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En español, por favor

A COMPARISON OF SKELETAL AND DENTOALVEOLAR CHANGES DURING FACEMASK THERAPY WITH GROWTH CHANGES IN UNTREATED CLASS III CONTROLS

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Parole chiave: Facemask, Class III, Dentoalveolar changes

Abstract: The purpose of this study was to compare the effects of facemask therapy in a slightly later age group than average (11.5 years for females, 11.8 years for males), with lighter forces than average (100-200g per side), to a Class III untreated control group and a normal control group. The treatment group consisted of 32 protraction headgear cases (15 males, 17 females). The Class III control group consisted of mixed longitudinal data from 50 untreated subjects (32 males, 18 females). The treatment group was also compared to subjects from the Bhatia and Leighton growth study. Linear and angular cephalometric measurements were taken before and after treatment. The facemask group showed significant dento-alveolar changes but no significant skeletal changes. Therefore facemask therapy in this age group and with light forces can be expected to help correct a Class III relationship with only dento-alveolar changes.

INTRODUCTION

The use of the protraction face-mask was first described more than 100 years ago by Potpeschnigg (1875). Delaire et al. (1976) revived the interest in this technique and later Petit (1983) modified the basic concepts of Delaire by increasing the amount of force generated by this appliance. There has been very little research in the UK when comparing the effects of protraction headgear to normal growth. Numerous studies have been done in Japan and to a certain extent in America. It is difficult to assess and compare the data from these studies to the UK population, as there are too many variables. Ideally, the effects of treatment with orthopaedic appliances should be compared with samples in the same skeletal category. For this study it has been possible to find a good sample size from the Greater London (UK) area and compare them to an untreated Class III growth study (Kangesu, 2000), and Bhatia and Leighton's growth study (1993). In this study the measurements are taken from longitudinal data and primarily linear measurements and ratios are analysed. These linear measurements would be a true indicator of any changes in normal skeletal growth during the protraction phase of therapy. It is known that the original design of the protraction headgear was to optimise the growth of the maxilla and to restrain the growth of the mandible. There are other documented changes that this type of therapy can introduce and dento-alveolar changes would be the most noticeable. Therefore, certain dental measurements have been included. The use of protraction headgear in the UK seems to be on the decrease but this form of therapy still stays popular in other orthodontic centres throughout the world. This study is to ascertain the outcome of protraction headgear that was used quite extensively at Kingston Hospital (Orton, 1992) during the 80's and early 90's. A number of questions need to be answered regarding the use of protraction headgear and hopefully this study can reveal the affects on skeletal growth with the use of the face-mask. It was intended to compare the treatment changes with normal growth and this would be done with linear and angular measurements. Longitudinal cephalometric radiographs of patients who had undergone orthodontic appliance therapy together with protraction facemasks were analysed with the following objectives in mind:

1. Does this mode of therapy really improve skeletal relationship?
2. Which clinical parameters are influenced the most?
3. Is the effect clinically significant and are treatment objectives obtained?

MATERIALS and METHOD

The material for this investigation was taken from 32 protraction headgear treated Class III cases (15 males and 17 females) at Kingston hospital, Surrey, UK. Supervision of these cases was by one Consultant Orthodontist who supervised a number of different operators. The criteria for these cases were that they did not have any surgical correction during treatment and no cleft lip and palate patients were included. Orthodontic treatment varied as some had removable appliances only whilst others had a combination of removable and fixed appliance therapy. The cephalometric lateral skull radiographs consisted of those at start of treatment, during treatment, end of treatment and out of retention. The number of radiographs for each period varied between the cases. The lateral skull radiographs that were taken during active protraction headgear treatment were noted with a positive sign (+) on the corresponding figures.

TABLE 1. Ages of sample at start of facemask therapy (years)

	Whole Group Mean SD	Males Mean SD	Females Mean SD
Start of Facemask Treatment	n=32 11.65 1.8	n=15 11.8 2.0	n=17 11.5 1.7

The salient cephalometric features of the male and female sample groups were as follows:

TABLE 2. Profile of Class III malocclusion in this study at 10 years old

Measurements	Male Sample	Female Sample
SNA	81.3°	76.95°
SNB	83°	78.27°
ANB	-1.71°	-1.32°
UI/Mx	110.92°	108.21°
LI/Md	84.38°	81.97°
Overjet	-0.45 mm	0.22 mm

The control group was taken from a UK Growth Study undertaken at King's College School of Medicine and Dentistry, London (Kangesu, 2000). This control group consisted of 50 Class III subjects (32 males and 18 females) and consisted of mixed longitudinal data from 6.5 to 20 years old. Furthermore, Bhatia/Leighton's Growth Study (1993) was also used and this data was from a continuous longitudinal study of normal growth. This study started with 736 subjects at birth and with wastage ended with 152 subjects at 18 years. The timing of protraction treatment and the variable length of treatment could not be controlled, as this was a retrospective study.

TABLE 3. Distribution of available records for different ages of the females in the total sample excluding the control group

(+) Denotes wearing of the protraction headgear

	Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1				*	**+	*+	*+		*				*		
2					*	*+	*+		*+						
3		*	*		*+			*							
4						*	*	*		*+					
5						*	*+		*+	*	*		*		*

6				*		*+	*+	*							
7				*		*+	*		*			*			
8						*		*+		*					
9			*			*+		**							
10				*		*			*+	*					
11		*				*	*+	*+							
12					*			*+		*	*				
13									*			*+			
14					*	*	*		*+	*+					
15					*	*	*		*+	*+					
16				*	*	*+		*+	*+						
17								*	*+	+*	*+				

TABLE 4. Distribution of available records for different ages of the males in the total sample excluding the control group

(+) denotes wearing of the protraction headgear

	Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1						*		*+	*+						
2				*	*		*+		*						
3								*		*+	*		*		
4									**+		*	*			
5					*		*	*	**+		*+	*+			
6			*		*	*		*+							
7					*			*+		*					
8				*	*	*	*+		*+			*			*
9			*	*		*+		*+	*				*		*
10		*	*+			*+			*			*			
11		*	*+		*										
12					*		*	*+	*+				*		
13			*				+					*			
14		*		*			*+		*						
15				*		*+			*+			*			

METHOD

Tracing Technique
A program was prepared with the list of 24 points to be digitised from each radiograph. The number, sex and age of the cases were recorded together with the number of radiographs. The longitudinal radiographs were digitised for each case in sequence noting the age of each radiograph. This ensured the same mental image was used for landmark identification. The landmarks, that were ambiguous due to lack of definition, were frequently checked to the others in the series.

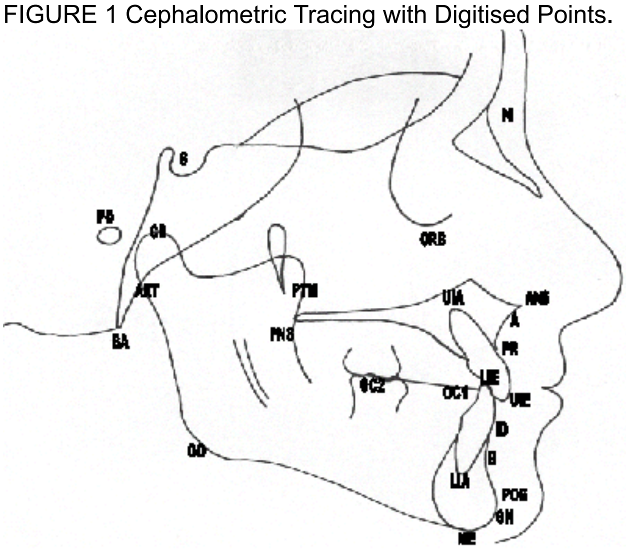
All digitisation's were carried out by one operator (JCS) and this was done using an integrated hardware and software computer system in the Orthodontic Department at King's College School of Medicine and Dentistry (Bhatia, 1987). The software package allows collection, editing and analysis of the data. The digitiser has a resolution of 0.025mm and an accuracy of 0.125mm, which is sufficiently sensitive to identify small yearly changes in skeletal dimensions.

