

Buccal and lingual soft tissue pressures In different malocclusions

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Abstract

Introduction: Muscular environment of the teeth is thought to be one of the major factors in determining the form and maintenance of the human dental arch. It is imperative to study the labial/buccal and lingual resting and swallowing pressure over the upper and lower central incisors and first permanent molars respectively, in different malocclusions, in natural head position, hence this being the aim of the study.

Material and Methods: The study sample consisted of 60 subjects (30 males and 30 females) with an average age of 19.35 years. The sample was divided into groups based on skeletal and dental classification, gender, and vertical growth pattern. EPL BO Diaphragm Pressure Transducer was used to measure the pressures exerted by buccal and lingual soft tissues. Pressure variability's were compared between subjects of normal occlusion with Class II division 1, Class II division 2, and Class III individuals statistically.

Results: Comparison showed a significant difference between the various skeletal classifications in generating pressure from the peri-oral musculature.

Conclusions: It was also observed that males had a greater magnitude of pressures than females of the same skeletal pattern. Vertical growth pattern analysis showed that low angle subjects had higher-pressure values than high angle individuals.

Keywords: Transducer; lip and cheek pressures; rest position; tongue

Introduction

Malocclusion is a developmental condition. In most instances, malocclusion and dentofacial deformity are caused not by some pathological process but by moderate distortion of normal development.¹

The muscular environment of the teeth has long been thought to be one of the chief factors in determining the form and maintenance of the human dental arch. This environment has been thought of principally as the tongue on the inside and the lips and cheeks on the outside modified by certain other factors such as the mutual support given by the teeth to each other, their

inclinations and their responses to the functional forces put upon them.²

Tomes proposed the concept that the position of the teeth in the dental arch is affected by the surrounding musculature as early as 1873.³ In spite of the continuous interest of orthodontists in the influence of soft tissues surrounding the dental arches on the position of teeth, this influence is far from clear.

The relationship between soft tissue pressures and the development of normal occlusion or malocclusion are much easier to understand from the perspective of equilibrium theory. Equilibrium theory as applied in engineering states that an object subjected to unequal forces will be accelerated and thereby will move to different position in space. From this perspective the dentition is obviously in equilibrium since the teeth are subjected to a variety of forces but do not move to a new location under usual circumstances. Proffit⁴ stated that equilibrium of environmental

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forces must exist around the dentition. According to this author, two major primary factors are involved in the equilibrium that determines the final position of the teeth. These are (1) the resting pressures of lip, cheek and tongue, and (2) forces produced by metabolic activity within the periodontal membrane.

Many researchers have studied the relationship between form and function of the stomatognathic system. It is widely accepted that an interaction exists between muscle function and dentofacial forms. However, it has long been debated whether muscle function influences bone morphology or merely adapts to local changes in the environment. For years, orthodontists have theorized that the size, posture, pressures from the lips, cheek and function of the tongue must have some relationship to the surrounding oral cavity.^{5,6,7,8,9,10} Luffingham,^{11,12} Thuer and Ingervall¹³ reported that the lip pressure against upper incisors in the rest position varied with overjet. Pressure from the tongue on the teeth has been measured by Winders,¹⁴ Proffit,^{15,16} Lear and Moorrees¹⁷ among other investigators.

Hence soft tissue pressures are still a question of debate; there are no comparisons of different malocclusions from the point of soft tissue pressures. Therefore the aim of the present investigation is to study the labial/buccal and lingual resting and swallowing pressure over the upper and lower central incisors and first permanent molars respectively, in different malocclusions, in natural head posture.

Material and Methods

A total of 60 subjects (30 males and 30 females), were selected in this study. The mean age for the total group was 19.35 ± 4.80 years. Mean age for males was 21.17 ± 4.24 years while females had a mean age of 17.53 ± 4.83 years. The subjects were selected according to the following criteria:

Healthy subjects with permanent dentition, good facial balance determined by visual inspection. None of the subjects reported any kind of habits that could effect lip, cheek or tongue pressure. None of the subjects had undergone previous orthodontic or surgical treatment. None of the subjects were under any pharmaceutical therapy that might influence muscle tone. A consent form was reviewed and signed by each subject.

