Original Article

Gender Differences in Class III Malocclusion

Tiziano Baccetti[a]; Brian C. Reyes[b]; James A. McNamara Jr[c]

Abstract: This study evaluated gender differences in the cephalometric records of a large-scale cross-sectional sample of Caucasian subjects with Class III malocclusion at different developmental ages. The purpose also was to provide average age-related and sex-related data for craniofacial measures in untreated Class III subjects that are used as reference in the diagnostic appraisal of the patient with Class III disharmony. The sample examined consisted of 1094 pretreatment lateral cephalometric records (557 female subjects and 537 male subjects) of Caucasian Class III individuals. The age range for female subjects was between three years six months and 57 years seven months. The male subject group ranged from three years three months to 48 years five months. Twelve age groups were identified. Skeletal maturity at different age periods also was determined using the stage of cervical vertebral maturation. Gender differences for all cephalometric variables were analyzed using parametric statistics. The findings of the study indicated that Class III malocclusion is associated with a significant degree of sexual dimorphism in craniofacial parameters, especially from the age of 13 onward. Male subjects with Class III malocclusion present with significantly larger linear dimensions of the maxilla, mandible, and anterior facial heights when compared with female subjects during the circumpubertal and postpubertal periods. (*Angle Orthod* 2005;75:510–520.)

Key Words: Class III Malocclusion; Craniofacial growth; Cephalometrics; Sexual dimorphism; Mandibular growth

INTRODUCTION

Class III malocclusion is the least prevalent type of Angle's classification of malocclusion, with a number of racial and ethnic groups demonstrating a greater tendency toward expression. This occlusal relationship appears to be particularly common in those of Asian ancestry (the prevalence of Class III malocclusion in a Chinese population can be as high as 12%[1,2]) and comparatively less prevalent in the European (1.5% to 5.3%) and North American Caucasian (~1–4%) populations.[3–6]

The dentofacial disharmony associated with Class III malocclusion is challenging in both the diagnostic and treatment arenas. Dental professionals and laypersons identify the clinical signs of this type of malocclusion (eg, mesial molar relationship, anterior crossbite) easily, but the underlying etiology is more difficult to elucidate. Treatment decisions and their success or failures rely heavily on the future growth potential in the Class III individual.

Unfortunately, knowledge of craniofacial growth in Class III malocclusion is not well established. The large-scale longitudinal growth studies providing information on so-called normal growth fail to offer much useful information about Class III malocclusion because they consist primarily of individuals categorized as having normal occlusion, Class I malocclusion, or Class II malocclusion.[7,8] In addition, there is only limited longitudinal investigation of untreated Class III individuals in the literature.

The cross-sectional approach to growth data requires investigators to assemble large samples of untreated Class III individuals at various stages of de-

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Accepted: May 2004. Submitted: April 2004.

velopment and to draw inferences about average growth in Class III individuals from these databases. Miyajima and associates[9] conducted the largest cross-sectional Class III study to date, but the sample was limited to Japanese female subjects. The literature lacks a large-scale cross-sectional study for orthodontically untreated Class III Caucasian male and female subjects.

One of the first fundamental steps in the diagnostic evaluation of the malocclusion and its related craniofacial components is to establish whether significant sexual dimorphism exists. Previous studies of craniofacial growth in untreated subjects have demonstrated many gender-related differences.[8,10,11] For example, most of the cephalometric variables that were analyzed in large-scale growth studies on Caucasian subjects presenting with a variety of malocclusions (The Bolton-Brush Growth Study,[7] The University of Michigan Elementary and Secondary School Growth Study[8]) exhibit significant differences between male and female subjects.

In contrast, previous investigations that have considered individuals with Class III malocclusion rarely recognized the issue of sexual dimorphism. Because of small sample sizes, several studies pooled male and female Class III subjects together.[12–19] Other investigators collected samples composed of a single sex (usually female subjects).[9,20,21] Only very few investigators have assembled samples of untreated Class III subjects belonging to both sexes and analyzed the craniofacial measurements separately by sex.[22,23]

It is the purpose of this investigation to estimate gender differences in the cephalometric records of a large-scale cross-sectional sample of Caucasian subjects with Class III malocclusion throughout the growth period. The aim also was to provide average age-related and sex-related data for craniofacial measures in Class III subjects. This information then is very useful as a reference in the diagnostic evaluation of the patient with Class III disharmony.

MATERIALS AND METHODS

Patients

To study Class III morphology at consecutive ages, we obtained a large cross-sectional sample of lateral cephalograms. The parent sample consisted of 1549 pretreatment lateral cephalometric records of Caucasian Class III patients collected from 12 private orthodontic practices in Michigan and Ohio and the University of Michigan Graduate Orthodontic Clinic and the Department of Orthodontics at the University of Florence, Italy.

TABLE 1. Sample Selection and Exclusionary Criteria

Sample Selection	n
Patient sample	1549
Exclusionary criteria	
1. Not Caucasian	41
2. Prior treatment	10
3. Missing teeth	10
4. Disqualified due to incisor/molar relationships	333
5. Poor quality radiographs	12
6. Serial cephalograms	44
Final sample	1094

TABLE 2. Chronologic Age Groups

Age	Female	Male
6 yr and younger	21	19
7 yr	57	30
8 yr	73	82
9 yr	65	65
10 yr	45	42
11 yr	35	33
12 yr	56	43
13 yr	52	50
14 yr	53	42
15 yr	31	32
16 yr	14	24
17 yr and older	54	75
Total	557	537

To be included in the final grouping, patients had to satisfy all the following criteria:

European-American ancestry (Caucasian),
No orthopedic/orthodontic treatment before cephalogram,
Diagnosis of Class III malocclusion,
Anterior crossbite,
Edge-to-edge incisal relationship,
Accentuated mesial step relationship of the primary second molars,
Permanent first molar relationship of at least one-half cusp Class III,
No congenitally missing or extracted teeth.