Each radiograph was digitised twice and the mean was taken for each value

DIGITISER LINKED TO DEDICATED COMPUTER

Cephalometric Landmarks

FIGURE 1 Cephalometric Tracing with Digitised Points.



Measurement Technique

The data of each patient's radiographs was combined into one file. This file contained all the data for all the patients regarding age in months and the means of all the co-ordinates of all the radiographs in a serial order. The intervals between the radiographs were not taken regularly and to overcome the missing periods, the co-ordinate files were first converted into a single co-ordinate system and then split into six monthly intervals. This technique as described by Bhatia (1987) allowed extrapolated values to be produced for missing intervals and enable the growth data to be produced on smoothed growth curves. The progam generated monthly incremental coordinate values by dividing the differences between the X and Y coordinates of two successive ages by the interval in months between them in the following way:

Xd = $\underline{X2 - X1}$ and Yd = $\underline{Y2 - Y1}$

A2 - A1 A2 - A1

where Xd and Yd are interpolated monthly increments derived from the two sets of co-ordinates, X1 and X2, and Y1 and Y2, from the two successive recorded ages A1 and A2. These co-ordinates of all the radiographs were converted previously to the same S-N co-ordinate system; this mathematical manipulation did not alter the data in any way, and did not affect the individual growth curves.

Linear Measurements

The following linear measurements were taken from each radiograph.

- Sella to Nasion
- Anterior Nasal Spine to Posterior Nasal Spine
- Articulare to Anterior Nasal Spine
- Articulare to Pogonium
- Menton to Gonion
- Condylion to Pogonium
- Upper incisor edge from Posterior Nasal Spine

- Lower incisor edge from Posterior Nasal Spine

The use of ratios is useful if we wish to see the change of jaw relationships with age and treatment, and the following were measured;

- Nasion to Sella / Anterior Nasal Spine to Posterior Nasal Spine
- Nasion to Sella / Menton to Gonion
- Anterior Nasal Spine to Posterior Nasal Spine / Menton to Gonium
- Overjet measured with relation to occlusal plane

Angular Measurements

It was felt that the following angular measurements would be recorded to show the correction of the Class III malocclusion:

- Sella - Nasion - A-point
- Sella - Nasion - B-point
- A-point - Nasion - B-point
- Upper incisor to maxillary plane
- Lower incisor to mandibular plane
- Maxillary and mandibular plane angle

STATISTICAL ANALYSIS

Descriptive Statistics

The following were calculated for each of the variables used:

- Mean $(X) = \frac{\sum X}{N}$
- Standard Deviation (S.D.) $= \sqrt{\frac{\sum (X-X)^2}{N}}$
- Standard Error of the Mean (S.E.) $= \frac{S.D.}{\sqrt{N}}$

where N = the number of observations

X = the value of each observation

Inferential statistics

An independent t-test was carried out for comparison between the mean values of the 10 and 15-year-old groups for the different sexes.

$$t = \frac{M_f - M_g}{\sqrt{(S.E._f + S.E._g)}}$$

where $S.E. = \frac{S.D.}{\sqrt{N}}$

and N = the number of male or female cases.

Error study

The variability in identification of the hard-tissue landmarks was determined by direct double digitisation of radiographs. It was attempted to digitise all radiographs of subject in one sitting to ensure that the same mental picture of a landmark was used. These coordinates were utilised to calculate the variability in the identification of the landmarks in X and Y directions. The variability of 24 landmarks is shown as standard deviations of the coordinates numerically in Table 5.

TABLE 5. The root mean squares (mm) of the differences between the coordinates obtained on double digitisation at 12 years

X	Y
N 0.19	0.33
S 0.17 BA 0.41	0.19 0.33
CD 0.55	0.67
ART 0.35	0.37
GO 0.6	0.5
ME 0.24	0.19
GN 0.33	0.33
PG 0.24	0.7
B 0.18	0.4
ID 0.14 LIE 0.28	0.33 0.3
LIA 0.47	0.59
UIE 0.22	0.25
UIA 0.50	0.49
PR 0.30	0.26
A 0.3	0.5
ANS 0.76	0.39
PNS 0.79	0.26
PTM 0.37	0.88
OC1 1.22	0.30
OC2 0.9	0.35
ORB 1.1	0.4
PO 0 .68	0.68

These above figures were compared to Bhatia and Leighton (1993) error study and it was noted that the values for the X and Y were similar which implied that error in identification was on par with their study.

RESULTS

Although the data for some patients ranged from 10 to 17 years, to improve the adequacy of the sample only ages 10 to 15 were considered. The following measurements were analysed in more detail for this study:

- SNA angle
- SNB angle
- ANB angle
- ANS - PNS length
- ART - ANS length

- ART - POG length
- Ratio of ANS - PNS/ME - GO

A t-test was performed on each of the above between the sample and the control group for each age group. Growth profiles of these measurements are presented in table as well graphical forms and compared to the control samples. For males see Tables 6 -11 and Table 13. For the females see Tables 14 - 19 and Table 21.

Furthermore the following were analysed in the sample group only:

- Upper incisor inclination
- Lower incisor inclination
- Overjet
- Maxillary and mandibular planes angle

A t-test was done between the age groups for each measurement.

The red line on each graph indicates when protraction headgear was applied for each group (mean age for males = 11.8 years and for females = 11.5 years).

Table 12 (males) and Table 20 (females) depicts the changes in the inclination of upper and lower incisors, overjet and maxillary and mandibular plane angle for the sample group and is compared to Bhatia and Leighton study only.

Table 22 (males) and Table 23 (females) compare changes for each measurement from 10 to 15 years and compare it to the control group.

TABLE 6.		**INCREMENTAL CHANGES WITH FACEMASK THERAPY**		
SNA Angle		**Males**		
	Age	**10**	**12.5**	**15**
Sample		81.3	80.6	80.04
Incremental Changes			-0.7	-0.56
Control		78.76	79.65	79.02
Incremental Changes			0.89	-0.62
t-test		0.927		0.614
Bhatia/Leighton Study		79.8	80.3	80.8

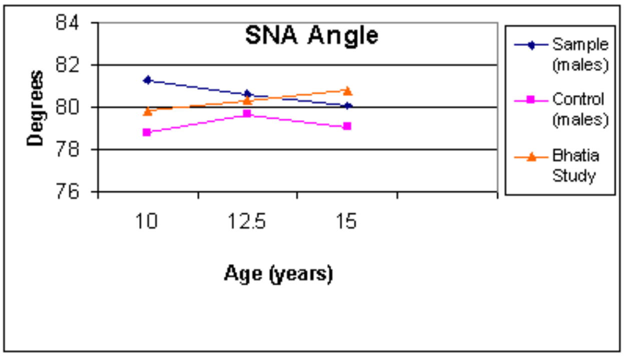


TABLE .7		**INCREMENTAL CHANGES WITH FACEMASK THERAPY**

SNB Angle		**Males**		
	Age	**10**	**12.5**	**15**
Sample		83	82.9	81.59
Incremental Changes			-0.1	-1.31
Control		79.94	80.47	82.36
Incremental Changes			0.53	1.89
t-test		1.717		-0.491
Bhatia/Leighton Study		76.5	77.1	78