Subjects with four kinds of malocclusion were selected. That is Angle's, Class I, Class II-division 1, Class II-division 2, and Class III dental and skeletal relationship. The dental classification of each subject corresponded with their skeletal classification. For example; a subject with Class I malocclusion was also skeletally Class I. The sample was grouped according to three categories;

According to the skeletal and dental classification into four groups (a) Class I (C1), (b) Class II division 1 (C21), (c) Class II division 2 (C22) and (d) Class III (C3).

According to gender difference. Males and females of each skeletal and dental classification group were separated thus resulting into eight groups. (a) M1, (b) M21 (c) M22, (d) M3, (e) F1, (f) F21, (g) F22, (h) F3.

According to the vertical pattern of growth into (a) high angle and (b) low angle groups. (SN-GoMe was used as the separating criteria. More than 38° SN-GoMe was considered to be high angle).

Plaster models, photographs, panoramic and lateral cephalometric films were taken initially. Cephalograms were used to determine the skeletal classification, while the dental classification was determined clinically and reconfirmed by the plaster models. Panoramic radiographs were used to rule out any major periodontal problem.

An Epl BO diaphragm pressure transducer was connected to a digital strain indicator to measure lip, cheek and tongue pressures exerted on the maxillary and mandibular dental arches.

Calibration - The pressure transducer was calibrated by using a pressure chamber, which had a pressure manometer (Figure.1). The transducer was placed in the chamber passing from a rubber bolt and air pressure was increased up to 1000 gm/cm². The values of the transducer were recorded on every 20 gm/cm² and the gauge factor of the monitor was correlated so that a one digit on the monitor of strain indicator would correspond to 1gm/cm² pressure.

Pressure recording method - The stents were fabricated on the duplicated models. Four stents were constructed for each subject, for maxillary and mandibular right central incisors and first molars. Using a bird beak plier a 0.016 x 0.016-inch stainless steel wire was shaped to mimic the crown morphology, extending from the labial/buccal gingival margin to the lingual/palatal gingival margin. The wire was closely adapted to the crown of the tooth. This wire served as a base for the acrylic cap. Self cure acrylic was then placed in such a way that the wire was embedded in it. The extension of the acrylic cap was approximately half the crown length on both the labial/buccal and lingual/palatal sides. Thus, the pressure was measured from the cervical one third of the crown. The stent did not encase the mesial or distal surfaces of the tooth (Figure. 2).

A pressure measuring system based on a strain indicator and an intraoral pressure transducer was adjusted. The fabricated stents were placed on the respective teeth to check their fit. Once confirmed the transducer was ligated to the wire extension of the stent. The distance of the transducer after ligation was approximately 1-2 mm, from the surface of the tooth. Maximum effort was made to ensure that the ligation did not exert any unintentional pressure on the transducer.

The subject was seated in the dental chair and natural head position was established with the relaxed subject sitting upright, fixing his/her gaze on a stationary eye level object six feet away. The patient was instructed not

to eat or drink anything too hot or too cold before the appointment. The stent-transducer complex was then placed on the desired tooth (Figure.3, 4, 5). To maintain the thermal compensation, the transducer was placed in the mouth and allowed to reach to the mouth temperature at least for 10 seconds. The upper lip was gently retracted from the transducer by using a mouth mirror and the balance of the gauge adjusted to zero. The lip was released and for the assessment of the rest position, the subjects were asked to count to determine the rest position. During recording of the rest position five readings were taken and an average of five was used while maximum values were recorded for other measurements.

Types of Pressures - Measured Resting and tensing pressures were recorded in the present study.

Resting pressures were recorded during lips and tongue in a relaxed position. Tensing pressures were measured when the subject swallowed 10 cc of water and during pronunciation of "U" sound for labial/buccal side, and pronouncing "EN" sound for lingual side. Pressures while pronouncing "U" and "EN" sounds were only recorded in the upper arch. At the recording session, recordings were made one at a time in the following locations;

- Maxillary right central incisor (labial and lingual)
- Maxillary right first molar (buccal and lingual)
- Mandibular right central incisor (labial and lingual)
- Mandibular right first molar (buccal and lingual).

Dahlberg's method was used to calculate the error of method. The measurements of 15 randomly selected patients were repeated an hour after the first recordings. There was no significant difference between the measurements. Statistical evaluation was made by using the first measurements.