A final sample of 1094 subjects with Class III malocclusion met the inclusionary criteria (Table 1). The sample consisted of 557 female subjects and 537 male subjects. The age range for female subjects was between three years six months and 57 years seven months. The male subject group ranged from three years three months to 48 years five months. Twelve age groups were identified and applied to the Class III sample (Table 2).

Cephalometric analysis

Lateral cephalograms were hand traced using 0.003″ matte acetate and a sharpened 2H lead-draft-

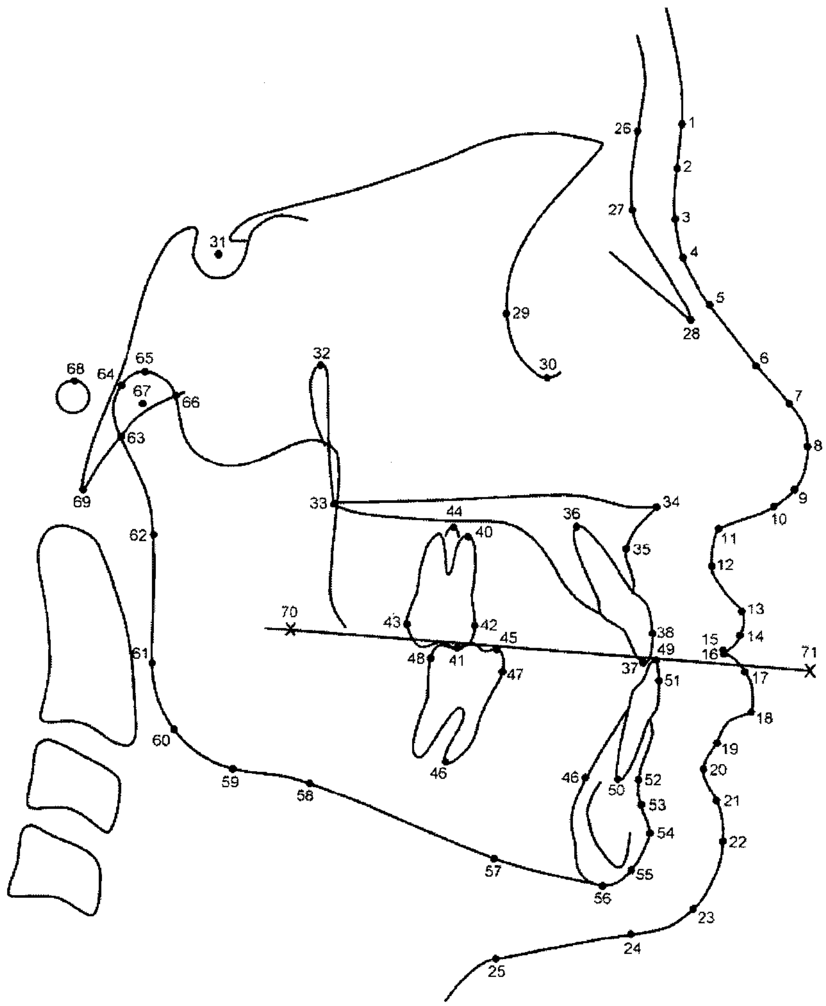

FIGURE 1. Digitized cephalometric landmarks.

ing pencil. One of two investigators traced each cephalogram, and then a third investigator verified landmark identification. Any disparity was addressed by retracing of the structure. A customized digitization regimen of analysis was conducted using the Dentofacial Planner™ (Dentofacial Software, Toronto, Ontario, Canada). The descriptive cephalometric analysis required the digitization of 71 landmarks on each tracing (Figure 1). A cephalometric analysis, including measures adopted from the analyses of Steiner,[24] Jacobson,[25] Ricketts,[26] and McNamara,[27] was performed on each tracing included in the investigation.

Statistical analysis

The initial statistical approach to the collected data provided descriptive statistics for the examined dentofacial parameters in different gender groups at all age stages. The Shapiro-Wilks test revealed a normal distribution of the values for the cephalometric parameters in the two groups at the various age stages. Gender differences in the cephalometric variables were tested initially by using Hotelling's T^2 test to estimate whether the general model of differences was significant. Because significant differences were identified ($F = 4.12$; $P < .01$), independent sample *t*-tests were applied to individual age groups to assess significant differences between male and female subjects for each age group.

The data were analyzed with a commercial social science statistical package (SPSS for Windows Version 10.0, SPSS Inc, Chicago, Ill). Statistical significance was tested at $P < .05$, and $P < .01$.

Assessment of skeletal maturity

The cervical vertebral maturation (CVM) method[28] was used to assess individual skeletal maturity of the subjects examined. The prevalence rate for the stages in CVM at different age periods was calculated both in male and female groups.

All subjects in the six-years and younger group showed CVMS I (prepubertal). All subjects in the 17-years and older group showed CVMS V (adult).

RESULTS

Table 3 shows the results along with the statistical comparison of male vs female groups at each age period.

Six years and younger

No significant differences between the two sexes were identified in this early age group. The length of the anterior cranial base represented the only exception, which was significantly shorter in female subjects.