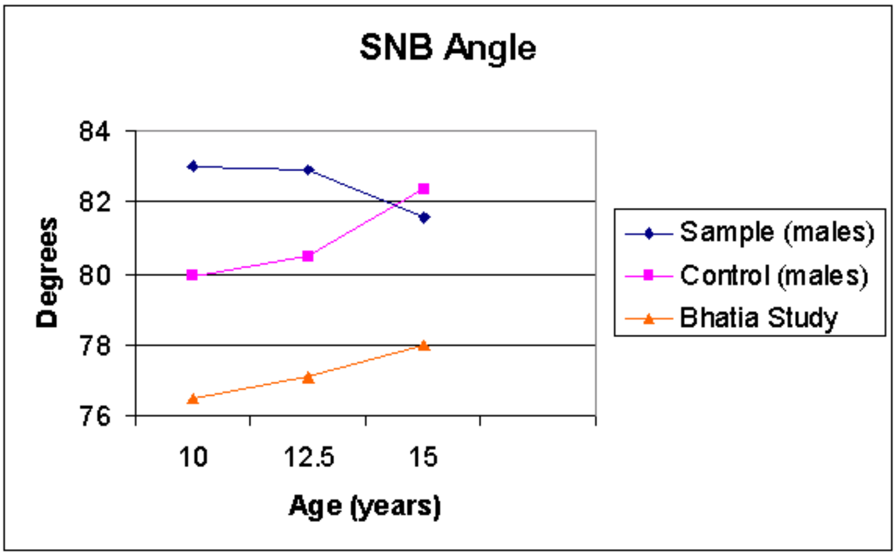


TABLE 8.		**INCREMENTAL CHANGES WITH FACEMASK THERAPY**		
ANB		**Males**		
	AGE	10	12.5	15
Sample		-1.71	-2.31	-2.01
Incremental Changes			-0.6	0.3
Control		-1.18	-2.19	-3.34

Incremental Changes			0.35	2.51
t-test		0.53		-1.119
Bhatia/Leighton Study		3.3	3.2	2.8

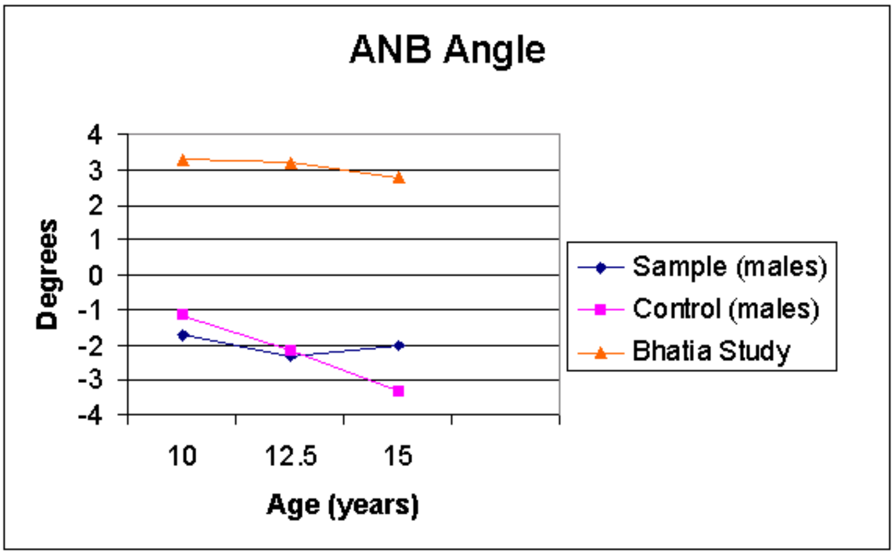


TABLE 9.		**INCREMENTAL CHANGES WITH FACEMASK THERAPY**		
ANS-PNS		**Males**		
	Age	**10**	**12.5**	**15**
Sample		48.07	49.62	51.46
Incremental Changes			1.55	1.84
Control		43.2	46.56	46.58
Incremental Changes			3.36	0.02
t-test		3.233		4.948
Bhatia/Leighton Study		47.4	49	51.8

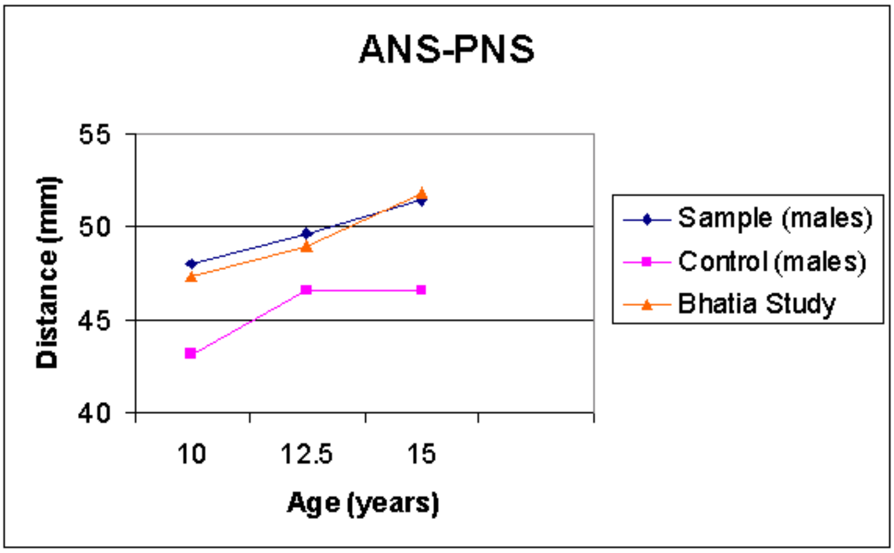


TABLE 10.		INCREMENTAL CHANGES WITH FACEMASK THERAPY		
ART-POG		Males		
	Age	10	12.5	15
Sample		99.42	104.11	111.33
Difference			4.69	7.22
Control		99.09	105.21	110.84
Difference			6.12	5.63
t-test		0.108		0.209
Bhatia/Leighton Study		93.4	97.1	105.2

