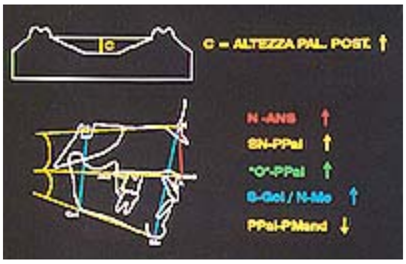
1) The increase of the anterior widths is related with:
- increase of the palatal lenght (ANS-PNS)
- increase of the maxillary protrusion (SNA)
- increase of the posterior lower facial height express by S-Go/N-Me rate
- increase of posterior width (A and B post.) and of posterior area

2)The increase of the anterior widths is related with:
- decrease the divergence between palatal plane and mandibular plane

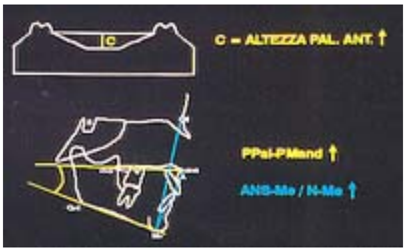
Posterior widths (posterior A and B.)



1) The increase of the posterior widths is related with:
- increase of the palatal length (ANS-PNS)
- increase of the maxillary protrusion (SNA)
- increase of the posterior lower facial height expressed by S-Go/N-Me rate
- increase of posterior width (A and B post.) and of posterior area



2) The increase of the posterior widths is related with:
- decrease in the divergence between palatal plane and mandibular plane



Depth of anterior section (C anterior segment)
The increase of the anterior depth is related with:
- increase of the divergence between palatal plane and mandibular plane
- increase of the anterior lower facial height expressed by ANS-Me/N-Me rate
- increase of ovj value

Depth of posterior section (C posterior segment)
1) The increase of the posterior depth is related with:
- increase of the palatal length (ANS-PNS)
- increase of the linear measurement of anterior upper facial height (N-ANS)
- increase of the posterior lower facial height (S-Go/N-Me rate)
- increase of the alveolar process height ("O"- palatal plane)

2) The increase of the posterior depth is related with:
- decrease in the divergence between palatal plane and mandibular plane

Anterior area
1) The increase of the anterior area is related with:
- increase of the posterior lower facial height (S-Go/N-Me rate)
- increase of the palatal length (ANS-PNS)
- increase of ovj value
- increase of posterior width (posterior A e B.) and of the posterior area

2) The increase of the anterior area is related to:
- decrease of the palatal plane inclination on SN plane (pal. Plane.- SN)

Posterior Area
1) The increase of the posterior area is related with:
- increase of the palatal length (ANS-PNS)
- increase of the posterior lower facial height (S-Go/N-Me rate)
- increase of the alveolar process height ("O"- palatal plane)
- increase of both the anterior and posterior upper facial height (N-ANS e SE-PNSp)

2) The increase of the posterior area is related to:
- decrease in the divergence between palatal plane and mandibular plane

Hard palatal length: linear distance ANS-PNS (cephalometric measurement)
1) The increase of the palatal length is related to:
- increase of maxillary protrusion (SNA)
- increase of depth of anterior section (segment C post.)
- increase of anterior and posterior area
- increase of posterior and lower facial height (S-Go/N-Me)
- increase of ovj and ovb values

2) The increase of the palatal length is related to:
- decrease in the divergence between palatal plane and mandibular plane
- decrease in the divergence between palatal plane and SN plane (pal. plane- p. SN).

5. RESULTS AND DISCUSSION

From the results and the analysis, one can see interesting correlations between palatal roof morphology and cephalometric parameters. These are almost exclusively related to vertical parameters. One unique exception is

that palatal transversal dimensions of the palatal roof, expressed by the length of A and B segments, are highly correlated with maxillary protrusion, also substantiated by a larger palatal length (radiographically measured). The increase in palatal width is correlated with a tendency to hypodivergency expressed by an increase of S-Go/N-Me and by a decrease in the angle of the palatal plane with the mandibular plane. This correlation is valid for both anterior and posterior sections. Conversely, the decrease in transverse palatal dimensions is strictly correlated with increased hyperdivergency between mandibular and palatal plane, and with a reduction of posterior facial height. This tendency is confirmed by the depth, measured on study models.
The depth of the palatal roof ("C" segment) showed different and sometimes opposite correlations in the two transversal sections. In the anterior level a larger depth is positively associated with an increase of facial divergency (ANS-Me/N-Me rate) and by the maxillary and mandibular position.

In the posterior section, the increase of the palatal roof depth is related to an increase in posterior facial height (S-Go/N-Me) and with a lower palatal plane, shown by the increase in the distance between the point "O" and the palatal plane and by a lower ANS point, with respect to N. This data is topographically related with the variation of SN-Palatal plane angle.
The correlation between the "C" posterior segment and the alveolar process height (cephalometric measurement) would seem to be obvious since these are two values from the same anatomical region.

But it allows us to remember the role in determining the vertical balance. (Franchi e Coll. 1993).
The hypodivergency is strictly related to the vertical growth of dental-alveolar posterior zone, the bigger mandibular ramus dimensions and according with S-Go/N-Me rate. Waiting a further research update on a larger statistical group and with a different group distribution for different malocclusions we can now point out the existence of a generic, but strong interdependency between the morphologic palatal roof conditions and the various cranio-facial typologies. This interdependency is more relevant if compared with the weak or absent role of the sagittal facial typologies in determinining the same morphology.

SUMMARY

This study evaluates the relationship between the shape of

the palate and the craniofacial morphology to put both form and dimensions of dental arch into correlation with the various facial typologies. A significant correlation of both palatal width and depth with vertical skeletal features is found. These results entail important clinical implications as far as diagnosis is concerned.

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