Seven years

The results in the seven-year-old group were similar to the previous age period, with the addition of significant differences in the vertical position of the lower incisors (significantly more extruded in male subjects), and in the position of the lower lip in relation to the esthetic plane (E-plane) (significantly more advanced position in male subjects).

Eight years

At the age of eight, the length of the cranial base again was significantly shorter in female subjects, the lower incisors significantly more extruded in male subjects, with a significantly larger lower anterior facial height in male subjects as well.

Nine years

The male vs female comparison of craniofacial pattern at the age of nine years replicated the differences at the previous age period.

Ten years

The gender comparison of craniofacial pattern at the age of 10 replicated the differences at the two previous age periods.

Eleven years

No significant differences existed between the male and female groups for any of the examined measurements at this age stage.

Twelve years

At this stage in chronologic age, the only significant difference between male and female subjects was represented by a more retruded position of the lower lip to the E-plane in female subjects.

Thirteen years

The craniofacial measures at the age of 13 showed several significant differences between male and female subjects. Female subjects presented with a shorter anterior cranial base, shorter midfacial and mandibular lengths, shorter upper and lower anterior facial heights, less extruded upper incisors, upper molars, and lower incisors. The maxillary incisors were more proclined in female subjects. Both upper and lower lips exhibited a more retrusive position in relation to the E-plane in the female group.

Fourteen years

The male-to-female comparison at this age period revealed differences that were very similar to the previous age period. The exception was the lack of statistical significance for the vertical position of the maxillary molars and incisors.

Fifteen years

The gender comparison at this age period revealed differences that were very similar once again to the 13-year age period. The only exception was the lack of statistical significance for the position of the lower lip relative to the E-plane.

Sixteen years

All parameters that were significantly different between male and female subjects at the previous age period showed a significant difference at this age period as well, with two exceptions ie, the maxillary molar was more extruded in male subjects than in female subjects, and no significant differences were recorded for the soft tissue measurements at this age.

Seventeen years and older

At the young adult age period, the female group showed a significantly shorter anterior cranial base, less retrusive position of point A relative to Nasion perpendicular, shorter midfacial and mandibular lengths, smaller maxillomandibular differential, shorter upper and lower anterior facial heights, less extruded upper molars and incisors, and less extruded lower incisors.

DISCUSSION

This study analyzed differences in the cephalometric measurements of male and female subjects with Class III malocclusion at consecutive age periods during active growth, with the aim of evaluating sexual dimorphism in the craniofacial pattern of the Class III patient. All subjects presented with prepubertal growth stage at the initial age group (six years and younger)

TABLE 3. Descriptive Statistics and Between-Gender Comparisons of Cephalometric Measures at Each Age Period[a]

	6 y and Younger					7 y				
	Male (n = 19)		Female (n = 23)		*t*-Test	Male (n = 30)		Female (n = 57)		*t*-Test
	X	SD	X	SD	Sig.	X	SD	X	SD	Sig.
Cranial base										
SNFH (°)	9.8	4.0	7.5	2.4	NS	7.1	3.9	8.2	2.7	NS
S-N (mm)	69.3	6.6	65.1	2.3	*	69.4	3.0	67.3	3.5	**
Cranial flexure (°)	116.0	4.1	116.4	3.8	NS	119.7	4.7	121.5	5.8	NS
Maxillary skeletal										
SNA (°)	78.3	3.8	80.4	2.1	NS	80.6	3.9	80.2	3.0	NS
PtA to NaPerp (mm)	−3.0	3.9	−1.8	2.4	NS	−2.0	2.9	−1.6	3.1	NS
PP-FH (°)	−0.5	5.6	−2.3	2.5	NS	−0.2	3.6	−0.6	3.4	NS
Co-Pt A (mm)	81.8	10.8	75.4	3.4	NS	82.5	3.6	81.0	4.5	NS
Mandibular skeletal										
SNB (°)	78.1	2.8	79.4	2.3	NS	80.4	3.7	79.0	3.1	NS
Pog-Na perp (mm)	0.4	1.2	−0.6	1.0	NS	0.2	1.3	0.3	1.1	NS
Facial angle (°)	88.2	4.9	86.6	3.6	NS	87.5	3.4	88.3	3.3	NS
Co-Gn (mm)	107.0	18.0	95.7	4.5	NS	107.4	4.2	105.2	5.7	NS
Maxillary/mandibular										
FMA (°)	25.1	2.5	27.2	7.3	NS	27.0	4.2	26.1	4.0	NS
ANB (°)	−1.8	2.1	0.0	2.0	NS	0.2	2.6	1.2	1.9	NS
Wits (mm)	−6.2	4.2	−4.9	4.3	NS	−4.6	2.5	−4.1	1.8	NS
Mx-Md diff (mm)	25.2	8.0	20.3	2.5	NS	24.9	3.1	23.5	3.5	NS
Molar relation (mm)	−3.6	1.0	−3.7	1.1	NS	−3.9	1.9	−3.4	1.7	NS
Vertical										
Nasion to ANS (mm)	46.4	6.4	42.9	1.8	NS	45.9	4.8	46.2	2.6	NS
ANS to Me (mm)	59.9	10.5	56.5	7.2	NS	61.6	3.0	59.9	4.7	NS
UFH/LAFH ratio	81.5	7.8	77.5	8.7	NS	78.5	8.3	80.1	7.4	NS
U1-ANS (mm)	24.9	5.0	22.9	1.8	NS	24.6	2.3	23.6	2.6	NS
U6-PP (mm)	17.8	3.5	12.6	8.6	NS	18.3	1.7	17.8	2.0	NS
L1-Me (mm)	36.7	4.2	34.0	2.1	NS	37.2	2.2	35.4	2.5	*
Dentoalveolar										
U1-Pt A (V) (mm)	−0.9	2.1	−1.2	1.2	NS	0.5	2.2	0.7	2.9	NS
U1-SN (°)	88.8	10.9	89.3	7.6	NS	100.5	8.6	99.7	10.4	NS
IMPA (°)	81.3	7.9	85.5	5.3	NS	87.1	7.0	88.5	6.8	NS
FMIA (°)	73.6	7.0	67.3	7.4	NS	65.9	7.1	65.4	6.4	NS
L1-A Pog (mm)	2.3	1.3	2.4	1.8	NS	3.3	1.6	2.6	1.8	NS
Interincisal angle (°)	155.0	11.9	150.5	12.6	NS	138.3	11.5	136.5	12.4	NS
Soft tissue										
UL-E-plane (mm)	−5.0	2.4	−2.5	3.0	NS	−2.9	2.3	−3.7	2.4	NS
LL-E-plane (mm)	−1.8	3.8	0.5	1.9	NS	0.5	2.4	−0.9	2.6	*
Nasolabial angle (°)	113.8	15.11	104.1	12.3	NS	109.3	14.0	114.4	13.3	NS