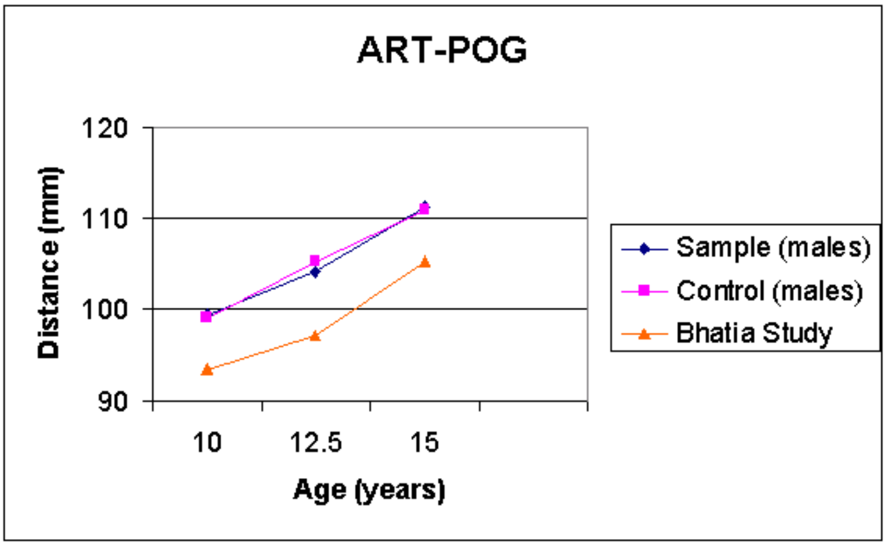


TABLE 11.		INCREMENTAL CHANGES WITH FACEMASK THERAPY		
ART-ANS		Males		
	Age	10	12.5	15
Sample		80.88	84.2	87.38
Incremental Changes			3.32	3.18
Control		78.6	81.91	79.91
Incremental Changes			3.31	-2
t-test		0.743		3.184
Bhatia/Leighton Study		81.2	83.6	88.4

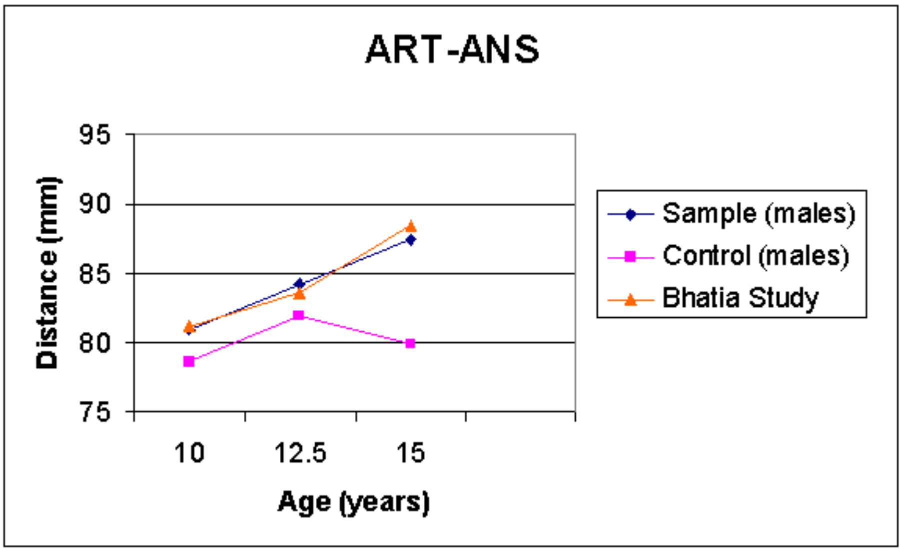


TABLE 12.		INCREMENTAL CHANGES WITH FACEMASK THERAPY				
<u>UI/Mx Plane Angle</u>			**Males**			
	<u>AGE (years)</u>	**<u>10</u>**	**<u>12.5</u>**	**<u>15</u>**		**<u>t-test</u>**
Sample		110.92	115.11	115.08		1.307
Incremental Changes			4.19	-0.03		
Bhatia/Leighton study		109.2	109.5	109.6		
t-test		0.952		2.373		
<u>LI/Md Plane Angle</u>						
Sample		84.38	79.77	78.13		-2.742
Incremental Changes			-4.61	-1.64		
Bhatia/Leighton study		90.2	91.7	91.8		
t-test		3.02		6.163		
<u>Overjet</u>						
Sample		-0.45	1	1.82		1.669
Incremental Changes			1.45	0.82		
Bhatia/Leighton study						

t-test						
Mx/Md Plane Angle						
Sample		28.32	29.14	31.16		-1.17
Incremental Changes			0.82	2.02		
Bhatia/Leighton study		29.3	28.8	27.6		
t-test		0.534		1.941		

Table 13.	**RATIOS**	**Males**		
Mx/MD				
	Age	10	12.5	15
Sample		0.72	0.69	0.69
Control		0.64	0.66	0.62
Bhatia/Leighton Study		0.74	0.74	0.73
t-test for Sample and Control				
		3.81		5

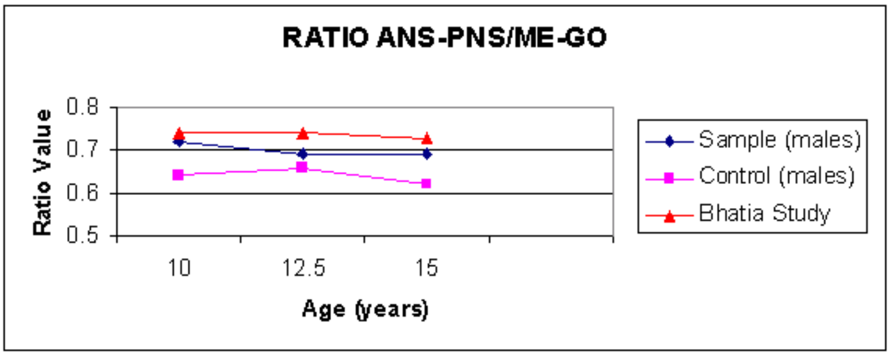


TABLE 14.		**INCREMENTAL CHANGES WITH FACEMASK THERAPY**		
SNA Angle		**Females**		
	Age	**10**	**12.5**	**15**

Sample		76.95	78.57	80
Incremental Changes			1.62	1.43
Control		76.77	77.67	77.51
Incremental Changes			0.9	-0.06
t-test		0.102		1.852
Bhatia/Leighton Study		79.4	79.9	80

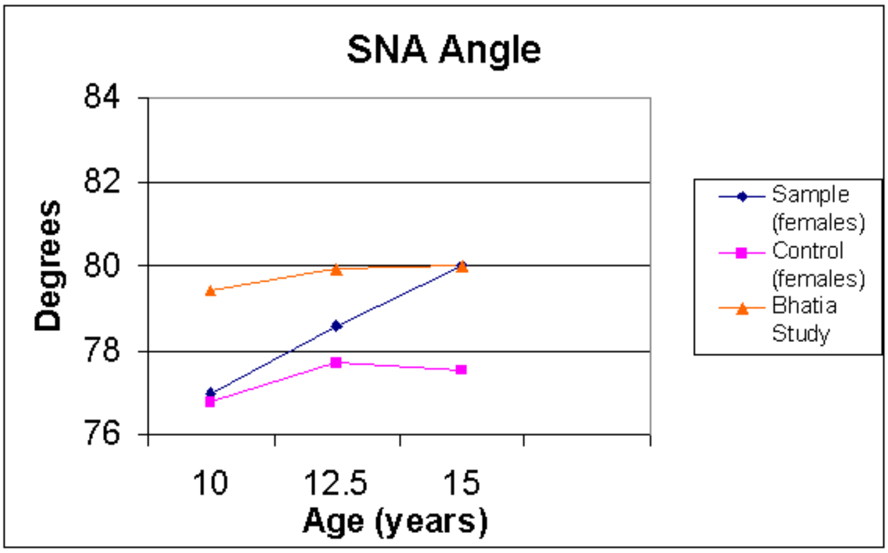


TABLE 15.		**INCREMENTAL CHANGES WITH FACEMASK THERAPY**		
SNB Angle		**Females**		
	Age	**10**	**12.5**	**15**
Sample		78.27	80.08	79.65
Incremental Changes			1.81	-0.43
Control		78.13	78.7	79.26
Incremental Changes			0.63	0.5
t-test		0.104		0.272

