Facial flatness indices: application in orthodontics

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Facial flatness indices have been used in anthropology to discern differences among populations. They were evaluated on skulls from around the world. **Aims.** 1- to evaluate the use of facial flatness indices in orthodontics and 2- to assess their variation among malocclusions, age and sex. **Materials and Methods.** 322 cone beam computed tomography radiographs were digitized and three facial indices (frontal, simotic and zygomaxillary) along with three transverse distances (fmo1 – fmo2, zma1- zma2 and n1-n2) were assessed and compared between different groups. **Results.** The zygomaxillary index was increased in Class II (32.6 ± 0.42; p ˂0.001) and decreased in Class III malocclusions (29.4 ± 0.66; p ˂0.001) compared to Class I (31.18 ± 0.3; p ˂0.001). The frontal and nasal flatness are not characteristic features of any of the sagittal malocclusions. Facial flatness indices did not differ between males and females and between growing and non-growing patients. **Conclusion.** The position of subspinale point (A point) forward or backward relative to the zygomaxillary width is a factor of assessment of facial flatness. The zygomaxillary index could be helpful in weighting proportionally the width of the maxilla (expansion) relative to its sagittal position in Class II and Class III malocclusions.

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Abstract

Facial flatness indices have been used in anthropology to discern differences among populations. They were evaluated on skulls from around the world.

Aims. 1- to evaluate the use of facial flatness indices in orthodontics and 2- to assess their variation among malocclusions, age and sex.

Materials and Methods. 322 cone beam computed tomography radiographs were digitized and three facial indices (frontal, simotic and zygomaxillary) along with three transverse distances (fmo1 – fmo2, zma1- zma2 and n1-n2) were assessed and compared between different groups.

Results. The zygomaxillary index was increased in Class II (32.6 ± 0.42; p <0.001) and decreased in Class III malocclusions (29.4 ± 0.66; p <0.001) compared to Class I (31.18 ± 0.3; p <0.001). The frontal and nasal flatness are not characteristic features of any of the sagittal malocclusions. Facial flatness indices did not differ between males and females and between growing and non-growing patients.

Conclusion. The position of subspinale point (A point) forward or backward relative to the zygomaxillary width is a factor of assessment of facial flatness.

The zygomaxillary index could be helpful in weighting proportionally the width of the maxilla (expansion) relative to its sagittal position in Class II and Class III malocclusions.

Introduction

Facial flatness has often been considered in the assessment and evaluation of disparity among populations[1-12].

Various measurements have been used to evaluate frontal and facial flatnesses in different populations to compare modern to ancient human beings [13]. In 1934, Woo and Morant[14] evaluated facial flatness on dry skulls and subsequently, many anthropologists have used their method with minor modifications. In 1973, Yamaguchi[4] proposed three sets of facial flatness measurements: the frontal index, the simotic index (described by Woo and Morant in 1934)[14] and the zygomaxillary index (described by Alekseev and Debets in 1964)[15]. These indices have been mostly used in anthropological studies where all measurements have been performed on dry skulls and fossils in many regions around the world [13, 16-19], and none on three-dimensional radiographs.

In orthodontics, facial flatness is usually assessed clinically through the visualization of the face and has been mostly related to maxillary hypoplasia[20]. With the advent of cephalometrics, the position of the maxilla has served as the only practical measurement for flatness through the relative position of point A (subspinale) to the cranial base (SNA angle)[21-27]. Therefore, the application of facial flatness indices on three-dimensional craniofacial radiographs would help describe and assess the flatness at different level of the face (frontal, nasal, zygomatic) and would allow a new perception of facial flatness in the orthodontic field.

