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Craniofacial Morphometric Measurements of Children with Celiac Disease

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Abstract

Objectives: To examine the craniofacial morphologic features of children with celiac disease and to investigate the presence of specific features in this disease.
Methods: Totally 100 celiac patients between the ages of 3 and 17 years who were diagnosed with celiac disease by biopsy and 100 healthy age- and sex-matched children were included in the study. Photographs of the children were taken using a SLR digital camera by one and the same person at a natural head position. The parameters specified on the photograph were measured with ImageJ 1.50b software. Twenty eight landmarks were identified on the photos. Using these landmarks, 41 distances and 5 angles were measured. Thirty eight anthropometric ratios were calculated.
Results: Twenty seven distances, 1 angle and 9 ratios were determined shorter; 3 distances, 2 angles and 7 ratios were determined larger in patients with celiac disease compared with the healthy individuals. These differences were statistically significant.
Conclusions: There were significant alterations in some craniofacial morphometric parameters in children with celiac disease when compared with healthy controls. However, since the data is limited, a clear conclusion could not be achieved about a morphological feature directly associated with celiac disease in children. Further prospective studies with longer follow-up periods are warranted to determine the effects of celiac disease on craniofacial morphological measurements.

Keywords: Celiac Disease, Craniofacial Morphometry, Facial Analysis

1. Background

Celiac disease is a genetic, autoimmune disease caused by the oral intake of gluten, a protein found in wheat, barley and rye. The disease can manifest itself in quite different clinical manifestations at any stage of life. Growth and development retardation is one of the major complications of childhood celiac disease. If the disease presents with typical features of malabsorption and positive celiac serology, the suspicion and diagnosis is not difficult; but in the absence of gastrointestinal or classical symptoms the diagnosis may be tricky. For that reason defining some other clinical characteristics of celiac disease may be helpful at least to suspect the disease and may facilitate the diagnosis (1-9).

Since craniofacial anthropometry and morphometric measurements are affected by genetic, embryogenic and environmental factors, these measurements are used in determination of variations and medical problems associated with the development (7, 10-17). Although growth retardation is a well-known, common finding in children with celiac disease, the extent to which craniofacial development is affected is not known clearly (16). In literature there are only few publications about the craniofacial morphometric features of children with celiac disease, and the parameters investigated in these publications are also limited (7, 16, 18).

2. Objectives

The aim of this study was to examine the craniofacial morphologic features of children with celiac disease and to investigate the presence of specific features in this disease.

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3. Methods

Totally 100 celiac patients between the ages of 3 and 17 years who were diagnosed with celiac disease and followed up at the outpatient clinic for at least 6 months and 100 age- and sex-matched healthy children were included in the study. Medical and family histories, physical examination findings and laboratory results of patients were extracted from the patient records. Healthy controls were selected from children without any gastrointestinal system disease or malnutrition who were admitted to the outpatient clinic due to acute illnesses. The study was approved by the Gaziantep University Medical Faculty Ethics Committee (date: 2016, number: 55). Informed consent was obtained from the parents of the children.

Photographs of the children were taken using a SLR digital camera (Nikon 300D, 24.85 mm) by one and the same person. Individuals involved in the study were photographed from the front and side faces at a distance of 150 cm. These photographs were taken at a natural head position with a standardized and reproducible orientation when looking at a distant point at eye level. The photographs were drawn together with the ruler to ensure the calibration. The photographs of the patient and control groups were mixed and the researcher had to perform a single blind study. The parameters specified on the photographs were measured with ImageJ 1.50b software. Twenty eight landmarks were identified on the photos (Figure 1 and Table 1). Using these landmarks, 41 distances were measured, 35 were from the front (Figure 2) and 6 were from the side photos (Figure 3A and Table 2), and 5 angles (Figure 3B and Table 3) were measured from the side photographs. Thirty eight anthropometric ratios were calculated (Table 4). In literature, face height has been studied in two different ways, as physiognomic and morphologic (Table 2). For this reason, in this study both physiognomic and morphologic face heights were evaluated.

3.1. Statistical Analyses

The normality of distribution of continuous variables was tested by Shaphiro Wilk test. To compare the two independent groups, Student's *t*-test (for continuous variables) or chi-squared test (for categorical variables) were used. To adjust the effects of age and gender on measurements, general linear models were built for each outcome. All analyses were performed by SPSS for Windows version 22.0. A two sided P value < 0.05 was defined as statistically significant.

4. Results

A total of 100 patients with celiac disease (47 female and 53 male) with a mean age of 9.29 $\pm$ 3.73 years and 100 healthy control cases (45 female and 55 male) with a mean age of 10.43 $\pm$ 3.09 years were included in the study. The mean age of the groups were significantly different (P = 0.020), but gender distribution was similar (P = 0.777).

The distances and angles measured in study participants are summarized in Table 5 while some anthropometric ratios calculated using these parameters are shown in Table 4.