Bhatia/Leighton Study		76.7	77.5	77.9

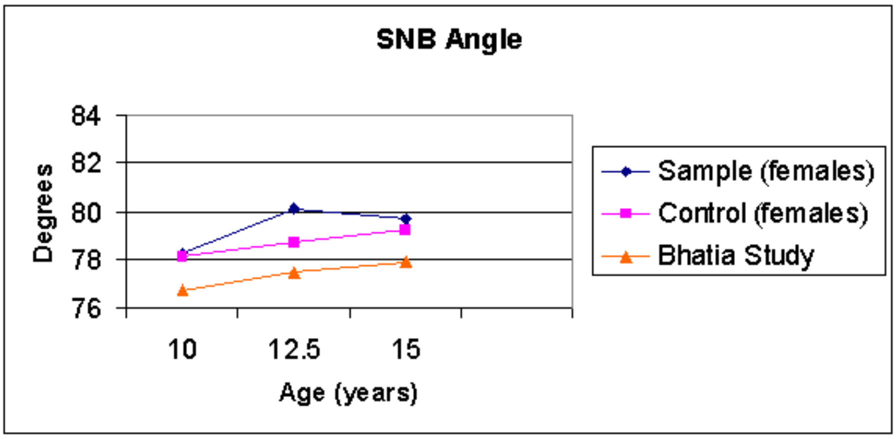


TABLE 16.		INCREMENTAL CHANGES WITH FACEMASK THERAPY			
ANS-PNS		Females			
	Age	10	12.5	15.5	17
Sample		44.99	47.22	47.33	48.66
Difference			2.23	0.11	1.33
Control		43.73	45.1	46.93	45.7
Difference			1.37	1.83	-1.23

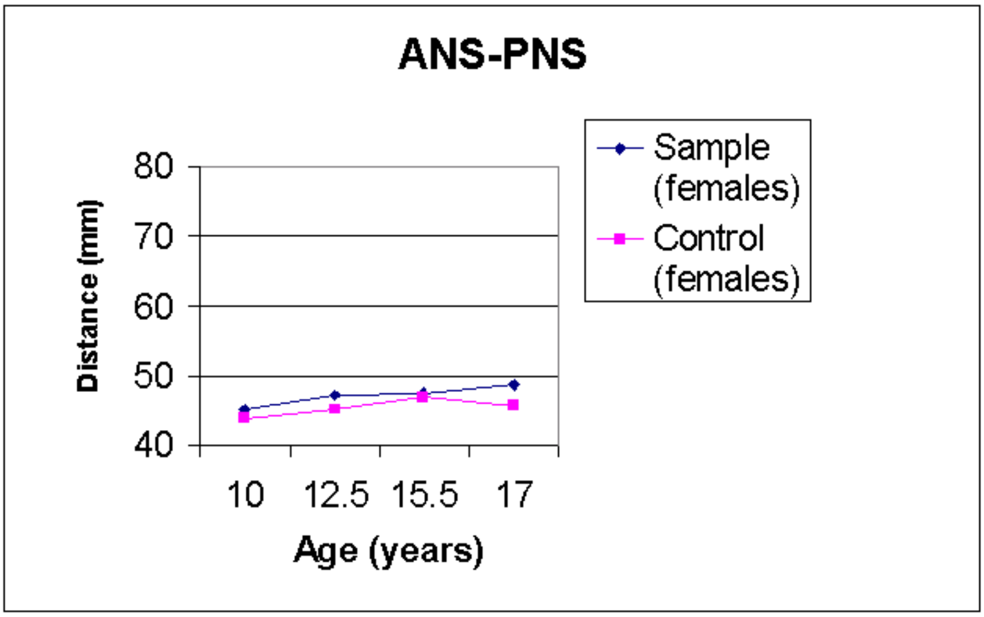


TABLE 17.		INCREMENTAL CHANGES WITH FACEMASK THERAPY					
ART-POG		Females					
	Age	10	12.5	15.5	17		
Sample		94.62	99.55	102.84	105.5		
Difference			4.93	3.29	2.66		
Control		96.87	101.38	105.22	105.71		
Difference			4.51	3.84	0.49		

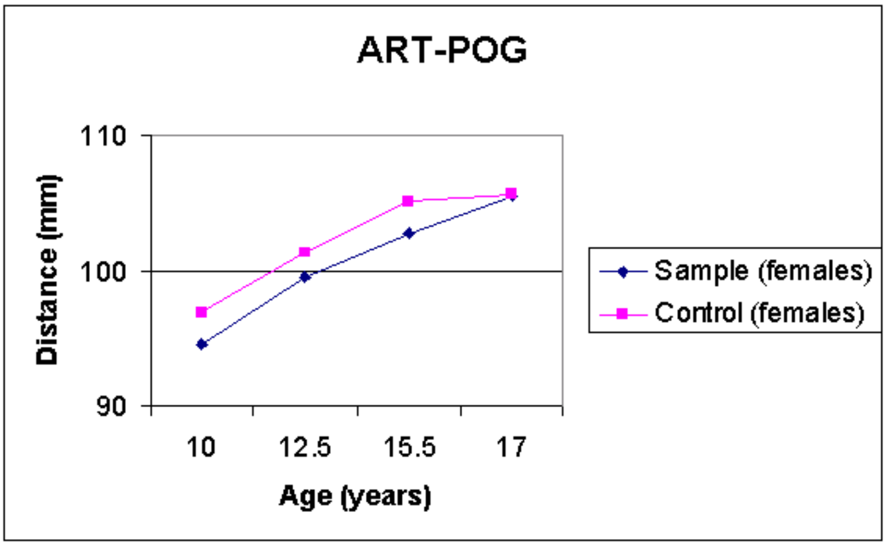


TABLE 18.		INCREMENTAL CHANGES WITH FACEMASK THERAPY					
ART-POG		**Females**					
	Age	**10**	**12.5**	**15**			
Sample		94.62	99.55	102.97			
Incremental Changes			4.93	3.42			
Control		96.87	101.38	104.35			
Incremental Changes			4.51	2.97			
t-test		-1.521		-0.644			
Bhatia/Leighton Study		91.4	95.8	100.4			

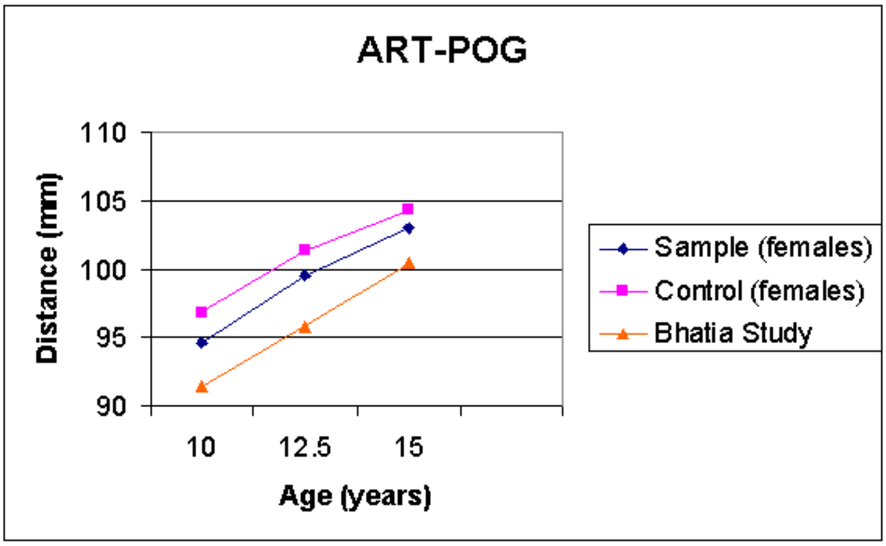


TABLE 19.		INCREMENTAL CHANGES WITH FACEMASK THERAPY		
ART-ANS		**Females**		
	Age	**10**	**12.5**	**15**
Sample		76.3	79	79.69