Figure 1: Laboratory calibration (the calibration of the transducer by using a pressure chamber)

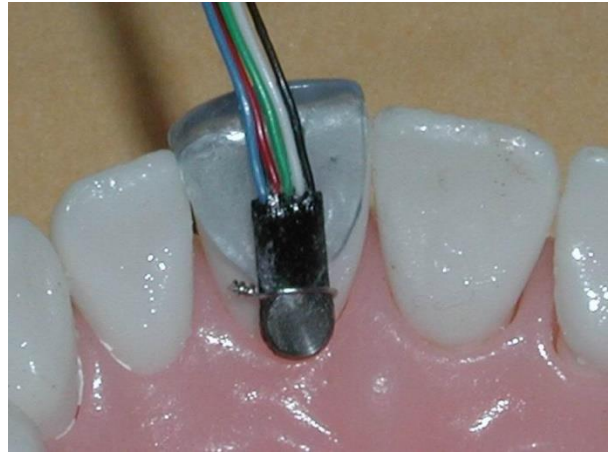


Figure 4: Transducer placed on the lingual surface of upper central incisor

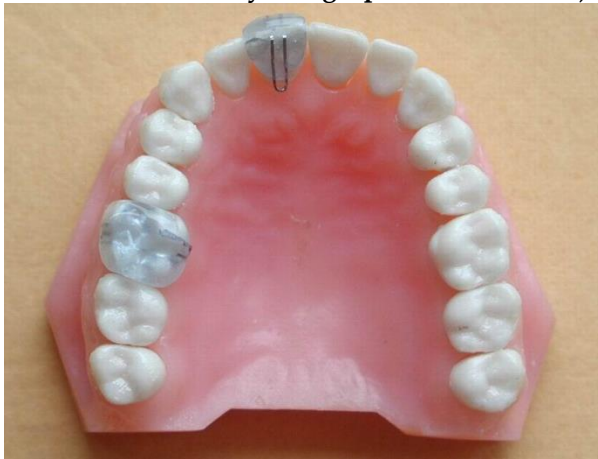


Figure 2: Customized acrylic stents



Figure 5: Transducer placed on the buccal surface of lower first molar.



Figure 3: Transducer placed on the labial surface of upper central incisor.



Figure 6: Transducer and stent thickness.

The data in this study was evaluated by SPSS program for windows. The groups were compared with each other by Mann Whitney U test.

Results

Malocclusion groups

Almost all the results according to skeletal classification were statistically significant. Mean Cephalometric values are listed in Table I. Mean pressure values are listed in Table II and their comparisons in Table III.

Lip pressures

Upper incisor buccal resting pressures were recorded highest in Class II div 1 subjects ($26.10\text{gm}/\text{cm}^2 \pm 2.20$) and lowest in Class III subjects ($12.36\text{gm}/\text{cm}^2 \pm 1.65$) (Table II). Comparison among the groups showed significant difference in C1 x C21 ($p < .000$) (Table II), C21 x C22 ($p < .001$) (Table III), and C21 x C3 ($p < .000$) (Table III). During swallowing greatest pressures were recorded in Class II div II ($106.37\text{gm}/\text{cm}^2 \pm 2.33$) and lowest in Class II div 1 ($45.44\text{gm}/\text{cm}^2 \pm 2.40$) (Table II). Comparisons among the groups revealed great significance in all the groups. Speech pressures like resting pressures were higher in Class II div 1 subjects and lower in Class III subjects.

In the lower arch highest pressures at rest were in Class III subjects, $83.22\text{gm}/\text{cm}^2 \pm 2.35$, and lowest in Class II div 2 subjects, $27.68\text{gm}/\text{cm}^2 \pm 1.71$ (Table II). During swallowing maximum pressures were recorded in Class II div 2 subjects, $111.93\text{gm}/\text{cm}^2 \pm 1.85$, and minimum in Class III subjects, $51.43\text{gm}/\text{cm}^2 \pm 2.49$ (Table II). Comparisons among groups revealed great significance in all groups, except C1 x C21 ($p < .436$) (Table III) during swallowing.