Physiognomic face height (t-gn), middle face height of physiognomic face height (gl-sn), lower face height of physiognomic face height (sn-gn), morphologic face height (n-gn), upper face height of morphologic face height (n-st), upper lip height (sn-st), upper vermilion height (ls-st), lower face height of morphologic face height (st-gn), lower lip height (st-sl), cutaneous lower lip height (li-sl), chin height (sl-gn), minimum frontal breadth (ft-ft), binocular width (ex-ex), right eye fissure width (ex-en), left eye fissure width (ex-en), interocular distance (intercanthal width) (en-en), distance from the lower point of circumference of pupils (p-p), maximum facial breadth (z-z), bitragal width (tr-tr), nose width (al-al), right nostril floor width (sa-sn), left nostril floor width (sa-sn), mouth width (labial fissure width) (ch-ch), lower face width (mandible width) (go-go), the distance between the subnasal and pronasal (sn-prn), ear length (spa-sba), ear width (pra-pa) and nasomental angle (nma) were determined to be statistically significantly shorter in patients with celiac disease compared with the healthy individuals (Table 5).

Nasal root width (mf-mf), the distance between the tragion and nasion (tr-n), middle face depth (maxillary depth) (tr-sn), nasofrontal angle (nfra) and nasofacial angle (nfca) were determined to be statistically significantly larger in patients with celiac disease compared with the healthy individuals (Table 5).

Among the ratios investigated, t-gl/t-gn, n-sn/t-gn, li-st/st-sl, fz-fz/z-z, z-z/t-gn, tr-sn/tr-gn, and tr-n/tr-gn were statistically significantly larger, while sn-gn/t-gn, ft-ft/z-z, al-al/z-z, ch-ch/z-z, ch-ch/en-en, ch-ch/ex-ex, right sa-sn/al-al, left sa-sn/al-al, and al-al/n-sn were statistically significantly shorter in patients with celiac disease compared with the healthy individuals (Table 4).

5. Discussion

In this study, we compared the craniofacial measurements of celiac disease patients with the control cases and found significant alterations in children with celiac disease.

Development of craniofacial structures and morphometric measurements and ratios is a complex process affected by many factors (6-8, 10-15). Due to malabsorption most prominently in proximal small intestine, celiac disease is characterized by vitamin and mineral deficiencies including calcium, copper, foliate, and zinc deficiencies (11). The data on the effects of these vitamin deficiencies in

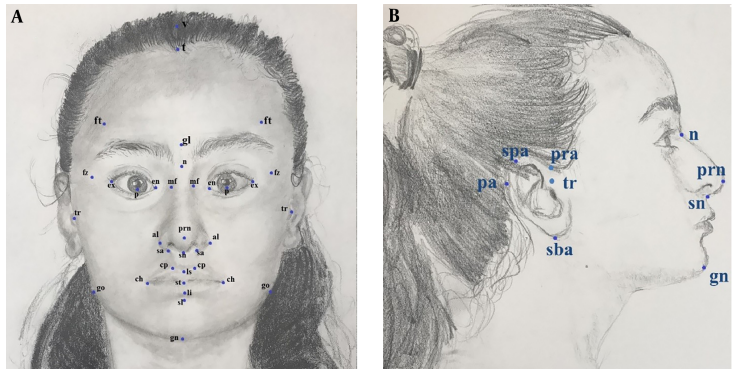

Figure 1. Reference landmarks of the face from the front (A) and from the side (B) photos

Table 1. Definition and Abbreviation of Anthropometric Landmarks Used in This Study

Anthropometric Landmark	Definition
Alar, al	The most lateral point of nasal ala
Chelion, ch	The point at which outer ends of the upper and lower lip meet, The outer corner of the mouth where the outer edges of the upper and lower vermilions meet
Crista philtre, cp	The point on the crest of the philtrum, the vertical groove in the median portion of the upper lip, just above the vermilion border
Endocanthion, en	The point at which the inner ends of the upper and the lower eyelid meet
Exocantion, ex	The point at which the outer ends of the upper and the lower eyelid meet
Frontotemporale, ft	The most medial point on the temporal crest of the frontal bone
Frontozygomatic, fz	The most lateral point on the frontozygomatic suture
Glabella, gl	Most forward-projecting point of the forehead in the midline of the supraorbital ridges
Gnathion, gn	In the midline, the lowest point on the lower border of the chin
Gonion, go	The most lateral point at the angle of the mandible
Labiale inferior, li	The midpoint of the vermilion border of the lower lip
Labiale, ls	The midpoint of the vermilion border of the upper lip
Maxillofrontale, mf	The anterior lacrimal crest of the maxilla at the frontomaxillary suture
Nasion, n	The midpoint of the nasofrontal suture
Postaurel, pa	The most posterior point of the ear
Preaurel, pra	The most anterior point of the ear
Pronasale, prn	The most prominent anterior point on the nasal tip
Pupil, p	Lower point of circumference of pupil
Stomion, st	The midpoint of the labial fissure when the lips are closed naturally
Subalar, sa	Labial insertion points of the alar base
Subaurel, sba	The most inferior point of the ear
Sublabial, sl	The midpoint of the labiomental sulcus
Subnasale, sn	The midpoint at the base of the columella
Superaurel, spa	The most superior point of the ear
Tragion, tr	Located just above the tragus of the ear
Trichion, t	The midpoint of the hairline
Vertex, v	The highest point of the cranium
Zygion, z	The most lateral point on the zygomatic arch

craniofacial morphologic features is limited. Arakeri et al. (2) suggested the potential influence of maternal and paternal celiac disease on the etiology of non-syndromic cleft lip and palate as an unfavorable pregnancy outcome which may be associated with folic acid malabsorption.