82   The purpose of this study was to evaluate the use of facial flatness indices in orthodontics and
83   assess the association between facial flatness indices and age, sex and sagittal malocclusions,
84   measured through three-dimensional radiographic technology.
85
86   **Materials & Methods**
87
88   Prior to data collection, the study was approved by the Institutional Review Board of the
89   American University of Beirut (IRB ID: BIO-2018- 0065) that waived the need for consent form.
90
91   *Study population*
92
93   The pre-treatment cone beam computerized tomography (CBCT) radiographs of 322 patients
94   (121 females, 201 males; age 16.5 ± 11 years) were selected from the database of initial
95   orthodontic records in a private radiologic center.
96   Excluded were subjects who had previous or current orthodontic treatment, craniofacial
97   anomalies, or low-quality pre-treatment CBCT.
98
99   Females younger than 16 years old and males younger than 18 years were considered as
100   "growing" (n=244), and the remaining as non-growing (n= 78).
101   The sagittal skeletal malocclusion was classified into 3 groups (Table 1):
102   Class I (n= 161): $0 \leq ANB \leq 4$;
103   Class II (n= 136): $ANB > 4$;
104   Class III (n= 25): $ANB < 0$.
105
106   *Radiographic analysis*
107
108   All CBCTs were digitized by one operator (CC) using the View Box 4 imaging software (dHAL
109   Software, Kifissia, Greece).
110
111   Nine points were localized on CBCTs as illustrated in Figure 1:
112   1- Frontomalare orbitale right (fmo1) and left (fmo2): defined as the junction of the fronto-
113   zygomatic suture and the orbit rim[28].
114   2- Nasion (n): defined as the suture between the frontal and nasal bones[22].
115   3- Deepest point on the lateral wall of nasal bone right (n1) and left (n2)[14]
116   4- Nearest point of the median ridge of the nasal bone (n') [14]
117   5- Zygomaxillary anterius right (zma1) and left (zma2): defined as the most inferior point on the
118   zygomaxillary suture[28].
119   6- Subspinale (ss) or point A: defined as the deepest midline point on the premaxilla between the
120   anterior nasal spine and prosthion[22].
121

122 After digitization, three facial indices (frontal, simotic and zygomaxillary) were computed as
123 follows (Fig. 2):
124 • Frontal index of flatness: defined as the percentage of the nasion subtense to the chord between
125 the frontomalaria orbitalia (Fig1, A).
126 • Simotic index: defined as the percentage of the minimum subtense of the median ridge of the
127 nasalia to the simotic chord (minimum horizontal breadth of the nasalia) (Fig1, B).
128 • Zygomaxillary index of flatness: defined as the percentage of subspinale subtense to the chord
129   between the zygomaxillaria anteriora (Fig1, C).
130 The subtenses are obtained by direct measurements of the distance from the summit to the chord.
131 The smaller the value of these indices, the greater the flatness.
132
133 In addition, three transversal measurements were performed to assess the facial width at different
134 levels of the face:
135   1- fmo1 – fmo2: distance between right and left frontomalaria orbitalia, measured to assess
136   the width of the head;
137   2- zma1- zma2: distance between right and left zygomaxillaria anteriora, measured to assess
138   the midfacial width;
139   3- n1-n2: distance representing minimum horizontal breadth of the nasalia, measured to
140   assess the nasal width.
141
142
143 **Statistical analysis**
144
145 All measurements were normally distributed for all the compared groups as assessed by the
146 Shapiro Wilks normality test. A three-way between subjects analysis of variance (ANOVA) was
147 used to assess the presence of interaction between sex (male, female), growth (growing, adult)
148 and malocclusion (Class I, II, III) on the facial flatness indices and to compare the different
149 groups. When no interaction between the independent variables was detected, a main effect of
150 each variable was reported, followed by multiple comparison post-hoc Tuckey tests when
151 comparing the malocclusion groups in case a statistically significant difference was found. The
152 three-way ANOVA was followed by the "simple effects" for the variables that showed a
153 significant interaction between the independent variable.
154 The three transversal measurements were compared using a two-way ANOVA to check the
155 effect of sex and growth together.
156 The Pearson product moment correlation coefficient was performed to correlate the widths of the
157 facial structures at different level of the face.
158 SPSS statistical package was used to perform all tests, at a level of significance of p≤0.05.
159 Inter-rater reliability was calculated on all variables of randomly chosen CBCTs (n=30). Intra-
160 class correlation coefficients ranged between 0.82 and 0.99. The lowest coefficient 0.82 was
161 obtained for the distance n1- n2, possibly because of the geometric definition of these nasal
162 landmarks (n1 and n2) in a 3D record.
163

164 **Results**

165

166 *Reliability of the measurements*

167

168 For all three indices, there was no significant three-way or two-way interaction between any of
169 the variables in their effect on the measurements, thus, the main effects of sex, growth and
170 malocclusion were reported and compared, with the estimated marginal means and their standard
171 errors (Table 2).
172 There was a significant two-way interaction between sex and growth, on the two distances fmo1-
173 fmo2 (F=8.428, p=0.004) and zma1-zma2 (F=4.03, p=0.046), therefore, the simple main effects
174 of each variable, sex and growth, were reported. For the n1-n2 distance, the interaction was not
175 statistically significant, and subsequently, the main effect was reported
176 (Table 3).