[a] NS, not significant; * $P < .05$; ** $P < .01$.

and with postpubertal, adult growth stage at the final observation (17 years and older).

Most of the dentofacial parameters did not show a significant sexual dimorphism in Class III malocclusion until the age of 13, even though male subjects exhibited usually larger size for most linear measures when compared with female subjects. However, a very distinctive group composed of a few variables indicated the divergence of the average Class III female subject vs male subject in the early developmental ages. Almost consistently, from the early ages on, female subjects with Class III malocclusion presented with a shorter anterior cranial base (S-N) when compared with male subjects. Tollaro and coworkers[29] have previously described this characteristic as a feature of the cranial base in Class III children four to six years old in comparison with children with normal occlusion. This study also revealed that during the early stages the distance from the incisal edge of the lower incisors to the inferior part of the symphysis (L1-Me) is significantly shorter in female subjects than in male subjects, along with a shorter lower anterior facial height (ANS-Me).

TABLE 3. Extended

8 y					9 y					10 y				
Male (n = 82)		Female (n = 73)		*t*-Test	Male (n = 65)		Female (n = 65)		*t*-Test	Male (n = 42)		Female (n = 45)		*t*-Test
X	SD	X	SD	Sig.	X	SD	X	SD	Sig.	X	SD	X	SD	Sig.
8.4	2.6	9.1	3.3	NS	8.6	2.8	9.3	2.8	NS	7.8	2.8	8.4	2.9	NS
70.8	3.5	68.1	3.2	**	70.4	3.6	68.7	3.9	*	71.4	4.3	69.7	3.0	*
121.5	4.5	122.7	5.5	NS	120.9	4.7	122.4	5.0	NS	121.4	5.8	121.5	4.2	NS
79.8	3.4	79.6	3.8	NS	80.1	3.4	80.0	3.4	NS	80.8	4.5	81.4	3.4	NS
−1.7	2.4	−1.2	2.7	NS	−1.3	3.2	−0.7	3.0	NS	−1.4	3.9	−0.1	2.7	NS
−0.4	3.3	−0.3	3.4	NS	−0.6	3.4	−0.6	3.4	NS	−0.2	3.2	−0.2	3.0	NS
84.6	4.7	82.9	4.8	NS	84.5	4.5	83.5	4.2	NS	86.8	4.8	85.8	4.1	NS
79.0	3.2	79.1	3.7	NS	79.4	3.2	79.5	3.5	NS	80.2	3.7	81.0	3.5	NS
0.5	1.2	0.7	1.3	NS	0.4	1.1	0.5	1.3	NS	0.6	1.2	1.0	1.1	NS
87.7	2.5	88.5	3.0	NS	88.3	2.9	89.1	3.2	NS	89.3	2.9	90.0	2.8	NS
109.3	5.9	107.6	5.2	NS	110.2	5.9	109.0	5.9	NS	113.8	5.8	112.7	5.7	NS
26.4	4.7	25.8	5.0	NS	26.3	4.7	25.3	5.1	NS	26.3	5.0	25.5	3.7	NS
0.8	2.1	0.6	2.3	NS	0.7	2.2	0.5	2.4	NS	0.7	2.8	0.4	1.9	NS
−4.1	2.5	−4.7	3.7	NS	−4.5	2.5	−4.6	2.4	NS	−4.4	2.6	−4.6	2.3	NS
24.7	3.2	25.3	3.6	NS	25.8	3.6	25.5	3.6	NS	27.0	3.7	27.0	3.7	NS
−3.5	1.6	−4.0	1.7	NS	−3.8	1.8	−4.0	1.8	NS	−4.2	1.9	−3.8	1.7	NS
48.4	3.4	48.1	3.4	NS	49.5	3.6	48.7	3.5	NS	50.5	2.5	49.6	2.6	NS
62.4	4.8	60.8	4.1	*	63.2	4.3	61.2	5.2	*	64.8	5.1	62.3	4.2	*
81.7	7.6	83.2	7.2	NS	82.4	6.8	83.5	8.0	NS	81.7	7.0	82.9	5.7	NS
25.1	2.9	24.8	2.3	NS	25.8	2.6	25.4	2.6	NS	27.1	2.7	26.4	2.6	NS
18.8	2.0	18.3	2.8	NS	19.3	2.4	19.3	2.4	NS	20.8	2.3	20.2	1.9	NS
37.9	2.4	36.5	2.3	*	38.4	2.8	36.9	2.4	*	38.7	2.2	37.6	1.9	NS
0.3	2.1	1.0	2.4	NS	1.2	2.5	1.8	2.6	NS	1.5	2.6	3.0	2.2	**
99.0	8.0	101.3	7.9	NS	101.4	7.2	102.0	7.6	NS	102.8	8.4	106.0	6.7	NS
87.0	7.1	88.0	6.6	NS	87.8	6.1	89.6	7.2	NS	87.1	7.0	87.7	8.2	NS
66.5	6.7	66.2	6.9	NS	65.9	5.5	65.2	6.8	NS	66.6	7.3	66.8	7.8	NS
2.6	1.8	3.1	1.8	NS	3.4	2.0	3.4	1.7	NS	3.1	1.7	3.1	2.2	NS
139.1	11.8	135.8	9.4	NS	135.9	9.8	133.9	10.4	NS	136.0	11.0	132.4	10.6	NS
−3.7	2.1	−4.1	1.9	NS	−3.8	2.3	−4.4	2.2	NS	−3.9	2.5	−4.5	1.9	NS
−0.4	2.4	−0.8	2.6	NS	−0.2	2.2	−0.4	2.1	NS	−0.5	2.5	−1.5	2.0	*
114.5	13.3	112.1	11.1	NS	113.3	13.2	115.2	11.7	NS	113.4	15.1	111.6	12.5	NS