Standardization with the Frankfort horizontal plane is achieved in many studies with craniofacial anthropometric measurements (3, 4, 17). In profile view, Frankfort horizontal plane is the line connecting the highest point of the opening of the external auditory canal and the lowest

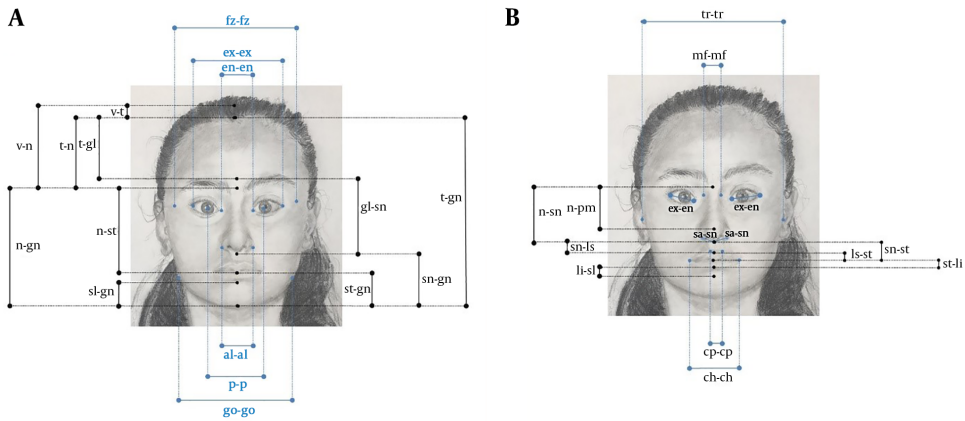

Figure 2. A and B, Anthropometric measurements of the face from the front.

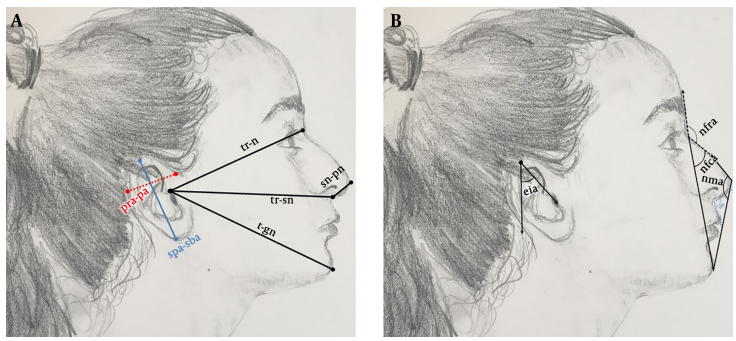

Figure 3. A, Anthropometric measurements; B, angles of the face from the side photo.

point on the infraorbital margin (10). Frankfort horizontal plane is utilized to orient the head. This plane is "unnatural" and difficult to obtain clinically, because it is based on internal skeletal landmarks. Natural head position is of paramount importance in facial analysis due to its reproducibility and, most importantly, because it is extremely simple to obtain (5, 13). Natural head position is the standardized and reproducible position of the head when looking at a distant point at eye level. The simplest way to obtain natural head position is having the patient to look at a point on the eye's level in the front wall (12, 13).

Both the Student *t*-test and the adjusted P values were determined by establishing a model to remove the effect of age and sex on the parameters evaluated between celiac disease and healthy cases (Tables 4 and 5). Thus, the results that could be incorrect in the parameters which are statistically significant in Student t-test and are meaningless in adjusted P test (v-n, fz-fz, cp-cp, tr-gn, al-al/ch-ch) and the parameters which are statistically meaningless in student *t*-test but significant in adjusted P test (tr-n, tr-sn) have been eliminated.

In many diseases, facial appearance is very important in diagnosis such as Cushing syndrome, Addison disease, myasthenia gravis or Horner syndrome. However, there is no generally accepted information about the facial appearance of the celiac disease at the diagnosis or later stages. The number of studies evaluating craniofacial morphometric measurements of cases with celiac disease in childhood is limited in the literature (7, 16, 18). Comparison of celiac disease patients with healthy controls regarding the distances and angles measured for determination of craniofacial morphometric parameters in the literature are shown in Tables 6 and 7. Zanchi et al. (18) stated that although changes in facial ratios attributable to celiac disease are irreversible, the condition can be avoided by early diagnosis of celiac disease. For this reason, it is very important to determine the craniofacial morphological features of celiac disease and to utilize these properties. Selimoglu et al. (16) reported that the presence of anemia is one of the factors that may be associated with face growth, and that forehead height to total height of the face ratio (t-gl/t-gn) is lower in anemic children than in others.