Incremental Changes			2.7	0.69
Control		76.47	78.23	79.43
Incremental Changes			1.76	1.2
t-test		0.11		0.13
Bhatia/Leighton Study		79.1	81.4	83.9

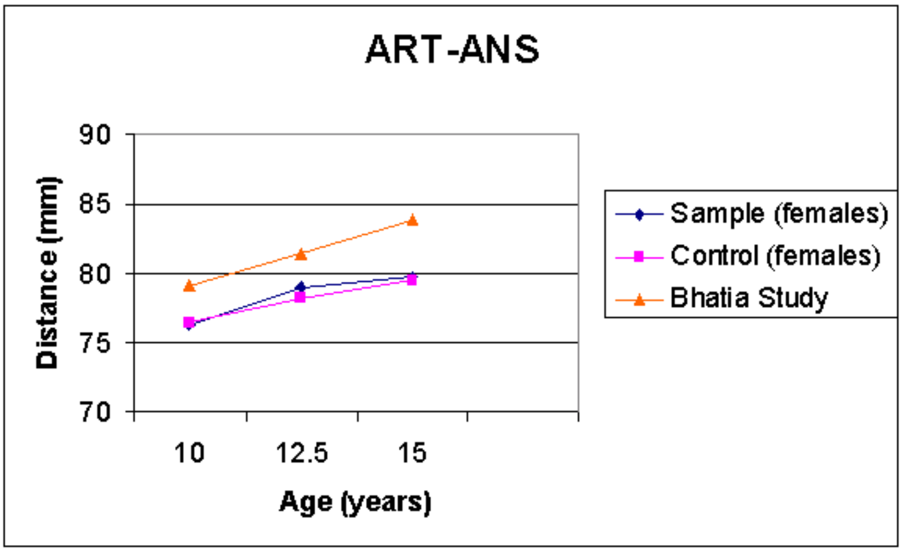


TABLE 20.		INCREMENTAL CHANGES WITH FACEMASK THERAPY				
UI/Mx Plane angle			**Females**			
	Age	**10**	**12.5**	**15**		**t-test**
Sample		108.21	113.58	115.43		-1.948
Incremental Changes			5.37	1.85		
Bhatia/Leighton study		109.8	109.4	109.2		
t-test		0.577		2.226		
LI/Md Plane angle						
Sample		81.97	80.32	76.3		1.431
Incremental Changes			-1.65	-4.02		

Bhatia/Leighton study		90.8	90.7	89.6		
t-test		3.013		4.688		
Overjet						
Sample		0.02	1.89	2.99		3.177
Incremental Changes			1.87	1.1		
Bhatia/Leighton study						
t-test						
Mx/Md Plane angle						
Sample		31.2	29.51	31.35		0.061
Incremental Changes			-1.69	1.84		
Bhatia/Leighton study		28.5	27.8	26.3		
t-test		1.49		2.666		

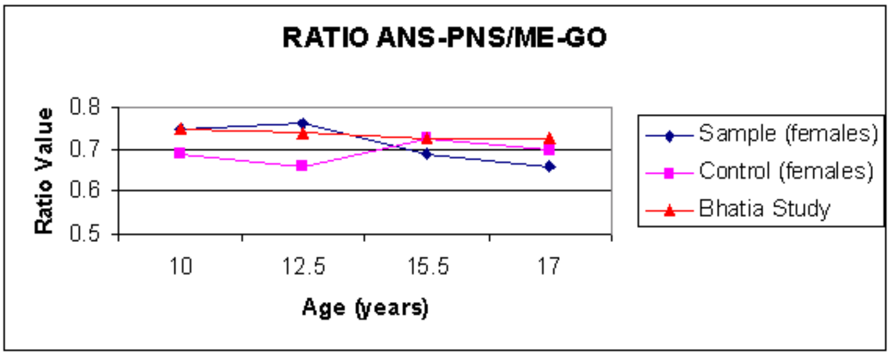


TABLE 21.		**INCREMENTAL CHANGES WITH FACEMASK THERAPY**		
RATIOS		**Females**		
Mx/MD				
	Age	**10**	**12.5**	**15**
Sample		0.71	0.71	0.71
Control		0.69	0.68	0.69
Bhatia Study		0.75	0.74	0.73
t-test between Sample and Control		1.818		0.942

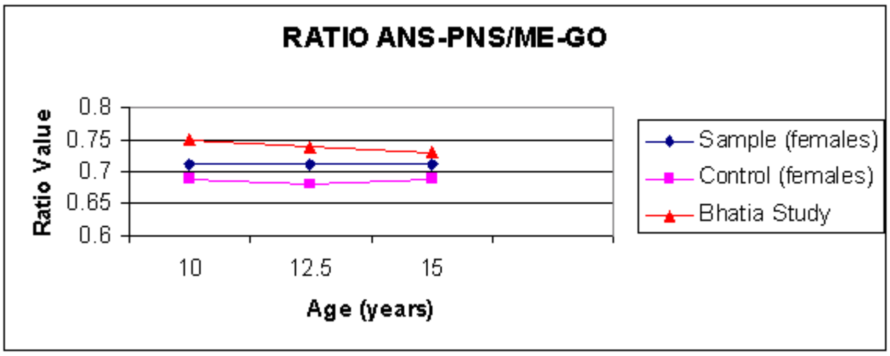
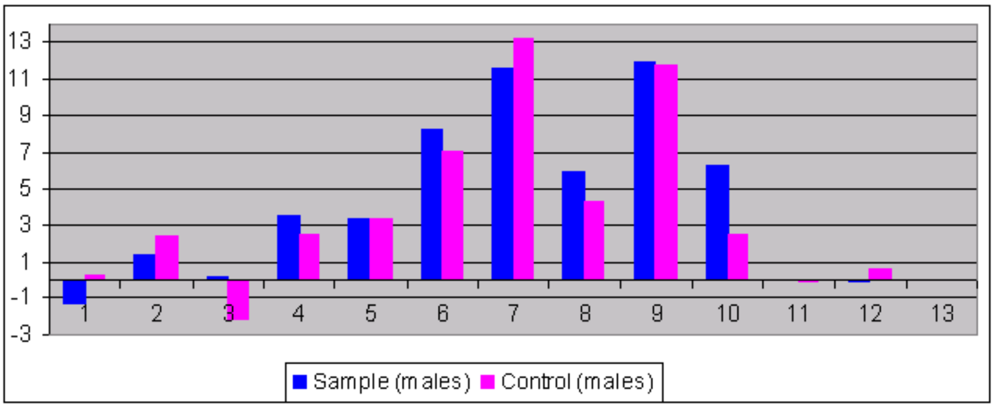