177

178 *Sexual dimorphism*

179

180 None of the three indices displayed a statistically significant difference between males and
181 females, regardless of malocclusion and growth (p>0.05, Table 4).

182

183 In both growing and adults subgroups, the fmo1-fmo2 distance was statistically significantly
184 larger in males (93.331 ± 4.582 mm and 100.594 ± 3.501 mm respectively) compared to females
185 (90.762 ± 3.963 mm and 94.433 ± 3.544 mm respectively) (p<0.001; Table 3). The interaction
186 between the growth and sex factors is evident with a smaller average difference in growing
187 individuals (2.569 mm) compared to adults (6.161 mm).
188 The same trend was found for the zma1-zma2 distance, with a significant difference of 1.803 ±
189 0.713 mm between growing males and females (F= 6.401, p=0.012), and a larger difference of
190 5.155 ± 1.51 mm in adults (F= 11.656, p=0.001).
191 The n1-n2 distance displayed no significant differences among sex (F= 0.649; p=0.421; Table 4).
192 In the total sample, the largest difference between males and females (2.475 ± 0.524 mm) was
193 found for fmo1-fmo2 (F= 22.306; p<0.001) and a difference of 1.675±0.673 mm was observed
194 for zma1-zma2 (F= 6.198; p=0.013). Both fmo1-fmo2 and zma1-zma2 distances were
195 significantly larger in males (94.351 ±0.414mm and 83.964 ±0.513 mm respectively) compared
196 to females (91.876 ±0.321 and 82.289 ± 0.412 (p<0.001 for fmo1-fmo2 and p=0.013 for zma1-
197 zma2; Table 4).
198 The ratio of the zygomatic width relative to the frontal width is approximately 0.57% more in
199 males compared to females.

200

201

202

203

204 *Effect of growth*

205

206 There was no statistically significant difference in the three flatness indices when assessing the
207 main effect of growth (p>0.05; Table 5).

208

209 Both fmo1-fmo2 and zma1-zma2 distances were significantly larger in adults compared to
210 growing individuals, in both males and females subgroups (p<0.001; Table 3). The difference in
211 both distances was found to be approximately twice in males (7.263 mm for fmo1-fmo2 and 7.03
212 mm for zma1-zma2) compared to females (3.671 mm for fmo1-fmo2 and 3.678 mm for zma1-
213 zma2 (p<0.001; Table 5).
214 No difference between growing and non-growing individuals was detected for the n1-n2 distance
215 (F=0.374, p=0.541; Table 5).
216 Similarly, in the total sample, fmo1-fmo2 and zma1-zma2 distances were significantly larger in
217 adults (95.776 ±0.498mm and 85.974 ±0.639 mm respectively) compared to growing individuals
218 (81.941 ±0.361 and (p<0.001; Table 5). The difference was approximately the same for the
219 frontal and zygomatic width between growing and adults (3.919±0.572mm for fmo1-fmo2 and
220 4.033 mm for zma1-zma2 (p<0.001; Table 5).
221 The ratio of the zygomatic width relative to the frontal width increases with age approximately
222 0.56% in adults.

223

224

225 *Effect of sagittal malocclusion*

226 When comparing the flatness indices among the three groups of malocclusion (Class I, II and
227 III), there was no statistically significant difference in the frontal (F=0.064, p=0.938) and simotic
228 (F=0.137, p=0.872) indices.
229 Only the zygomaxillary index displayed a significant difference among malocclusions (F=8.958,
230 p<0.001): it was significantly larger in Class II (32.6 ± 0.42 mm) than Class I (31.18 ± 0.3 mm)
231 followed by Class III (29.4 ± 0.66 mm) (Table 6).