Table 2. Anthropometric Measurements Used in This Study

Measurements	
Head height (between the highest point of the cranium and nasion)	v-n
Between the tragion and nasion	t-n
Calva height	v-t
Physiognomic face height	t-gn
A) Upper face height/forehead height	t-gl
B) Middle face height	gl-sn
C) Lower face height	sn-gn
Morphologic face height	n-gn
A) Upper face height	n-st
1. Nose height	n-sn
2. Upper lip height	sn-st
a. Philtrum length	sn-ls
b. Upper vermilion height	ls-st
B) Lower face height	st-gn
1. Lower lip height	st-sl
a. Cutaneous lower lip height	li-sl
b. Lower vermilion height	li-st
2. Chin height	sl-gn
Nasal bridge length	n-prn
Minimum frontal breadth	ft-ft
Supraorbital breadth	fz-fz
Nasal root width	mf-mf
Biocular width	ex-ex
Eye fissure width	ex-en
Interocular distance (intercanthal width)	en-en
Distance from the lower point of circumference of pupils	p-p
Maximum facial breadth	z-z
Bitragal width	tr-tr
Nose width	al-al
Nostril floor width	sa-sn
Philtrum width	cp-cp
Mouth width (labial fissure width)	ch-ch
Lower face width (mandible width)	go-go
Between the subnasale and pronasale	sn-prn
Between the tragion and nasion	tr-n
Middle face depth (maxillary depth)	tr-sn
Lower face depth (mandibular depth)	tr-gn
Ear length	spa-sba
Ear width	pra-pa

Table 3. Definition of Anthropometric Angles Used in This Study

Angle	Definition
Nasofrontal angle, nfra	The glabella through the nasion that intersect a line drawn tangent to nasal dorsum
Nasofacial angle, nfca	Formed by drawing a vertical line tangent to the forehead at the glabella and tangent to the chin at pogonion (the most anterior point on the contour of the chin located midway between pogonion and menton) so that a line drawn along the nasal dorsum intersects it
Nasomental angle, nma	Formed by a line drawn through the nasal dorsum intersecting a line drawn from the nasal tip to soft tissue chin (pogonion)
Nasolabial angle, nla	Corresponds to the angle, whose vertex is the subnasale, lying in a tangent line to the nasal tip and another tangent line to the upper lip
Ear incline angle, eia	The angle between vertical axis and the subaurel-superaurel line

There are differences in the definition of forehead height in the literature. In some studies forehead height

Table 4. Anthropometric Proportions of Children with Celiac Disease and Control Group (n = 100)[a]