Cheek pressures

In the upper arch highest pressures during rest and swallowing were recorded in Class II div 2 subjects ($44.21\text{gm}/\text{cm}^2$ & $98.95\text{gm}/\text{cm}^2$), and lowest in Class III subjects ($24.74\text{gm}/\text{cm}^2$ & $45.15\text{gm}/\text{cm}^2$) (Table II). Comparisons between the groups revealed that C1 x C3

($p < .595$) (Table III) showed no significance at rest, while comparisons of all other groups at rest and swallowing showed great significant difference (Table III). During speech the highest pressures were in Class II div 1 subjects ($67.91\text{gm}/\text{cm}^2 \pm 2.48$), and lowest in Class I subjects ($38.20\text{gm}/\text{cm}^2 \pm 4.15$) (Table II). In the lower arch pressure values were highest in Class III subjects ($39\text{gm}/\text{cm}^2 \pm 2.74$) and lowest in Class II div 1 subjects ($18.77\text{gm}/\text{cm}^2 \pm 2.53$) (Table II). While swallowing greatest pressure was recorded in Class II div 2 individuals ($127.81\text{gm}/\text{cm}^2 \pm 2.11$). Comparisons between groups showed no significance between C1 x C21 ($p < .412$) (Table III) during swallowing, while all other comparisons during rest and swallowing showed great significance (Table III).

Lingual pressure

In the upper incisor lingual area highest pressures were recorded in Class II div 1 subjects ($34.29\text{gm}/\text{cm}^2 \pm 2.54$), and lowest in subjects of Class II div 2 ($18.56\text{gm}/\text{cm}^2 \pm 1.84$) (Table II). When the groups were compared with each other all the comparisons had great significant difference except that of C1 x C3 ($p < .412$) (Table III). While in molar area highest values were in Class I subjects ($34.12\text{gm}/\text{cm}^2 \pm 3.11$) and lowest in Class II div 1 subjects ($0.00\text{gm}/\text{cm}^2 \pm 3.04$) (Table II). Great significant differences were seen when the groups were compared with each other (Table III). However swallowing pressures were highest both at the incisor and molar area in Class I subjects. During speech highest pressure recordings were observed in Class II div 1 subjects in the incisor area, while Class I subjects showed the highest speech values in the molar area.

Lower incisor lingual resting pressures were highest in Class I subjects ($29.96\text{gm}/\text{cm}^2 \pm 3.32$) while the lowest in Class II div 1 subjects ($2.31\text{gm}/\text{cm}^2 \pm 2.24$) (Table II). When all the groups were compared with each other they showed significant differences (Table III). In

the molar area pressures were highest in Class I subjects (24.99gm/cm²±2.81) and lowest in Class II div 1 subjects (12.14gm/cm²±1.70) (Table II). Comparisons showed significant differences in C21 x C3, C22 x C3, C1 x C22 and C1 x C21 (p<.05) (Table III). During swallowing highest pressure values in the incisor area were in Class II div 2 subjects (128.86gm/cm²±2.08) and lowest in Class III subjects (75.60gm/cm²±1.96)(Table II). In the molar area greatest pressures were in Class II div 2 subjects (142.34gm/cm²±2.35) and lowest in subjects of Class III (101.14gm/cm²±2.41) (Table II). No significance was shown in C1 x C21 (p<.461), while comparisons of other groups with each other were all highly significant (Table III).

Gender groups

It was observed that males had significantly higher pressure values than females irrespective of the skeletal class or vertical growth pattern (Tables IV, V, VI).

Vertical growth groups

Low angle individuals showed higher-pressure values than high angle subjects, but only some values were statistically significant (Table VII).

Table I: The Mean values of Cephalometric Parameters of Class I, Class II Division I, Class II Division II and Class III Subjects