TABLE 22.	CHANGES IN MEASUREMENTS BETWEEN 10 AND 15 YEARS OLD					
<u>SAMPLE</u>	**<u>MEAN</u>**	**<u>S.D.</u>**		**<u>MEAN</u>**	**<u>S.D.</u>**	**<u>Difference</u>**
Male	**10 Years Old**			**15 Years Old**		**<u>in mean</u>**
SNA	81.3	3.07		80.04	3.65	-1.26
SNB	83	3.26		81.59	4.31	1.41
ANB	-1.71	1.54		-1.55	2.34	0.16
N-S	65.33	1.7		68.85	3.98	3.52
ANS-PNS	48.07	1.73		51.46	1.99	3.39
ME-GO	66.58	4.14		74.8	5.39	8.22
CD-POG	106.88	4.16		118.42	6.99	11.54
CD-ANS	81.4	3.68		87.33	5.31	5.93
ART-POG	99.42	4.26		111.34	5.98	11.92
ART-ANS	80.88	3.74		87.17	5.08	6.29
RATIO N-S/ANS-PNS	1.36	0.05		1.33	0.06	-0.03
RATIO N-S/ME-GO	0.98	0.05		0.92	0.06	-0.06
RATIO ANS-PNS/ME-GO	0.72	0.03		0.69	0.04	-0.03
UI/MxP	110.92	7.34		115.08	6.42	4.16
UIE-PNS	45.6	2.66		49.66	2.26	4.06
LIE-PNS	46.06	3.66		47.84	3.38	1.78
Overjet	-0.46	2.71		1.82	3.21	2.28
LI/MdP	84.38	3.39		78.13	6.26	-6.25

Mx/MdPA	28.32	5.33		31.16	5.22	2.84
CONTROL						
Male						
SNA	78.76	2.71	1	79.02	4.93	0.26
SNB	79.94	4.67	2	82.36	3.21	2.42
ANB	-1.18	2.85	3	-3.34	3.82	-2.16
N-S	64.66	3.16	4	67.19	4.01	2.53
ANS-PNS	43.2	4.62	5	46.58	3.52	3.38
ME-GO	67.17	5.41	6	74.32	3.77	7.15
CD-POG	105.17	9.1	7	118.44	5.86	13.27
CD-ANS	79.14	5.54	8	83.44	6.46	4.3
ART-POG	99.09	9	9	110.84	5.73	11.75
ART-ANS	78.6	5.67	10	81.1	6.45	2.5
RATIO N-S/ME-GO	0.96	0.05	12	0.9	0.06	0.611
RATIO ANS-PNS/ME-GO	0.64	0.06	13	0.62	0.04	-0.02

Comparison of the differences in the mean values between Sample and Control (Males)



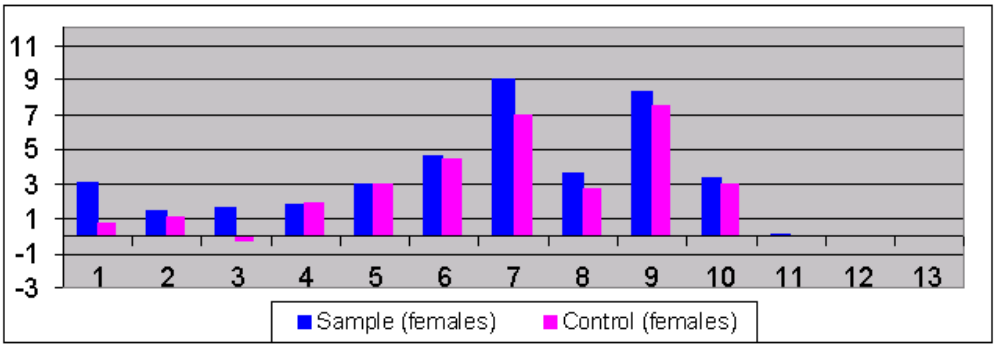
	Index of Numbers			7	CD-POG
1		SNA		8	CD-ANS
2		SNB		9	ART-POG
3		ANB		10	ART-ANS
4		N-S		11	RATIO N-S/ANS-PNS
5		ANS-PNS		12	RATIO N-S/ME-GO

6		ME-GO		13	RATIO ANS-PNS/ME-GO

TABLE 23.	CHANGES IN MEASUREMENTS BETWEEN 10 AND 15 YEARS OLD								
	SAMPLE		**MEAN**	**S.D.**		**MEAN**	**S.D.**		**Difference**
	Female		**10 Years Old**			**15 Years Old**			**in mean**
	SNA		76.95	3.21		80	3.06		3.05
	SNB		78.27	3.41		79.65	4.05		1.38
	ANB		-1.32	1.53		0.35	3.33		1.67
	N-S		62.5	2.32		64.38	3.11		1.88
	ANS-PNS		44.99	1.84		47.97	2.24		2.99
	ME-GO		63.05	2.39		67.62	3.67		4.57
	CD-POG		102.08	4.89		111.06	4.57		8.98
	CD-ANS		77.43	3.08		81.02	4.84		3.59
	ART-POG		94.62	4.3		102.97	4.35		8.35
	ART-ANS		76.3	3.03		79.69	4.44		3.39
RATIO N-S/ANS-PNS			1.39	0.04		1.34	0.06		0.05
RATIO N-S/ME-GO			0.99	0.05		0.95	0.05		-0.04
RATIO ANS-PNS/ME-GO			0.71	0.02		0.71	0.05		0
	UI/MxP		108.21	7.76		115.43	8.79		7.22
	UIE-PNS		41.82	3.16		47.74	3.98		5.92
	LIE-PNS		41.8	3.32		44.75	4.6		2.95
	Overjet		0.02	1.58		2.99	2.55		2.97
	LI/MdP		81.97	8.72		78.27	8.92		-3.7
	Mx/MdPA		31.2	5.14		31.35	5.85		0.15
	CONTROL								
	SNA		76.77	3.74	1	77.51	3.64	0.74	0.74
	SNB		78.13	4.19	2	79.26	2.89	1.13	1.13

	ANB		-1.37	3.1	3	-1.75	2.98	-0.38	-0.38
	N-S		63.62	1.35	4	65.54	2.48	1.92	1.92
	ANS-PNS		43.73	1.35	5	46.64	3.21	2.91	2.91
	ME-GO		62.87	3.17	6	67.25	4.16	4.38	4.38
	CD-POG		103.51	1.47	7	110.47	3.85	6.96	6.96
	CD-ANS		77.55	3.23	8	80.31	4.57	2.76	2.76
	ART-POG		96.87	0.99	9	104.35	3.52	7.48	7.48
	ART-ANS		76.47	3.09	10	79.43	4.2	2.96	2.96
RATIO N-S/ANS-PNS			1.45	0.03	11	1.4	0.08	-0.05	-0.05
RATIO N-S/ME-GO			1	0.04	12	0.97	0.07	-0.03	-0.03
RATIO ANS-PNS/ME-GO			0.69	0.02	13	0.69	0.06	0	0

Comparison of the differences in the mean values between Sample and Control (Females)



	Index of Numbers				
				7	CD-POG
1		SNA		8	CD-ANS
2		SNB		9	ART-POG
3		ANB		10	ART-ANS
4		N-S		11	RATIO N-S/ANS-PNS
5		ANS-PNS		12	RATIO N-S/ME-GO
6		ME-GO		13	RATIO ANS-PNS/ME-GO