Parameter	Celiac Disease	Control Group	P[b]	Adjusted P[c]
t-gl/t-gn	0.29 ± 0.04	0.28 ± 0.03	0.001[d]	0.001[d]
gl-sn/t-gn	0.37 ± 0.03	0.37 ± 0.02	0.581	0.375
sn-gn/t-gn	0.33 ± 0.04	0.35 ± 0.03	0.001[d]	0.001[d]
n-sn/t-gn	0.31 ± 0.03	0.30 ± 0.02	0.001[d]	0.001[d]
v-t/t-gn	0.11 ± 0.03	0.11 ± 0.03	0.832	0.993
sn-st/t-gn	0.12 ± 0.02	0.12 ± 0.01	0.809	0.415
st-sl/t-gn	0.09 ± 0.01	0.10 ± 0.01	0.071	0.331
ls-st/sn-st	0.25 ± 0.07	0.27 ± 0.06	0.101	0.221
li-st/st-sl	0.50 ± 0.13	0.45 ± 0.10	0.020[d]	0.020[d]
en-en/z-z	0.27 ± 0.02	0.27 ± 0.02	0.226	0.343
en-en/ex-ex	0.38 ± 0.02	0.38 ± 0.02	0.388	0.434
ft-ft/z-z	0.80 ± 0.05	0.82 ± 0.05	0.001[d]	0.001[d]
fz-fz/z-z	0.88 ± 0.03	0.86 ± 0.04	0.001[d]	0.001[d]
go-go/z-z	0.77 ± 0.04	0.77 ± 0.04	0.540	0.261
ex-en (R)/z-z	0.23 ± 0.02	0.22 ± 0.01	0.371	0.246
ex-en (L)/z-z	0.23 ± 0.01	0.22 ± 0.01	0.749	0.741
al-al/z-z	0.26 ± 0.02	0.27 ± 0.02	0.003[d]	0.026[d]
ch-ch/z-z	0.36 ± 0.03	0.38 ± 0.03	0.001[d]	0.001[d]
en-en/al-al	1.03 ± 0.09	1.01 ± 0.10	0.108	0.292
en-en/ex-en (R)	1.20 ± 0.11	1.22 ± 0.12	0.122	0.125
en-en/ex-en (L)	1.20 ± 0.11	1.22 ± 0.12	0.427	0.577
al-al/ch-ch	0.74 ± 0.08	0.72 ± 0.06	0.037[d]	0.054
ch-ch/en-en	1.33 ± 0.15	1.40 ± 0.15	0.002[d]	0.009[d]
ch-ch/ex-ex	0.50 ± 0.04	0.53 ± 0.04	0.001[d]	0.001[d]
sa-sn (R)/al-al	0.47 ± 0.05	0.50 ± 0.04	0.001[d]	0.001[d]
sa-sn (L)/al-al	0.46 ± 0.05	0.50 ± 0.04	0.001[d]	0.001[d]
cp-cp/al-al	0.30 ± 0.05	0.30 ± 0.05	0.348	0.355
cp-cp/z-z	0.08 ± 0.01	0.08 ± 0.01	0.570	0.900
cp-cp/go-go	0.10 ± 0.02	0.11 ± 0.02	0.524	0.713
t-n/p-p	1.03 ± 0.15	1.00 ± 0.14	0.231	0.353
al-al/n-sn	0.60 ± 0.07	0.64 ± 0.07	0.001[d]	0.001[d]
t-n/n-sn	1.14 ± 0.18	1.13 ± 0.15	0.758	0.845
z-z/t-gn	0.72 ± 0.04	0.70 ± 0.05	0.014[d]	0.041[d]
n-gn/z-z	0.33 ± 0.03	0.33 ± 0.03	0.864	0.864
tr-n/tr-sn	1.06 ± 0.04	1.06 ± 0.05	0.742	0.206
tr-sn/tr-gn	0.95 ± 0.05	0.90 ± 0.05	0.001[d]	0.001[d]
tr-n/tr-gn	1.02 ± 0.08	0.96 ± 0.07	0.001[d]	0.001[d]
spa-sba/t-gn	0.33 ± 0.03	0.33 ± 0.03	0.864	0.787

Abbreviations: L, left; R, right.
[a] Values are expressed as mean ± SD.
[b] Student *t*-test.
[c] Adjusted P values for age and gender
[d] Significant at 0.05 level.

is defined as t-n/n-sn while it is defined as t-gl/t-gn in some others (7, 16, 18). In order to compare the measurements with different forehead height definitions, in present study forehead height measurements were made according to both definitions. Finizio et al. (7) reported that adult celiac disease patients had larger forehead height than the normal population and this is the first craniofacial morphological alteration that occurs in celiac disease (t-n/n-

sn). For this reason, it has been suggested that scanning the forehead width through the finger. Along with other findings of celiac disease, presence of wide forehead has been suggested as a sign for diagnosis. Zanchi et al. (18) reported that the t-n/n-sn parameter in childhood celiac disease was not different from the normal population (P = 0.92). In adults, celiac patients have been reported to have a tendency for wide foreheads, but this is not regarded as a strong clinical sign for celiac disease (P = 0.083 for t-n/n-sn). Selimoglu et al. (16) reported that there was no wide forehead height in childhood celiac disease. However, unlike other studies, Selimoglu et al. (16) considered the forehead height as t-gl/t-gn. In the study of Finizio et al. (7), in which the forehead height is assessed by the t-n/n-sn parameter, a significant difference between celiac patients and healthy subjects was shown, while there was no significant difference in the study of Zanchi et al. (18) and in the present study. Selimoglu et al. (16), who defined forehead height as t-gl/t-gn reported that there was no significant difference between celiac patients and healthy individuals, while there was a significant difference in our study in this ratio. Regarding the data in previous literature and the results of this study, it is thought that large forehead height cannot be regarded as a symptom in celiac disease. Although there was no statistically significant difference in n-sn value in present study and the study of Zanchi et al. (18), Selimoglu et al. (16) reported statistically significantly larger n-sn values in celiac disease patients. While there was a significant difference regarding the sn-gn and t-gn values in the present study in favor of control group, Selimoglu et al. (16) reported a statistically significant difference in favor of the celiac group but Zanchi et al. (18) did not determine any significant differences between the two groups. In the present study, there was no statistically significant difference in the parameters of t-gl, n-prn, v-t and spa-sba of the two groups. Selimoglu et al. (16) reported a significant difference in favor of celiac disease patients regarding these parameters. In the present study, significant differences were found in the parameters of gl-sn, ch-ch, z-z, al-al, en-en, ex-ex and ex-en in favor of control group. Selimoglu et al. (16) found significant differences in these parameters in favor of celiac group. In the present study, there was a significant difference in nfra measurement in favor of celiac patients, while Selimoglu et al. (16) found no significant difference. There was no significant difference between the two groups regarding nla measurements in the present study and the study of Selimoglu et al. (16) (Table 6).