Cephalometric Parameters	C1 (n=15)		C21 (n=15)		C22 (n=15)		C3 (n=15)	
	X	SD	X	SD	X	SD	X	SD
SNA	79.86	2.64	78.24	2.33	80.16	1.94	77.13	2.64
SNB	78.16	2.38	73.40	2.32	75.06	3.12	81.46	3.09
ANB	1.70	0.75	4.83	2.16	5.10	1.79	-4.06	2.62
WITS	-0.43	1.27	4.26	2.00	3.93	3.41	-12.00	5.51
N ⊥ A	2.40	2.06	4.00	2.71	2.60	2.34	6.10	2.82
Max. Depth(°)	86.60	2.79	86.06	2.77	87.16	1.94	84.13	2.64
Effective Max. Length	93.53	4.02	88.80	4.75	92.06	4.44	86.06	5.46
Effective Mand. Length	122.93	6.16	111.53	5.46	117.00	4.82	128.26	6.51
SNGo-Me	34.86	4.13	34.73	4.49	35.26	5.05	39.13	3.50
SGo/NMe	66.94	4.01	64.90	4.93	66.58	5.03	63.44	4.40
ANSMe/NMe	55.85	2.53	56.74	2.84	56.27	3.09	57.02	3.22
Facial axis angle	88.20	2.70	88.13	4.38	86.80	4.73	88.53	3.11
UI-SN (°)	104.20	2.51	110.53	5.68	95.73	5.47	105.93	4.57
IMPA (°)	93.06	3.32	94.66	5.69	93.26	5.96	77.33	3.85
Overjet	2.70	0.59	8.93	3.05	1.66	0.95	-2.33	2.80
Overbite	1.66	0.61	3.16	1.27	4.50	1.10	0.10	2.26
Upper Lip strain	3.66	1.86	4.23	2.21	1.33	1.87	3.13	1.99
Lower Lip strain	-1.00	1.86	-3.56	2.04	-2.83	1.59	-0.26	2.40
Holdaway	1.50	2.87	2.66	2.71	1.60	4.97	-0.30	4.16
Upper Lip Length	24.50	3.53	21.53	2.38	23.86	2.13	22.60	3.54
Lower Lip Length	51.10	3.75	48.00	3.12	50.00	4.78	54.73	4.41

Table II: The Mean values of Pressure Parameters of Class I, Class II Division I, Class II Division II and Class III Subjects

Pressure in gm/cm ²	C1 (n=15)		C21 (n=15)		C22 (n=15)		C3 (n=15)	
	X	SD	X	SD	X	SD	X	SD
1BR	13.26	4.21	26.10	2.20	13.82	1.86	12.36	1.65

1LR	27.04	3.65	34.29	2.54	18.56	1.84	28.59	1.96
1BS	79.38	3.39	45.44	2.40	106.37	2.33	50.19	1.89
1LS	138.15	2.32	113.53	2.67	112.29	1.92	65.57	1.97
1BU	29.18	2.82	36.11	2.62	18.64	1.77	7.89	1.78
1LN	38.55	2.25	51.34	2.49	26.06	2.54	33.37	2.21
6BR	25.40	3.36	40.82	2.48	44.21	1.80	24.74	1.56
6LR	34.12	3.11	0.00	3.04	29.08	5.07	12.00	1.84
6BS	73.62	4.50	80.88	2.98	98.95	4.11	45.15	1.78
6LS	142.06	6.69	77.13	2.63	134.67	2.57	132.79	2.79
6BU	38.20	4.15	67.91	2.48	59.75	2.19	54.17	2.10
6LN	41.55	4.29	24.57	2.58	30.91	2.00	41.42	1.69
1BR	35.82	4.05	58.38	2.18	27.68	1.71	83.22	2.35
1LR	29.96	3.32	2.31	2.24	9.92	1.90	25.46	2.01
1BS	75.31	3.15	74.76	2.07	111.93	1.85	51.43	2.49
1LS	93.83	5.15	78.16	1.90	128.86	2.08	75.60	1.96
6BR	24.46	2.98	18.77	2.53	20.96	1.00	39.00	2.74
6LR	24.99	2.81	12.14	1.70	22.24	3.21	14.83	1.74
6BS	73.42	4.69	74.62	2.86	127.81	2.11	101.92	2.21
6LS	115.83	4.73	115.07	2.12	142.34	2.35	101.14	2.41

B: Buccal, R: Resting, L:Lingual, S: Swallowing, U: During pronouncing U voice, N: During Pronouncing EN voice, 1:Upper incisor, 6 : Upper first molar, 1:Lower incisor, 6 : Lower first molar.