[a] NS, not significant; * $P < .05$; ** $P < .01$.

At the age of 11, no significant differences between male and female subjects could be detected. Interestingly, at this age none of the male subjects had reached the pubertal growth spurt (76% of the male subjects were at CVMS I, and 24% at CVMS II),[28] whereas two thirds of the girls (64%) were at CVMS II, and 24% of them had undergone the accelerative portion of the growth spurt already (CVMS III). Then, at the age of 12, only 18% of the male subjects showed the postpubertal growth stage CVMS III, whereas 82% of the female subjects were at this stage in skeletal development. These differences in the timing of skeletal maturation are extremely helpful in the interpretation of the data that pertain to sexual dimorphism in Class III malocclusion.

The lack of significant differences in the craniofacial parameters between male and female subjects at 11 and 12 years is because of the substantially higher prevalence of female subjects undergoing their pubertal growth spurt at these age periods when compared with male subjects. The onset of the pubertal growth spurt in female subjects compensates for the general

TABLE 3. Extended[a]

	11 y					12 y				
	Male (n = 33)		Female (n = 34)		*t*-Test	Male (n = 43)		Female (n = 56)		*t*-Test
	X	SD	X	SD	Sig.	X	SD	X	SD	Sig.
Cranial base										
SNFH (°)	9.4	3.0	8.6	2.8	NS	8.8	2.5	9.5	3.4	NS
S-N (mm)	71.5	3.5	70.6	4.2	NS	72.2	3.3	71.4	3.8	NS
Cranial flexure (°)	122.0	5.3	123.3	4.1	NS	121.8	4.2	123.0	5.2	NS
Maxillary skeletal										
SNA (°)	80.1	2.8	79.9	4.0	NS	80.3	4.2	80.3	4.1	NS
PtA to NaPerp (mm)	−0.7	3.1	−1.5	3.8	NS	−1.0	3.5	−0.2	3.8	NS
PP-FH (°)	−4.4	2.8	−0.2	3.2	NS	0.0	2.8	−0.3	3.9	NS
Co-Pt A (mm)	87.4	4.7	87.2	5.4	NS	90.5	4.9	88.5	6.0	NS
Mandibular skeletal										
SNB (°)	79.5	3.2	79.8	3.4	NS	80.2	3.5	79.8	3.9	NS
Pog-Na perp (mm)	0.8	1.1	1.1	1.6	NS	1.3	1.8	1.5	2.1	NS
Facial angle (°)	89.2	2.3	89.0	2.9	NS	89.6	3.0	90.2	3.5	NS
Co-Gn (mm)	116.7	5.0	117.2	6.8	NS	121.2	6.1	119.0	7.5	NS
Maxillary/mandibular										
FMA (°)	27.3	5.2	27.8	4.0	NS	27.1	4.7	26.9	6.3	NS
ANB (°)	0.6	2.2	0.1	2.0	NS	0.1	2.5	0.5	2.5	NS
Wits (mm)	−4.8	2.0	−5.3	2.3	NS	−5.2	2.9	−4.7	3.3	NS
Mx-Md diff (mm)	29.4	3.4	30.0	4.1	NS	31.7	3.6	30.6	4.7	NS
Molar relation (mm)	−4.2	1.8	−4.6	1.6	NS	−5.9	2.2	−5.7	1.6	NS
Vertical										
Nasion to ANS (mm)	52.7	3.0	51.9	4.1	NS	54.0	3.7	53.0	3.9	NS
ANS to Me (mm)	66.7	5.5	66.4	4.9	NS	69.0	5.5	67.0	5.4	NS
UFH/LAFH ratio	82.6	7.1	81.7	7.8	NS	81.5	8.1	82.7	7.8	NS
U1-ANS (mm)	28.2	2.9	27.7	3.2	NS	28.5	3.2	28.1	3.3	NS
U6-PP (mm)	22.1	2.3	21.8	2.3	NS	23.1	2.6	22.5	2.2	NS
L1-Me (mm)	39.7	2.2	39.1	3.0	NS	40.8	2.9	39.9	2.8	NS
Dentoalveolar										
U1-Pt A (V) (mm)	2.5	2.1	3.4	2.6	NS	3.8	2.5	3.4	2.2	NS
U1-SN (°)	102.2	5.5	104.9	7.2	NS	104.9	5.6	103.6	5.9	NS
IMPA (°)	87.0	6.0	86.3	6.8	NS	85.5	6.9	84.7	7.1	NS
FMIA (°)	65.7	5.3	66.0	7.6	NS	67.4	8.1	68.3	7.8	NS
L1-A Pog (mm)	4.2	1.8	3.9	2.8	NS	3.8	2.5	2.8	2.5	NS
Interincisal angle (°)	134.1	8.8	132.8	11.6	NS	133.7	9.0	135.2	9.5	NS
Soft tissue										
UL-E-plane (mm)	−4.5	2.5	−5.0	2.5	NS	−4.9	3.1	−5.9	2.9	NS
LL-E-plane (mm)	−1.1	2.4	−1.2	2.9	NS	−1.0	3.6	−2.4	2.9	*
Nasolabial angle (°)	110.5	14.2	107.3	10.1	NS	115.2	11.3	112.3	14.7	NS