DISCUSSION

This study is based on clinical records from subjects that had protraction headgear therapy at Kingston Hospital, where it was previously felt that protraction headgear therapy was beneficial in the treatment of Class III malocclusions using the lightest force that would still produce a useful clinical result. The present study investigates this principle with a view in isolating skeletal changes from dento-alveolar changes. The timing with the application of protraction headgear is later than conventionally applied and this could be due to the later age of referring to the hospital in the UK. Thus it could be expected that the study might not show any skeletal changes. This study had a mean of 11.8 years for the males (S.D. = 2.0) and 11.5 years for the females (S.D. = 1.7). Patient co-operation is of major importance for the treatment outcome and it is suggested, the younger the patient, the more co-operative the patient will be. Furthermore early intervention with orthopaedic maxillary protraction could provide a non-surgical alternative. Cozzani (1981) advocated starting at a young age, even as young as 4 years old and he concluded that starting after 6 years of age would limit the orthopaedic changes. On the contrary, Merwin et al. (1997) found that similar skeletal response can be obtained when maxillary protraction was started either before age 8 (5-8 years) or after 8 (8-12 years). The main control group (Class III) was from a mixed longitudinal study that has a disadvantage of not being a true continuous longitudinal study. The other control group (Bhatia/Leighton) is a true longitudinal growth study but the data was taken from normal growth patterns incorporating mainly Class I subjects.

Changes in skeletal relationship
Angular Measurements

Male Group
In the male sample group, SNA reduces (1.26 degrees) between 10 and 15 years, whilst the control group shows very little change (0.27 degrees). Bhatia/Leighton's sample increases for this period by 1 degree. However, SNB reduces by 1.41 degrees compared to the other 2 control studies that both show increases (> 2 degrees for the control). This is further reflected with ANB angle, which increases for the sample whilst with the 2 control groups it decreases. The trend shows an increase in ANB but it is not statistically significant.

Female Group
In the female sample group, the SNA increases between 10 and 15 years old (average + 3.05 degrees), whilst the control group shows very little change (0.84 degrees), as does Bhatia/Leighton's study. SNB does not show statistically any significant changes between the 3 groups. However, ANB shows an increase by 1.67 degrees compared to the other 2 groups that both show a decrease in value. The trend shows an improvement in ANB but once again not statistically significant.

Linear Measurements

Male Group
In the male sample group, ANS - PNS length did show a statistically significant ($p<0.001$) increase compared to the control group but not when compared to Bhatia/Leighton's study. The ART - POG measurements for the 3 groups do not show any significant differences when compared to each other. However, ART - ANS for the sample group did show a significant increase (6.5mm) when compared to the control group (1.31mm) but increases in the same proportion when compared to Bhatia/Leighton's study (7.2mm). The ratio of maxillary length to mandibular length is statistically significantly higher in the male sample when compared to the control group ($p<0.001$), which seems to be due to a larger ANS - PNS measurement in the sample group.
The male sample group seemed to respond better when the measurement ART-ANS was compared to the control group and the indication is that the protraction therapy facilitated the full growth potential. Female Group In the female sample group, ANS - PNS length and ART- POG length increases incrementally in the same proportion between all three groups. The increases in ANS - PNS length of the sample (2.98mm) and control group (2.91mm) are similar when they are compared to Bhatia/Leighton's study (2.8mm). Similarly, the ART-POG length (8.35mm) is not significantly greater in length when compared to Bhatia/Leighton's study (9mm) and when compared to the control group (7.48mm). The incremental changes in ART - ANS lengths are proportionally similar between all three groups as was shown with ART - POG length. The ratio Mx length/Md length for the sample did not alter from 10 to 15 year age groups but did slightly reduce for the control and Bhatia/Leighton's study group.
In this study the ART - ANS and ART - POG measurements seem to indicate that the maxillary length for the sample and control seems to slow down in growth when compared to Bhatia/Leighton's study. Furthermore, protraction therapy with light forces and applied at a later age do not induce any significant skeletal changes.

Dento-alveolar Changes

Male sample group
Clinically and radiographically, it was noted that the upper incisors proclined (4.16 degrees) and the lower incisors retroclined (6.25 degrees) and a positive overjet (1.82mm) was achieved. The Mx/Md plane angle increased by 2.9 degrees and this compares to a reduction of 2 degrees in Bhatia/Leighton's study.

Female sample group
The upper incisors proclined by 7.22 degrees and the lower incisors retroclined by 5.67 degrees. The overjet corrected by 2.97 mm and this was statistically significant ($p<0.001$). The Mx/Md plane angle reduced by 0.15 degrees and this compares to 2.5 degrees in Bhatia/Leighton's study.

The significance of this data was obscured by the wide range of variability of the different patients in this sample. This has been a problem in past studies and Delaire (1997) noted that SNA ranged from 68 to 90 degrees, SNB from 70 to 90 degrees and ANB between -5 to +7.5 degrees in 172 cases treated with facemasks. This vast range of variables increases the difficulty to analyse the data successfully and a number of different approaches have been used to overcome this problem. Certain studies used a smaller group with similar starting measurements (Pangrazio-Kulbersch et al., 1998), whilst others only measured incremental growth changes (Franchi et al., 1998). Delaire used cranio-facial architectural analyses and superimposition to overcome the wide variance. However, the data did show the different tendencies when protraction headgear was applied and the individual responses from skeletal and dento-alveolar structures were noted.
The facemask appliance used at Kingston Hospital was used at a later age when compared to other centres and the force applied was approximately 100-200 g per side. Delaire (1997) uses anything up to 1000 g per side when using protraction facemasks. The skeletal response for this sample was not significant when compared to the control group and the Bhatia/Leighton's growth study. The mean age for the females was 11.5 and 11.8 for the males which is much later than suggested by Tindlund (1994) and Ngan et al. (1996) who recommended use of protraction headgear in the early mixed dentition. Delaire (1997) noted that an increase in SNA from protraction reduced as the patient got older and the average for the 12-14 years group was an average increase of 1.84 degrees. In other studies an increase of up to 3.6 degrees with SNA was reported (Cozzani, 1981) but treatment was started before the age of 9 years. Cozzani also advocated forces approximately 1000 g per side.
In this study SNA increased by 3.05 degrees for the female sample but then decreased by 1.26 degrees for the male sample. The change in ANB was not significant but it did show an improvement and a correcting trend was noted for the protraction group when compared to the control group.
The male group responded more favourably with protraction therapy than the female group when the ART - ANS changes was compared to the control and Bhatia/Leighton's study.
Dento-alveolar changes were most significant with the protraction sample as correction of overjet was on average 2.62mm. Upper incisors proclined on average by 5.69 degrees and lower incisors retroclined by 5.96 degrees. The Mx/Md plane angle did not change in the female group but did increase by 2.9 degrees for the males.

CONCLUSION

In summary, the protraction group did show dento-alveolar changes during protraction therapy but no significant skeletal changes. The main factors for this are:

- Later age of application of facemasks
- Light forces used with facemask therapy
- Most of the force was applied to removable appliances, which do not fully transmit the forces to the skeletal structures.

In view of the above, it would seem that protraction therapy as previously used at Kingston Hospital was designed to correct mild Class III malocclusions effectively by dento-alveolar means only.
Considering the great diversity of anatomical forms of Class III, it is not surprising that protraction headgear gives widely varying results.
Unfortunately this study does not answer the question regarding post-treatment relapse or if normal growth will catch up?
However, from this sample only one patient continued treatment with a surgical correction.
Clinically it was noted that certain cases showed a mild form of relapse, which was evident when measuring the overjet.

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