232

233

234 *Correlations*

235

236 Moderate positive correlations were detected between transverse dimensions at the level of the
237 head (fmo1-fmo2) and the midface (zma1-zma2) in the total sample (r=0.636, p<0.001), and in the
238 males (r=0.618, p<0.001) and females (r=0.636, p<0.001) subsamples. Low positive correlations
239 were found between n1-n2 and fmo1-fmo2 in the total sample (r=0.246, p<0.001) and in males
240 (r=0.18, p=0.048) and females (r=0.267, p<0.001) separately. No significant correlation was found
241 between n1-n2 and zma1-zma2 (p>0.05) (Table 7).

242

243

Discussion

Facial flatness has been evaluated through series of measurements on human cranium throughout the years. Some features related to facial flatness were the subject of interpopulation phylogenetic variations [14,29]. In 1973, Yamaguchi described three facial indices evaluating flatness at different levels of the face, which have been used only on dry skulls in anthropological studies.

To our knowledge, this is the first study where the flatness measurements are extrapolated and applied on 3D radiographs (CBCTs), to try to induce new interpretations of flatness related to age and sex in orthodontics.

Expectedly, males, in this study, presented wider faces than females as the distances between right and left frotomalareorbitale, zygomaxillary anterius and deepest points on the lateral wall of nasalia were increased in males compared to females.

The transversal growth of the face was the most found at the level of the front, less at the level of the midface and the least at the level of the nose.

The present findings are in agreement with the results of previous studies that found sexual dimorphism in some characteristic phenotypes within the facial structures [30-33], with men tending to have larger facial features than women and even a larger facial- width to- height ratio[34].

Wider faces were also noted in adults compared to growing individuals of our total sample. The computation of the difference in width of the front and the midface for the growing and adults groups separately was found to be approximately the same (4 mm). Additionally, higher correlations were noted in transversal dimensions at the level of the head and the midface but not at the level of the nose. Both distances increase proportionally with age as the ratio of the zygomaxillaryanterius distance over frotomalareorbitale distance remains approximately the same, the difference being only 0.5 %. The same trend was found by Hellman[35] who concluded that the transformation of the infant face into that of the adult occurs by increases in size and some changes in proportions.

On the other hand, facial flatness indices did not differ between males and females and between growing and adults. This might be due to the fact that all individuals of the study sample were ascended from the same ancestry [4, 5,7,9,12,14].

The zygomaxillary index was the only facial flatness index that significantly differed among malocclusion classes: it was significantly decreased in Class III and increased in Class II compared to Class I. As the frontal and simotic index were not different among malocclusions, it could be concluded that the frontal and nasal flatness are not characteristic features of any of the sagittal malocclusions classes.

282   Therefore, assessment of flatness would be limited to the anterior protrusion of subspinale point
283   with the sole difference that it is weighed relative to the breadth of the zygomatic region and not
284   to the cranial base.
285   Class II malocclusion have been evaluated through the literature by the amount of maxillary
286   protrusion (subspinale region) relative to the profile (Nasion)[21-23]. Controversies were found
287   regarding the association between transverse dentoskeletal deficiency of the maxilla and its
288   protrusion in Class II malocclusion. In 2005, Franchi and Baccetti[36] had found this association to
289   be highly present in Class II subjects mainly with mandibular retrusion. On the contrary,
290   Vasquez et al in 2009 had reported no significant transverse deficiency was associated with Class
291   II malocclusion when it is characterized by maxillary skeletal protrusion[37]. Their transversal
292   measurements were expanded to different levels of the face. The outcomes of our study can be
293   helpful to clarify these controversies as the zygomaxillary index was found significantly
294   increased in Class II subjects indicating maxillary protrusion and/or transverse deficient maxilla.
295   Consequently, it will be important to evaluate the zygomaxillary index changes between Class II
296   division 1 and Class II division 2 as the morphologic features are different between the two
297   groups. Specifically, the differential between skeletal projection and dentoalveolar projection in
298   the face might be better understood through the evaluated indices. As orthodontists, we mainly
299   affect the dentoalveolar component. Moreover, it will be valuable to compare this index between
300   Class II malocclusions associated with mandibular retrognathism and those due to maxillary
301   protrusion. In either case, maxillary expansion, if needed, would normalize the zygomaxillary
302   index in Class II subjects and permit to achieve more harmonious and proportional facial
303   features.
304
305   In the Class III group, the zygomaxillary index was significantly decreased reflecting more
306   midfacial flatness. According to our study, this flatness at the midface is not noticeable between
307   growing and adults as no significant difference was perceived regarding this index between both
308   groups. Therefore, the flatness of the midface proportionally to the midfacial width would not be
309   worsened with age regardless of mandibular prognathism.
310   Many systematic reviews and meta-analyses have analyzed the protraction of maxilla using the
311   face mask appliance. They showed a clinically significant improvement in the sagittal
312   relationship between the jaws and forward movement of subspinale point[38-41]. Subsequently, it
313   might be valuable to calculate the zygomaxillary index after maxillary protraction in Class III
314   growing patients to check if any changes in width would have occurred at the level of the
315   zygomaxillary area specially that histological changes of the circumaxillary sutures have been
316   shown in several animal studies[42-45]. In other words, the calculation of the zygomaxillary index
317   before and after maxillary protraction with a face mask would determine if the correction of the
318   Class III malocclusion was achieved by a skeletal or a dental effect and if the midfacial flatness
319   was corrected.
320