[a] NS, not significant; * $P < .05$; ** $P < .01$.

tendency of size deficiency in craniofacial measurements in female subjects when compared with male subjects. At the age of 13, 94% of the female subjects had reached a postpubertal stage in skeletal development, but also 54% of the male subjects already had gone through the growth spurt. This increased prevalence rate of boys with growth acceleration most probably is a fundamental factor that accounts for the appearance of a large set of significant gender differences at the age of 13, which will be maintained at later age periods.

The main features concerning sexual dimorphism in Class III malocclusion at pubertal and postpubertal ages (13 years and older) are a shorter anterior cranial base, shorter midfacial (Co-PtA) and mandibular (Co-Gn) lengths, and shorter upper and lower anterior facial heights in female subjects when compared with male subjects (Figures 2 through 4). A relatively larger amount of retrusion of the upper lip and milder amount of protrusion of the lower lip appear to be characteristics of Class III female subjects during the circumpubertal ages. These differ-

TABLE 3. Extended

13 y					14 y					15 y				
Male (n = 50)		Female (n = 52)		*t*-Test	Male (n = 42)		Female (n = 53)		*t*-Test	Male (n = 32)		Female (n = 31)		*t*-Test
X	SD	X	SD	Sig.	X	SD	X	SD	Sig.	X	SD	X	SD	Sig.
9.0	2.8	9.1	2.3	NS	8.3	3.4	9.0	3.2	NS	8.4	3.2	9.7	2.7	NS
73.5	3.8	70.8	2.9	**	75.5	3.3	71.9	4.0	**	75.6	4.2	72.1	3.4	**
121.1	5.5	122.6	5.5	NS	121.1	5.2	122.8	6.1	NS	120.7	5.4	122.2	6.8	NS
80.5	3.8	80.8	3.4	NS	81.0	4.6	80.7	4.0	NS	82.2	4.4	80.5	3.7	NS
−0.5	3.1	−0.1	3.4	NS	−0.8	4.3	−0.4	4.2	NS	0.6	4.6	0.1	3.0	NS
−0.1	2.9	−0.4	3.1	NS	0.5	3.8	−0.1	3.7	NS	−1.1	3.3	−0.6	3.1	NS
91.5	5.4	88.2	4.8	**	93.7	4.6	90.0	4.4	**	94.4	5.5	89.7	4.4	**
79.8	3.2	80.9	2.9	NS	80.6	4.5	80.8	3.9	NS	82.0	4.3	81.4	3.4	NS
1.3	1.8	1.6	1.7	NS	1.4	2.1	1.6	1.6	NS	1.9	1.9	2.6	1.6	NS
89.8	2.6	90.9	3.2	NS	89.6	3.7	90.6	3.4	NS	91.3	3.7	92.4	3.0	NS
124.2	7.3	119.5	6.2	**	127.3	6.2	124.8	5.3	*	129.7	7.2	125.7	5.4	*
27.5	4.3	26.3	4.6	NS	26.6	5.0	26.9	5.5	NS	24.4	5.1	24.1	5.0	NS
0.8	2.4	−0.2	2.7	NS	0.4	2.4	−0.1	2.0	NS	0.2	2.8	−0.9	2.8	NS
−4.7	2.7	−5.1	3.0	NS	−4.5	3.8	−5.7	2.9	NS	−3.9	3.3	−5.6	4.0	NS
32.7	4.6	31.3	3.9	NS	33.7	4.5	34.8	4.1	NS	35.3	5.5	36.0	4.9	NS
−5.9	2.9	−5.1	1.7	NS	−5.8	1.7	−6.4	2.1	NS	−5.5	2.1	−5.7	2.4	NS
55.3	3.6	52.8	3.0	**	56.4	3.7	54.3	3.8	*	56.6	3.6	54.6	3.7	*
72.1	6.0	66.3	5.2	**	72.9	6.1	70.4	6.2	*	72.4	5.4	69.4	4.8	*
80.2	6.8	82.9	6.7	NS	80.8	6.8	79.0	7.7	NS	80.9	7.2	81.1	7.7	NS
30.0	3.2	27.4	3.0	**	29.7	3.0	29.9	3.3	NS	29.9	2.8	29.0	3.1	NS
24.4	2.8	22.5	2.2	**	25.1	2.5	24.8	2.4	NS	25.4	2.9	24.6	2.2	NS
42.3	3.2	38.9	3.1	**	43.2	3.4	41.1	3.3	**	42.6	2.9	39.7	2.8	**
3.6	2.2	4.5	2.3	NS	4.4	2.3	4.1	2.5	NS	4.0	2.8	4.4	2.5	NS
103.2	6.1	107.4	5.8	**	106.2	6.5	104.6	6.8	NS	105.4	6.7	105.0	6.6	NS
85.8	6.3	85.9	7.4	NS	85.4	7.2	84.0	7.2	NS	83.5	7.5	83.6	9.0	NS
66.6	6.9	68.8	8.6	NS	66.0	8.4	69.0	7.1	NS	72.2	8.1	72.2	8.2	NS
3.6	2.4	3.1	2.7	NS	3.9	3.0	3.4	2.6	NS	2.3	2.7	2.4	2.0	NS
134.4	9.2	132.3	10.8	NS	131.5	9.5	135.4	10.4	NS	138.4	10.0	137.6	11.1	NS
−4.9	3.3	−6.6	2.3	**	−5.4	2.3	−7.1	2.6	*	−6.2	2.8	−8.0	2.6	*
−1.3	3.7	−2.6	2.5	*	−1.4	2.8	−3.0	2.8	*	−3.0	3.2	−4.5	2.4	NS
113.2	10.5	113.8	10.9	NS	112.5	8.3	110.6	10.2	NS	109.1	12.4	110.7	10.9	NS