In the present study, there was no statistically significant difference between the two groups regarding the rate of gl-sn/t-gn while Selimoglu et al. (16) showed a significant difference in favor of control group. In the present study, there was a significant difference regarding the sn-gn/t-gn ratio in favor of control group; Selimoglu et al. (16) found a significant difference in favor of celiac disease group, but Zanchi et al. (18) did not show any significant difference between two groups. In the present study, there was a significant difference regarding the n-sn/t-gn ratio in favor of celiac group; Selimoglu et al. (16) and Zanchi et al. (18) did not show any significant difference between two groups. In the present study, there was no difference between two groups in the ratios of spa-sba/t-gn and v-t/t-gn, while Selimoglu et al. (16) reported a significant difference in favor of celiac patients group. In the present study and in the study of Selimoglu et al. (16) there was a significant difference regarding z-z/t-gn ratio in favor of celiac group while there was significant differences regarding al-al/z-z and ch-ch/z-z ratios in favor of control group. Although there was no statistically significant difference determined in the present study regarding en-en/z-z and ex-en/z-z ratios between two groups, Selimoglu et al. (16) reported a significant difference in favor of control group. In the present study and in the study of Selimoglu et al. (16) there was no significant difference regarding t-n/n-sn ratio between two groups (Table 7).

There are some limitations of this study that should be mentioned. First is the condition of gluten free diet (GFD) in those patients. All of our patients were under GFD for at least 6 months; but we don't know the adherence of our patients to the GFD. As we don't clearly know the effects of celiac disease on craniofacial morphological features, we also do not know the effects of GFD on these features. For that reason, prospective studies are warranted investigating the effects of GFD on those features with long follow-up periods. Another limitation of the study is that the measurements were based on two dimensional photographs. However, in recent years, three dimensional imaging modalities have been defined which may provide more data on craniofacial morphological features of participants (14). Although all measurements were performed by one and the same person, possibility of incorrect measurement depending on the measuring person should also be considered as another limitation.

5.1. Conclusions

We analyzed the craniofacial morphometric measurements of children with celiac disease and determined significant alterations in those parameters when compared with healthy controls. However, although there are only a few studies in literature evaluating these parameters in celiac patients, the data reported in those studies are not consistent with each other. For that reason, we cannot conclude whether a morphological feature is directly associated with celiac disease in children. Further prospective studies with longer follow-up periods are warranted to determine the effects of celiac disease on craniofacial morphological measurements.

Table 5. Anthropometric Measurements of Children with Celiac Disease and Control Group (n = 100)[a, b]

Parameter	Celiac Disease	Control Group	P[c]	Adjusted P[d]
v-n	77.57 ± 8.49	79.90 ± 7.65	0.001[e]	0.128
v-t	18.38 ± 4.09	19.33 ± 4.38	0.115	0.178
t-gl	48.33 ± 7.23	48.43 ± 7.39	0.922	0.734
t-n	58.02 ± 8.14	59.06 ± 8.24	0.370	0.578
n-st	70.11 ± 6.82	73.61 ± 4.98	0.001[e]	0.001[e]
gl-sn	60.82 ± 7.13	64.37 ± 5.25	0.001[e]	0.001[e]
sn-gn	54.62 ± 6.63	61.60 ± 5.79	0.001[e]	0.001[e]
st-gn	35.25 ± 5.02	40.78 ± 4.73	0.001[e]	0.001[e]
t-gn	164.20 ± 13.39	175.00 ± 13.06	0.001[e]	0.001[e]
n-gn	106.52 ± 10.52	114.99 ± 8.31	0.001[e]	0.001[e]
sl-gn	20.45 ± 3.77	23.60 ± 3.04	0.001[e]	0.001[e]
ft-ft	93.63 ± 6.56	100.74 ± 6.18	0.001[e]	0.001[e]
z-z	117.75 ± 6.59	122.71 ± 6.66	0.001[e]	0.001[e]
p-p	56.73 ± 4.39	59.00 ± 3.66	0.001[e]	0.003[e]
en-en	31.74 ± 2.89	33.50 ± 3.01	0.001[e]	0.001[e]
ex-en (R)	26.58 ± 2.11	27.46 ± 1.66	0.001[e]	0.032[e]
ex-en (L)	26.47 ± 2.04	27.66 ± 1.92	0.001[e]	0.001[e]
ex-ex	84.60 ± 5.65	88.68 ± 5.11	0.001[e]	0.001[e]
fz-fz	103.20 ± 6.23	105.54 ± 5.72	0.006[e]	0.125
go-go	90.60 ± 7.46	93.99 ± 7.76	0.002[e]	0.034[e]
n-sn	51.44 ± 6.15	52.23 ± 4.40	0.297	0.827
n-prn	42.91 ± 5.89	42.38 ± 4.52	0.473	0.054
al-al	30.81 ± 3.00	33.22 ± 3.05	0.001[e]	0.001[e]
mf-mf	21.11 ± 2.17	18.31 ± 2.18	0.001[e]	0.001[e]
sa-sn (R)	14.55 ± 2.13	16.73 ± 2.06	0.001[e]	0.001[e]
sa-sn (L)	14.21 ± 2.21	16.56 ± 2.00	0.001[e]	0.001[e]
sn-ls	15.42 ± 2.29	15.70 ± 2.17	0.366	0.519
cp-cp	9.42 ± 1.56	9.95 ± 1.81	0.028[e]	0.158
ls-st	4.90 ± 1.61	5.52 ± 1.32	0.003[e]	0.016[e]
li-st	7.52 ± 2.12	7.63 ± 2.01	0.688	0.639
sn-st	19.25 ± 2.40	20.62 ± 2.52	0.001[e]	0.001[e]
st-sl	15.43 ± 2.31	16.98 ± 2.46	0.001[e]	0.001[e]
li-sl	7.38 ± 2.06	8.56 ± 2.21	0.001[e]	0.002[e]
ch-ch	42.02 ± 4.43	46.59 ± 4.94	0.001[e]	0.001[e]
tr-tr	126.64 ± 7.43	134.19 ± 7.06	0.001[e]	0.001[e]
sn-prn	15.86 ± 2.49	17.56 ± 2.28	0.001[e]	0.001[e]
tr-n	99.81 ± 7.70	98.93 ± 7.58	0.428	0.020[e]
tr-sn	93.80 ± 8.70	92.83 ± 8.88	0.449	0.009[e]
tr-gn	98.87 ± 11.24	103.20 ± 9.73	0.005[e]	0.122
spa-sba	54.28 ± 4.89	57.57 ± 4.32	0.001[e]	0.001[e]
pra-pa	36.19 ± 3.32	38.41 ± 3.39	0.001[e]	0.001[e]
nfra	142.16 ± 7.30	138.77 ± 7.73	0.002[e]	0.001[e]
nfca	37.44 ± 3.75	35.60 ± 3.29	0.001[e]	0.002[e]
nma	125.91 ± 4.15	127.37 ± 4.33	0.017[e]	0.030[e]
nla	111.99 ± 10.02	113.19 ± 9.82	0.401	0.236
eia	27.31 ± 5.73	26.59 ± 4.43	0.348	0.306