Table III: Comparisons of Pressure values of Skeletal and Dental Group

PRESSURE	P					
	C1 X C21	C1 X C22	C1 X C3	C21 X C22	C21 X C3	C22 X C3
1BR	0.000***	0.389	1.000	0.001**	0.000***	0.061
1LR	0.001**	0.001**	0.412	0.001**	0.000***	0.000***
1BS	0.001**	0.04*	0.001**	0.001**	0.000***	0.000***
1LS	0.001**	0.05*	0.001**	0.187	0.000***	0.000***
1BU	0.05*	0.025*	0.001**	0.01*	0.001**	0.000***
1LN	0.05*	0.05*	0.001**	0.05*	0.001**	0.000***
6BR	0.000***	0.001**	0.595	0.001**	0.001**	0.000***
6LR	0.001**	0.001**	0.01*	0.000***	0.001**	0.000***
6BS	0.05*	0.001**	0.01*	0.000***	0.001**	0.000***
6LS	0.001**	0.001**	0.01*	0.000***	0.001**	0.061
6BU	0.001**	0.035*	0.01*	0.000***	0.001**	0.000***
6LN	0.05*	0.01*	0.653	0.000***	0.001**	0.000***
1BR	0.000***	0.000***	0.000***	0.000***	0.001**	0.000***
1LR	0.001**	0.000***	0.002**	0.000***	0.001**	0.000***
1BS	0.436	0.005**	0.001**	0.000***	0.001**	0.000***
1LS	0.001**	0.001**	0.001**	0.000***	0.001**	0.000***
6BR	0.001**	0.001**	0.001**	0.025*	0.000***	0.000***
6LR	0.05*	0.033	0.001**	0.001**	0.000***	0.000***
6BS	0.412	0.001**	0.001**	0.001**	0.000***	0.000***
6LS	0.461	0.001**	0.001**	0.001**	0.000***	0.000***

*p<0.05, **p<0.01, ***p<0.001

B: Buccal, R: Resting, L:Lingual, S: Swallowing, U: During pronouncing U voice, N: During Pronouncing EN voice, 1:Upper incisor, 6 : Upper first molar, 1:Lower incisor, 6 : Lower first molar

Table IV: The Mean values of Pressure Parameters of Male Class I, Class II Division I, Class II Division II and Class III Subjects

Pressure in gm/cm ²	MALES							
	M1 (n=8)		M21 (n=4)		M22 (n=8)		M3 (n=10)	
	X	SD	X	SD	X	SD	X	SD
1BR	16.24	3.32	28.71	1.17	15.29	1.15	13.12	1.37
1LR	29.83	1.81	36.34	0.89	19.92	0.85	29.42	1.81
1BS	81.95	2.15	47.85	0.63	107.95	1.52	51.10	1.49
1LS	139.61	1.58	116.86	0.99	113.59	1.25	66.50	1.49
1BU	31.29	2.10	39.64	1.30	19.81	1.21	8.32	1.96
1LN	39.80	1.45	53.74	0.93	27.36	2.61	33.19	2.37
6BR	27.92	1.96	43.86	1.57	45.11	1.62	25.35	1.54
6LR	36.11	2.15	-0.76	3.35	31.33	6.12	13.13	0.93
6BS	76.80	2.97	84.65	0.86	101.39	2.35	45.72	1.84
6LS	147.05	4.10	80.17	0.31	136.46	1.40	132.70	2.94
6BU	41.02	3.23	71.23	1.33	61.54	1.08	54.00	2.58
6LN	44.26	3.81	26.98	0.78	32.22	1.92	41.43	1.91
1BR	38.81	2.57	60.75	0.53	28.41	1.34	84.24	2.24
1LR	30.67	3.18	4.11	0.69	10.84	2.01	26.02	1.92
1BS	77.11	1.57	77.09	1.28	113.23	1.43	50.75	2.76
1LS	96.93	4.66	80.39	1.14	130.30	1.43	75.35	1.97
6BR	26.02	2.49	21.86	0.37	21.25	0.86	40.29	2.37

6LR	27.04	1.42	14.16	0.80	23.34	2.91	15.80	1.14
6BS	75.41	4.25	78.60	1.01	129.07	2.10	102.55	2.34
6LS	118.70	3.22	117.80	0.89	143.69	2.13	100.69	2.25

B: Buccal, R: Resting , L:Lingual, S: Swallowing, U: During pronouncing U voice, N: During Pronouncing EN voice, 1:Upper incisor , 6 : Upper first molar, 1:Lower incisor, 6 : Lower first molar.