321 Despite the substantial size of our sample, further research shall help validate our findings, by
322 increasing the sample size within each group. A longitudinal study would better answer the
323 effect of growth on the measured indices, although it is hard to achieve, given the irradiation risk
324 inherent to CBCTs. Future studies would also help investigate more thoroughly the difference in
325 these indices before and after orthopedic Class III correction.
326 While the zygomaxillary index provides mainly diagnostic instructions, it may indicate treatment
327 limitations. Additional research would hopefully determine such associations following
328 treatment of patients with various indices.
329

330 ## Conclusions

331

332 1- Facial flatness indices evaluation is important in orthodontics to appraise the harmonization
333   within the different proportions of the face.
334 2- The zygomaxillary index is decreased in Class III and increased in Class II malocclusions.
335 3- In Class II malocclusion the calculation of the zygomaxillary index may be helpful in
336   clarifying the controversies regarding the association between transverse maxillary
337   deficiency and maxillary protrusion.
338 4- Facial flatness assessment is evaluated according to the position of subspinale point and its
339   projection forward or backward relative to the zygomaxillary width so proportionally to the
340   width of the midface.
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343 ## References

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Figure 1

Digitized points from a frontal view

fmo1: Right Frontomalare orbitale*; fmo2*: Left Frontomalare orbitale; *n*: Nasion; *n'*: Nearest point of the median ridge of the nasal bone; *n1*: Right deepest point on the lateral wall of nasal bone; *n2*: Left deepest point on the lateral wall of the nasal bone ; *zma1*: Right zygomaxillary anterius; *zma2*: Left zygomaxillary anterius.