Abbreviations: L, left; R, right.
[a] Values are expressed as mean ± SD.
[b] The first 41 parameters are given as millimeter, mm; the last 5 parameters are given as angle, °.
[c] Student *t*-test.
[d] Adjusted P values for age and gender.
[e] Significant at 0.05 level.

Table 6. Some Anthropometric Measurements of Children with Celiac Disease and control Group Comparison with the Literature

	Children with Celiac Disease, mm	Healthy Children, mm	P Value
n-sn			
Selimoglu et al. (16)	45.7 ± 9.0	37.5 ± 7.5	< 0.0001[a]
Zanchi et al. (18)	47.30 ± 18.0	53.0 ± 20.0	0.130
Present study	51.44 ± 6.15	52.23 ± 4.40	0.827
sn-gn			
Selimoglu et al. (16)	49.0 ± 8.8	38.5 ± 9.3	< 0.0001[a]
Zanchi et al. (18)	59.0 ± 21.2	67.2 ± 27.0	0.068
Present study	54.62 ± 6.63	61.60 ± 5.79	0.001[a]
t-gn			
Selimoglu et al. (16)	154.6 ± 27.2	125.7 ± 23.3	< 0.0001[a]
Zanchi et al. (18)	168.9 ± 60.0	190.7 ± 74.3	0.080
Present study	164.20 ± 13.39	175.00 ± 13.06	0.001[a]
t-gl			
Selimoglu et al. (16)	47.5 ± 11.1	38.5 ± 7.7	< 0.0001[a]
Present study	48.33 ± 7.23	48.43 ± 7.39	0.734
n-prn			
Selimoglu et al. (16)	35.1 ± 7.7	30.2 ± 6.4	< 0.0001[a]
Present study	42.91 ± 5.89	42.38 ± 4.52	0.054
v-t			
Selimoglu et al. (16)	27.8 ± 8.5	19.2 ± 5.2	< 0.0001[a]
Present study	18.38 ± 4.09	19.33 ± 4.38	0.178
gl-sn			
Selimoglu et al. (16)	58.0 ± 11.6	48.7 ± 10.2	< 0.0001[a]
Present study	60.82 ± 7.13	64.37 ± 5.25	0.001[a]
spa-sba			
Selimoglu et al. (16)	46.2 ± 7.5	36.7 ± 10.4	< 0.0001[a]
Present study	54.28 ± 4.89	57.57 ± 4.32	0.001[a]
ch-ch			
Selimoglu et al. (16)	39.9 ± 6.9	35.1 ± 7.7	< 0.0001[a]
Present study	42.02 ± 4.43	46.59 ± 4.94	0.001[a]
z-z			
Selimoglu et al. (16)	111.2 ± 17.5	88.0 ± 17.81	< 0.0001[a]
Present study	117.75 ± 6.59	122.71 ± 6.66	0.001[a]
al-al			
Selimoglu et al. (16)	27.6 ± 4.8	23.2 ± 4.9	< 0.0001[a]
Present study	30.81 ± 3.00	33.22 ± 3.05	0.001[a]
nfra			
Selimoglu et al. (16)	144.6 ± 10.0	146.0 ± 13.6	0.134
Present study	142.16 ± 7.30	138.77 ± 7.73	0.001[a]
nla			
Selimoglu et al. (16)	105.3 ± 15.8	107.0 ± 11.3	0.308
Present study	111.99 ± 10.02	113.19 ± 9.82	0.236
en-en			
Selimoglu et al. (16)	29.8 ± 5.2	24.8 ± 5.4	< 0.0001[a]
Present study	31.74 ± 2.89	33.50 ± 3.01	0.001[a]
ex-ex			
Selimoglu et al. (16)	82.5 ± 14.4	70.0 ± 13.2	< 0.0001[a]
Present study	84.60 ± 5.65	88.68 ± 5.11	0.001[a]
ex-en			
Selimoglu et al. (16)	27.6 ± 4.7	23.3 ± 4.7	< 0.0001[a]
Present study, right	26.58 ± 2.11	27.46 ± 1.66	0.032[a]
Present study, left	26.47 ± 2.04	27.66 ± 1.92	0.001[a]