[a] NS, not significant; * $P < .05$; ** $P < .01$.

ences, however, were not present at later developmental phases.

Adults with Class III malocclusion who did not receive any treatment of the disharmony present with a considerable amount of sexual dimorphism. In addition to the differences that were highlighted during the immediate postpubertal period (13 to 16 years of age), adult female subjects with Class III malocclusion exhibited a smaller amount of maxillomandibular differential (because of smaller midfacial and mandibular dimensions) and smaller alveolar heights, both in the maxilla and in the mandible.

Linear dimensions for both midfacial and mandibular lengths and for anterior facial heights appear to be strictly coordinated during postnatal growth of the craniofacial region in Class III malocclusion. At the moment of enhanced gender differences in craniofacial measures (from the age of 13 years of age onward), all these parameters exhibit a similar behavior. These findings confirm the observations by Björk and Skieller[30] and Björk and Helm[31], who described the chronological concurrence of the greatest growth increase in the maxillary sutures and in the mandibular condyles.

According to the results of this study, the existence

TABLE 3. Extended[a]

	16 y					17 y and over				
	Male (n = 24)		Female (n = 14)		*t*-Test	Male (n = 75)		Female (n = 54)		*t*-Test
	X	SD	X	SD	Sig.	X	SD	X	SD	Sig.
Cranial base										
SNFH (°)	7.7	3.6	9.3	2.3	NS	7.8	3.3	8.8	3.2	NS
S-N (mm)	76.9	3.4	73.8	4.8	*	77.8	4.3	72.0	3.5	**
Cranial flexure (°)	122.8	5.5	124.3	6.9	NS	122.3	6.3	122.5	5.4	NS
Maxillary skeletal										
SNA (°)	81.8	4.5	81.1	3.1	NS	80.6	4.3	80.9	3.4	NS
PtA to NaPerp (mm)	−0.6	4.3	0.3	2.5	NS	−1.9	4.6	−0.4	3.8	*
PP-FH (°)	0.6	4.3	−0.1	2.3	NS	1.5	4.3	1.0	3.9	NS
Co-Pt A (mm)	96.7	4.6	93.4	4.2	*	97.3	5.6	89.9	4.9	**
Mandibular skeletal										
SNB (°)	81.5	4.4	82.2	4.8	NS	82.0	4.4	81.4	3.4	NS
Pog-Na perp (mm)	2.3	1.9	3.2	2.2	NS	3.1	2.0	2.4	2.0	NS
Facial angle (°)	91.2	3.2	93.0	3.4	NS	91.1	4.2	91.4	3.3	NS
Co-Gn (mm)	133.3	6.8	126.6	7.2	*	139.4	7.9	126.6	8.0	**
Maxillary/mandibular										
FMA (°)	27.3	5.6	24.6	7.0	NS	26.1	6.4	26.2	5.6	NS
ANB (°)	0.3	3.2	−1.1	2.6	NS	−1.3	2.8	−0.5	3.1	NS
Wits (mm)	−3.5	4.4	−5.5	3.5	NS	−6.3	4.6	−5.8	4.5	NS
Mx-Md diff (mm)	36.6	5.3	35.6	3.2	NS	42.1	5.7	36.7	5.5	**
Molar relation (mm)	−6.4	2.2	−6.0	2.1	NS	−7.3	3.9	−6.4	2.8	NS
Vertical										
Nasion to ANS (mm)	56.6	4.5	54.4	4.4	*	59.5	3.7	55.1	4.0	**
ANS to Me (mm)	77.6	5.9	69.6	5.6	**	79.2	6.1	71.0	7.6	**
UFH/LAFH ratio	76.5	8.4	81.7	6.7	NS	78.1	7.3	80.8	8.6	NS
U1-ANS (mm)	30.9	3.4	28.7	3.2	NS	31.7	3.5	29.1	3.7	**
U6-PP (mm)	27.4	2.6	25.1	2.2	**	28.4	2.7	25.4	3.1	**
L1-Me (mm)	45.3	2.9	40.7	2.7	**	46.4	2.9	41.5	3.7	**
Dentoalveolar										
U1-Pt A (V) (mm)	4.5	2.4	4.5	2.0	NS	4.3	3.1	4.1	3.2	NS
U1-SN (°)	107.3	6.6	106.9	6.6	NS	106.2	7.9	105.7	7.3	NS
IMPA (°)	84.2	7.2	84.0	8.1	NS	83.7	6.9	84.5	8.5	NS
FMIA (°)	68.5	7.3	73.4	10.0	NS	70.2	7.4	69.3	9.0	NS
L1-A Pog (mm)	3.4	2.0	2.2	2.5	NS	4.0	2.6	3.8	3.0	NS
Interincisal angle (°)	133.6	8.4	137.2	10.0	NS	136.2	9.8	134.8	11.8	NS
Soft tissue										
UL-E-plane (mm)	−6.5	3.0	−8.0	2.3	NS	−9.6	3.1	−8.6	3.5	NS
LL-E-plane (mm)	−2.9	2.4	−4.4	3.1	NS	−4.3	2.8	−3.7	3.7	NS
Nasolabial angle (°)	109.2	13.0	110.1	14.8	NS	106.9	11.8	104.8	11.5	NS