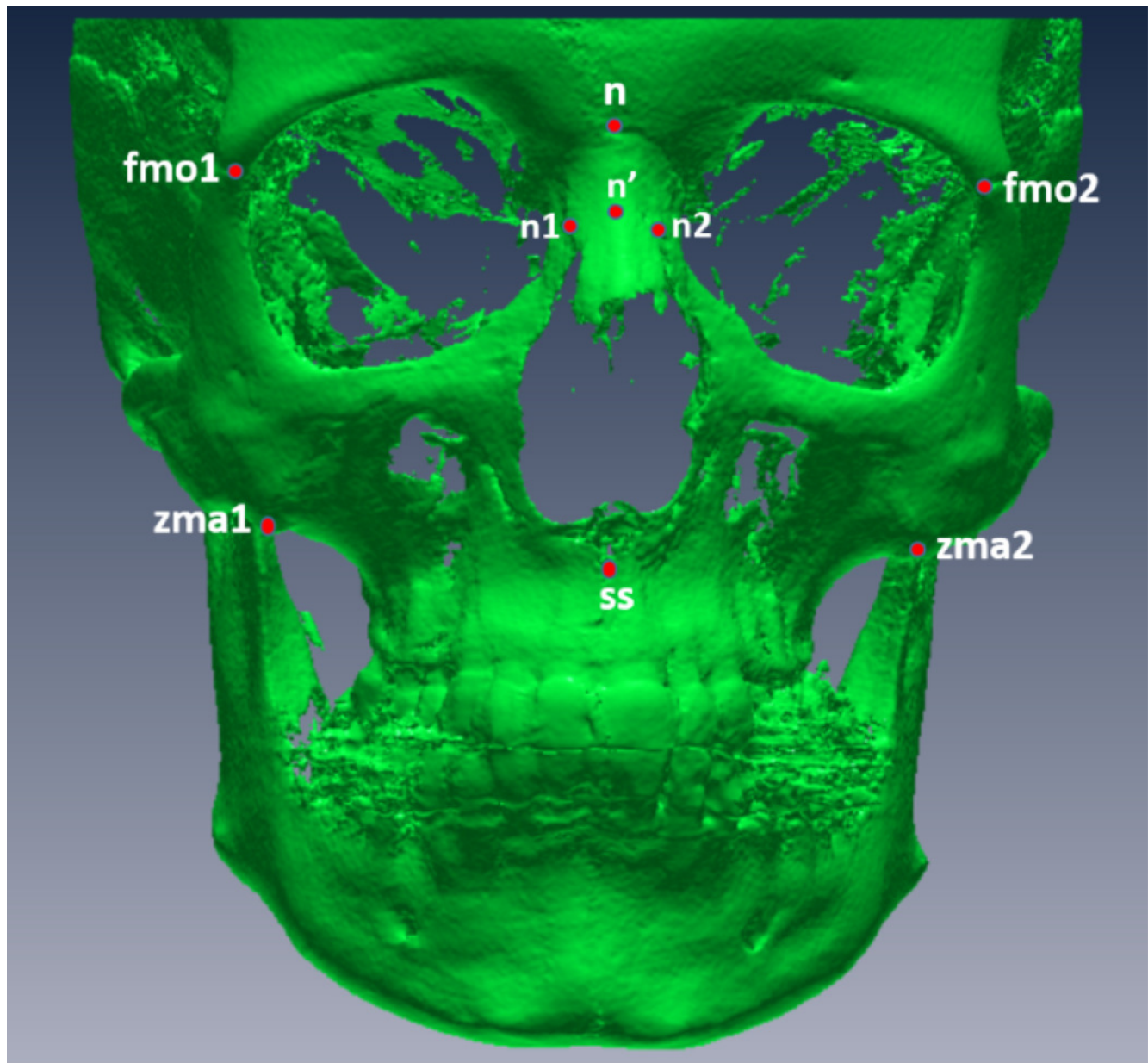
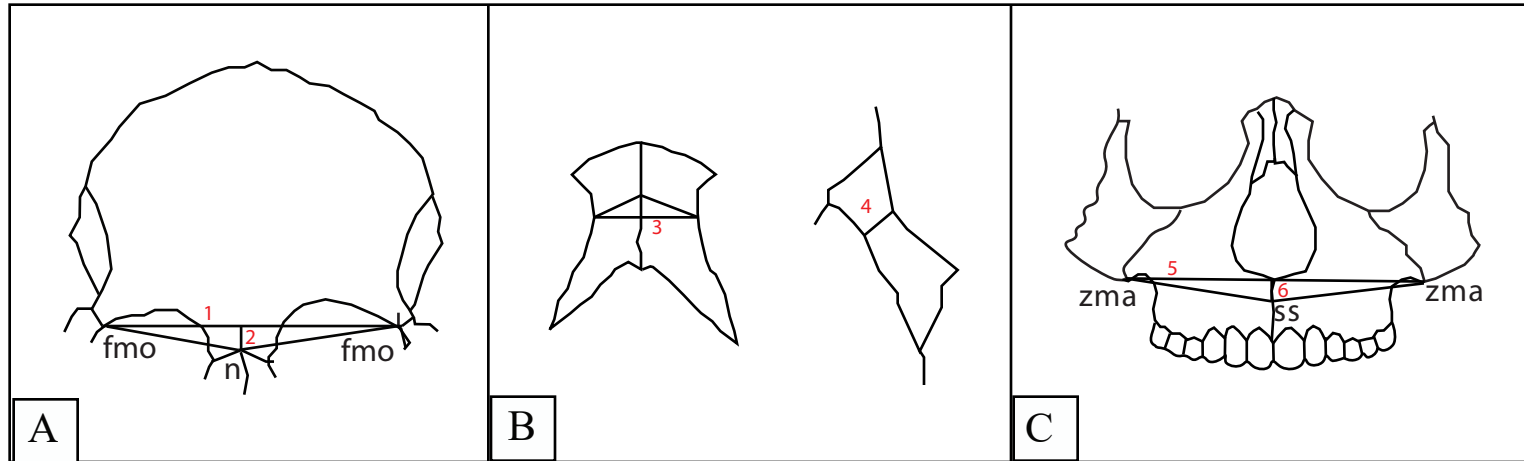