[a] Significance level = 0.05

Table 7. Some Proportions Measurements of Children with Celiac Disease and control Group Comparison with the Literature

	Children with Celiac Disease	Healthy Children	P Value
t-gl/t-gn			
Selimoglu et al. (16)	0.31 ± 0.04	0.31 ± 0.04	0.710
Present study	0.29 ± 0.04	0.28 ± 0.03	0.001[a]
gl-sn/t-gn			
Selimoglu et al. (16)	0.37 ± 0.03	0.39 ± 0.04	0.002[a]
Present study	0.37 ± 0.03	0.37 ± 0.02	0.375
sn-gn/t-gn			
Selimoglu et al. (16)	0.32 ± 0.03	0.31 ± 0.04	0.045[a]
Zanchi et al. (18)	0.35 ± 0.02	0.35 ± 0.03	0.760
Present study	0.33 ± 0.04	0.35 ± 0.03	0.001[a]
n-sn/t-gn			
Selimoglu et al. (16)	0.30 ± 0.02	0.30 ± 0.03	0.359
Zanchi et al. (18)	0.28 ± 0.02	0.28 ± 0.02	0.880
Present study	0.31 ± 0.03	0.30 ± 0.02	0.001[a]
spa-sba/t-gn			
Selimoglu et al. (16)	0.30 ± 0.03	0.29 ± 0.06	0.001[a]
Present study	0.33 ± 0.03	0.33 ± 0.03	0.787
v-t/t-gn			
Selimoglu et al. (16)	0.19 ± 0.07	0.15 ± 0.04	0.001[a]
Present study	0.11 ± 0.03	0.11 ± 0.03	0.993
z-z/t-gn			
Selimoglu et al. (16)	0.72 ± 0.09	0.70 ± 0.07	0.014[a]
Present study	0.72 ± 0.04	0.70 ± 0.05	0.041[a]
en-en/z-z			
Selimoglu et al. (16)	0.27 ± 0.07	0.28 ± 0.05	< 0.0001[a]
Present study	0.27 ± 0.02	0.27 ± 0.02	0.343
ex-en/z-z			
Selimoglu et al. (16)	0.25 ± 0.05	0.27 ± 0.04	< 0.0001[a]
Present study, right	0.23 ± 0.02	0.22 ± 0.01	0.246
Present study, left	0.23 ± 0.01	0.22 ± 0.01	0.741
al-al/z-z			
Selimoglu et al. (16)	0.25 ± 0.06	0.27 ± 0.05	< 0.0001[a]
Present study	0.26 ± 0.02	0.27 ± 0.02	0.026[a]
ch-ch/z-z			
Selimoglu et al. (16)	0.36 ± 0.08	0.40 ± 0.08	< 0.0001[a]
Present study	0.36 ± 0.03	0.38 ± 0.03	0.001[a]
t-n/n-sn			
Zanchi et al. (18)	1.35 ± 0.19	1.34 ± 0.19	0.920
Present study	1.14 ± 0.18	1.13 ± 0.15	0.845

[a] Significant at 0.05 level

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Footnotes

Authors' Contribution: Conception and design: Sedat Isikay, Ilhan Bahsi, Nese Kizilkan, and Mustafa Orhan. Collection and assembly of data: Sedat Isikay, Murat San, and Halil Kocamaz. Data analysis and interpretation: Sedat Isikay, Mustafa Orhan, and Seval Kul. Manuscript writing: Sedat Isikay, Ilhan Bahsi, and Mustafa Orhan. Final approval of manuscript was done by all authors. Final approval of the manuscript was done by all authors, except Nese Kizilkan because of her death.

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