Table V: The Mean values of Pressure Parameters of Female Class I, Class II Division I, Class II Division II and Class III Subjects

Pressure in gm/cm ²	FEMALES							
	F1 (n=7)		F1 (n=7)		F22 (n=7)		F3 (n=5)	
	X	SD	X	SD	X	SD	X	SD
1BR	9.85	1.74	25.16	1.65	12.15	0.65	10.86	1.03
1LR	23.86	2.29	33.55	2.56	17.01	1.35	26.94	1.02
1BS	76.45	1.63	44.57	2.21	104.57	1.69	48.38	1.19
1LS	136.48	1.88	112.33	1.93	110.82	1.43	63.71	1.45
1BU	26.78	0.87	34.84	1.54	17.32	1.33	7.05	1.09
1LN	37.13	2.23	50.47	2.31	24.59	1.52	33.75	2.08
6BR	22.53	1.98	39.72	1.70	43.19	1.51	23.53	0.72
6LR	31.86	2.46	0.27	3.04	26.51	1.44	9.77	0.73
6BS	69.99	2.85	79.52	2.14	96.17	4.00	44.03	1.10
6LS	136.37	3.78	76.04	2.17	132.65	2.02	133.00	2.81
6BU	35.00	2.35	66.70	1.45	57.72	0.91	54.52	0.52
6LN	38.47	2.29	23.70	2.44	29.43	0.52	41.42	1.38
1BR	32.41	2.27	57.52	1.88	26.85	1.81	81.21	0.74
1LR	29.16	3.55	1.66	2.27	8.87	1.15	24.36	1.91
1BS	73.27	3.34	73.92	1.61	110.45	0.93	52.79	1.06
1LS	90.29	3.04	77.36	1.41	127.24	1.40	76.12	2.06
6BR	22.69	2.59	17.65	1.94	20.63	1.13	36.44	1.16
6LR	22.66	2.05	11.41	1.30	20.99	3.28	12.90	0.82
6BS	71.14	4.35	73.18	1.60	126.38	0.83	100.67	1.38
6LS	112.56	4.09	114.08	1.42	140.82	1.57	102.06	2.71

B: Buccal, R: Resting , L:Lingual, S: Swallowing, U: During pronouncing U voice, N: During Pronouncing EN voice, 1:Upper incisor , 6 : Upper first molar, 1:Lower incisor, 6 : Lower first molar

Table VI: Comparisons of Pressure values of Gender Group

PRESSURE	P			
	M1XF1	M21XF21	M22XF22	M3XF3
1BR	0.001**	0.003**	0.000***	0.013*
1LR	0.001**	0.078	0.000***	0.008**
1BS	0.001**	0.018*	0.002**	0.008**
1LS	0.021*	0.003**	0.004**	0.008**
1BU	0.000***	0.001**	0.006**	0.254
1LN	0.029*	0.026*	0.021*	0.768
6BR	0.001**	0.006**	0.040*	0.028*
6LR	0.009**	0.343	0.009**	0.001**
6BS	0.001**	0.003**	0.006**	0.075
6LS	0.000***	0.001**	0.004**	0.953
6BU	0.004**	0.001**	0.000***	0.594
6LN	0.006**	0.026*	0.001**	1.000
1BR	0.001**	0.003**	0.072	0.008**
1LR	0.463	0.040*	0.029*	0.075
1BS	0.021*	0.018*	0.001**	0.254
1LS	0.006**	0.006**	0.002**	0.513
6BR	0.040*	0.001**	0.336	0.005**
6LR	0.001**	0.006**	0.072	0.001**
6BS	0.040*	0.001**	0.009**	0.129
6LS	0.014*	0.001**	0.021*	0.129

*p<0.05, **p<0.01, ***p<0.001

B: Buccal, R: Resting , L:Lingual, S: Swallowing, U: During pronouncing U voice, N: During Pronouncing EN voice, 1:Upper incisor , 6 : Upper first molar, 1:Lower incisor, 6 : Lower first molar

Table VII: Comparisons of Pressure values between High Angle and low Angle Subjects

Pressure (gm/cm ²)	HIGH ANGLE (n=26)		LOW ANGLE (n=34)		H X L	Sig.
	X	SD	X	SD		
1BR	14.52	5.08	17.82	6.75	0.063	
1LR	26.13	5.06	27.88	6.96	0.168	
1BS	67.39	25.03	72.61	24.86	0.561	
1LS	97.77	29.48	114.75	21.78	0.050	*
1BU	18.64	10.43	26.27	10.42	0.015	*