Figure 2

Figure 2: 1. Frontal chord; **2.** Frontal subtense; **3.** Simotic chord; **4.** Simotic subtense; **5.** Zygomaxillary chord; **6.** Zygomaxillary subtense. **A**: Frontal index: *denominator*: the frontal chord between the frontomalaria orbitalia, *numerator*: the subtense of the nasion from the frontal chord. **B**: Simotic index: *denominator*: the simotic chord (the minimum horizontal breadth of the nasal bone, *numerator*: simotic subtense (the minimum distance from the midian ridge of the nasal bone to the simotic chord. **C**: Zygomaxillary index: *denominator:* the zygomaxillary chord between the zygomaxillaria anteriora, *numerator*: zygomaxillary subtense (distance from the subspinale to the zygomaxillary chord).

all tables are illustrated in one DOC file

2
3 **Table 1: Definitions of the acronyms and specific terms**

Acronym	Definition
ANB	Cephalometric angular measurement formed by the line connecting A point (subspinale) to nasion and another joining nasion to B point (supramentale). This angle describes the anteroposterior relationship between the mandible and the maxilla.
Class I	Dental relationship described by Angle[46] in which the mesiobuccal cusp of the upper first molar is aligned with the buccal groove of the mandibular first molar.
Class II	The mesiobuccal cusp of the upper first molar is anterior to the mesiobuccal groove of the lower first molar.
Class III	The mesiobuccal cusp of the maxillary first molar lies posteriorly to the mesiobuccal groove of the mandibular first molar.

Three-way ANOVA for facial indices with sex, growth and sagittal malocclusion as factors

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Table 2: Three-way ANOVA for facial indices with sex, growth and sagittal malocclusion as factors

Variable	df	Frontal index		Simotic index		Zygomaxillary index	
		F	p	F	p	F	p
Sex	1	0.183	0.669	1.255	0.264	0.219	0.64
Growth	1	2.17	0.142	3.462	0.064	2.641	0.105
Malocclusion	2	0.064	0.938	0.137	0.872	8.958	**<0.001**[**]
Sex *Growth	1	0.292	0.589	0.352	0.553	0.065	0.798
Sex *Malocclusion	2	0.422	0.656	0.264	0.768	0.022	0.978
Growth*Malocclusion	2	0.857	0.425	1.188	0.306	1.014	0.364
Sex*Growth*Malocclusion	2	0.538	0.585	0.345	0.709	0.863	0.423

[**]Statistically significant at $p<0.01$.

Two-way ANOVA results for the transverse measurements with growth and sex as factors

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3 **Table 3: Two-way ANOVA results for the transverse measurements with**
4   **growth and sex as factors**

Variable	df	fmo1-fmo2		zma1-zma2		n1-n2	
		F	p	F	p	F	p
Sex	1	49.765	<0.001**	17.367	<0.001**	0.649	0.421
Growth	1	78.065	<0.001**	41.129	<0.001**	0.374	0.541
Sex *Growth	1	8.428	0.004**	4.03	0.046*	0.063	0.801

6 *Statistically significant, $p < 0.05$; **statistically significant. $p<0.01$.
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Difference in facial indices and transverse measurements between males and females

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5   **Table 4: Difference in facial indices and transverse measurements between**
6   **males and females**