[a] NS, not significant; * $P < .05$; ** $P < .01$.

of significant sexual dimorphism in Class III malocclusion (especially after the age of 13 years) provides evidence that male and female subjects with Class III malocclusion during the circumpubertal or postpubertal ages should not be pooled together for investigative purposes. Children with Class III malocclusion at prepubertal ages show a much milder amount of sexual dimorphism. These findings are similar to the data gathered by Ursi and coworkers[11] on subjects with excellent occlusions from the Bolton-Brush Study. Male subjects with good occlusion showed a larger anterior cranial base at all developmental ages, whereas effective lengths of the midface and mandible became different in the two sexes from the age of 14.

CONCLUSIONS

This study showed that (1) Class III malocclusion is associated with a significant degree of sexual dimorphism in craniofacial especially after the age of 13 and (2) female subjects with Class III malocclusion present with significantly smaller linear dimensions in the max-

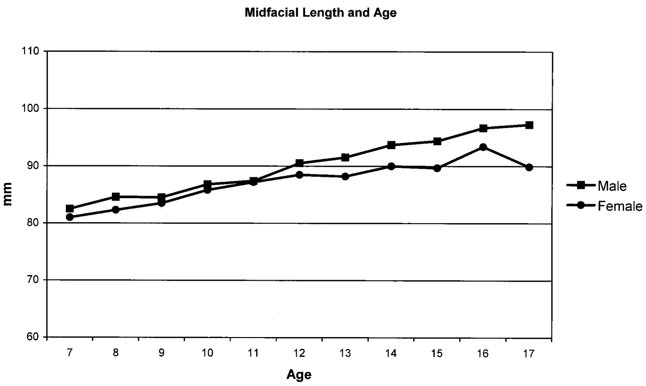

FIGURE 2. Diagram of average values for midfacial length (Co-PtA) at subsequent age periods for male and female subjects with Class III malocclusion.

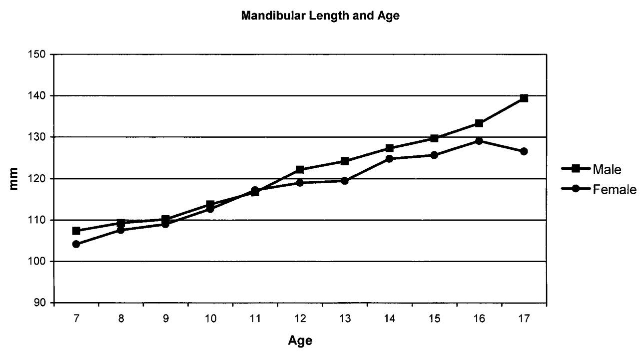

FIGURE 3. Diagram of average values for mandibular length (Co-Gn) at subsequent age periods for male and female subjects with Class III malocclusion.

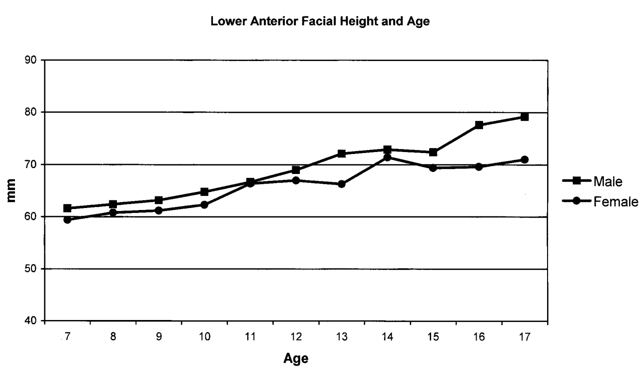

FIGURE 4. Diagram of average values for lower anterior facial height (ANS-Me) at subsequent age periods for male and female subjects with Class III malocclusion.

illa, mandible, and anterior facial heights when compared with male subjects during the circumpubertal and postpubertal periods.

This study also provides reference values for the cephalometric diagnosis of Class III male and female patients of Caucasian ancestry.

ACKNOWLEDGMENTS

The authors would like to thank Dr Alyssa S. Levin for her untiring efforts in helping assemble and analyze the cephalograms used in this investigation. This study was supported in part by funds made available through the Thomas M. and Doris Graber Endowed Professorship, Department of Orthodontics and Pediatric Dentistry, The University of Michigan.

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