	Males (n = 121)		Females (n =201)		Difference (M-F)		Univariate ANOVA	
	EMM	**SE**	**EMM**	**SE**	**Mean**	**SE**	**F**	**p**
Frontal index	18.23	0.41	18.01	0.31	0.22	0.51	0.183	0.669
Simotic index	62.45	1.85	59.85	1.41	-2.6	2.33	1.255	0.264
Zygomaxillary index	31.19	0.45	30.93	0.34	0.26	0.56	0.219	0.64
fmo1-fmo2	**94.351**	**0.414**	**91.876**	**0.321**	**2.475**	**0.524**	**22.306**	**<0.001**[**]
Growing	93.331	4.582	90.762	3.963	2.569	0.528	23.645	<0.001[**]
Non growing	100.594	3.501	94.433	3.544	6.161	0.119	30.311	<0.001[**]
zma1-zma2	**83.964**	**0.513**	**82.289**	**0.412**	**1.675**	**0.673**	**6.198**	**0.013**[*]
Growing	82.976	6.44	81.173	5.073	1.803	0.713	6.401	0.012[*]
Non growing	90.006	3.648	84.851	5.125	5.155	1.51	11.656	0.001[**]
n1-n2	**10.519**	**0.256**	**10.279**	**0.15**	**0.239**	**0.297**	**0.649**	**0.421**

8   EMM: Estimated Marginal Means; SE: Standard Error
9   *Statistically significant, p < 0.05; **Statistically significant. p<0.01.
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Difference in facial indices and transverse measurements between growing vs non-growing patients

2 **Table 5: Difference in facial indices and transverse measurements between growing**
3 **vs non-growing patients**

	Growing (n = 244)		Adults (n = 78)		Difference (G-A)		Univariate ANOVA	
	EMM	SE	EMM	SE	Mean	SE	*F*	*p*
Frontal index	18.49	0.24	17.74	0.45	0.75	0.51	2.17	0.142
Simotic index	58.99	1.11	63.32	2.04	4.33	2.33	3.462	0.064
Zygomaxillary index	31.52	0.27	30.61	0.49	0.91	0.56	2.641	0.105
fmo1-fmo2	**91.857**	**0.282**	**95.776**	**0.498**	**-3.919**	**0.572**	**46.896**	**<0.001****
Males	93.331	4.582	100.594	3.501	-7.263	1.067	46.296	<0.001**
Females	90.762	3.963	94.433	3.544	-3.671	0.626	34.381	<0.001**
zma1-zma2	**81.941**	**0.361**	**85.974**	**0.639**	**-4.033**	**0.734**	**30.201**	**<0.001****
Males	82.976	6.44	90.006	3.648	-7.03	1.44	23.823	<0.001**
Females	81.173	5.073	84.851	5.125	-3.678	0.845	18.962	<0.001**
n1-n2	**10.308**	**0.127**	**10.490**	**0.269**	**-0.182**	**0.297**	**0.374**	**0.541**

5 *Statistically significant, p < 0.05; **Statistically significant. p<0.01.
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Difference in facial indices between sagittal malocclusions (Class I, Class II and Class III)

Table 6: Difference in facial indices between sagittal malocclusions (Class I, Class II and Class III)

	Class I (*n*= 161)		Class II (*n*= 136)		Class III (*n*= 25)		Univariate ANOVA	
	EMM	SE	EMM	SE	Mean	SE	*F*	*p*
Frontal index	18.02	0.28	18.17	0.38	18.17	0.6	0.064	0.938
Simotic index	61.32	1.26	60.35	1.74	61.78	2.75	0.137	0.872
Zygomaxillary index	31.18[a]	0.3	32.6[b]	0.42[c]	29.4	0.66	8.958	**<0.001**[**]

*Statistically significant, p < 0.05; **Statistically significant. p<0.01; Alphabetic subscripts denote significantly different column means at p < 0.05 (Bonferroni correction).

Correlations between the different transversal distances of the face in the total sample and in the males and females subgroups

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5 **Table 7: Correlations between the different transversal distances of the face in the**
6   **total sample and in the males and females subgroups**

	zma1–zma2		n1–n2	
	r	p	r	p
TOTAL				
fmo1–fmo2	0.636	<0.001**	0.246	<0.001**
zma1–zma2	--	--	0.077	0.168
MALES				
fmo1–fmo2	0.618	<0.001**	0.18	0.048*
zma1–zma2	--	--	0.011	0.907
FEMALES				
fmo1–fmo2	0.636	<0.001**	0.267	<0.001**
zma1–zma2	--	--	0.106	0.134

7 *Statistically significant, $p < 0.05$; **Statistically significant. $p<0.0 1$
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