1LN	35.59	8.07	38.67	10.52	0.251	
6BR	31.38	9.63	35.64	8.52	0.060	
6LR	18.35	13.09	19.15	15.06	0.823	
6BS	67.90	21.94	79.82	16.57	0.028	*
6LS	126.08	22.03	118.30	29.27	0.623	
6BU	54.27	10.12	55.58	12.25	0.347	
6LN	35.64	6.93	33.84	8.41	0.359	
1BR	57.12	24.71	46.81	18.74	0.156	
1LR	18.70	10.69	15.55	12.20	0.502	
1BS	73.36	23.74	82.19	20.01	0.050	*
1LS	91.45	22.28	96.16	21.23	0.184	
6BR	29.27	9.66	23.15	5.99	0.023	*
6LR	17.83	5.10	19.11	6.31	0.516	
6BS	98.15	21.22	91.61	23.82	0.233	
6LS	115.77	16.89	120.76	13.89	0.112	

B: Buccal, R: Resting , L:Lingual, S: Swallowing, U: During pronouncing U voice, N: During Pronouncing EN voice, 1:Upper incisor , 6 : Upper first molar, 1:Lower incisor, 6 : Lower first molar

Discussion

In making diagnosis of malocclusion the Orthodontist must make a “scientific guess” and think into the tissue. Although several researchers have emphasized the importance of intraoral pressure, tongue pressure and intraoral pressure in different malocclusions has not been studied. Perhaps it is important to point out that the specific focus of this study is to compare soft tissue pressures of different malocclusions, rather than finding their absolute magnitude, since there is a remarkable inter individual variability.

The EPL BO diaphragm type transducer was used in this study due to its precise and reliable pressure measurement readings. Lindeman and Moore¹⁸ compared various pressure measuring devices and found the EPL transducer to be the superior pressure-measuring device. Moawad et al¹⁹reconfirmed these findings by comparing beam type with diaphragm type pressure transducer. The soft tissues are believed to exert fluid pressure rather than solid force, therefore the diaphragm type transducer was suggested for measuring pressure of soft tissue since it reacts to pressure rather than force.

Though our mean pressure values were higher than previously reported, this could be due to the higher sensitivity of the transducer used, as also reported by Lindeman and Moore.¹⁸ Our pressure transducer was 1 mm thick and 3.37 mm in diameter. This was according to the criteria set by Weinstein et

al²⁰ 1983, Gould and Picton²¹ 1962, and Lear et al²² 1965 who proposed that for an accurate resting pressure measurement the transducer should not be more than 2 mm away from the tooth surface. The thickness of our transducer and stent together was not more than 1.5 mm (Figure. 6). The stent-transducer complex did not exceed 2 mm from the tooth surface after its placement.

To minimize the pressure changes due to extension or flexion, as reported by Hellsing et al,²³ all readings were taken with the subjects in natural head position.

Comparison between different malocclusions

Labial/ Buccal Pressures - Our results showed that the upper lip pressure on the central incisors was 13.26 gm/cm² in Class I subjects. The maximum lip pressure was observed in Class II div 1 patients (mean 26.1 gm/cm²) and the least in Class III subjects (mean 12.36 gm/cm²). The findings for the lower lip were considerably different with the highest pressures recorded in Class III patients (83.22gm/cm²) and lowest in Class II div 2 individuals (27.68gm/cm²).

Luffingham^{11,12} and, Thuer and Ingervall¹³ reported that the lip pressure against upper incisors in the rest position varied with overjet, higher in subjects with increased overjet than in those with normal overjet. These observations relate to our findings as well, indicating the adaptive character of lip pressure. The resting lip pressure is a result of the position of the incisors. Also the pressure during rest is the result of a passive drape of the soft tissue against the dentition and facial/skeletal morphology. Highest lower lip resting pressures can be explained by the hypertonic lower lip with increased mentalis activity in Class III subjects exerting increased pressure. The lowest lower lip resting pressures in Class II div 2 can be explained by the increased overbite, thus the lower lip resting more on the upper incisors as explained by Lapatki et al.²⁴ Highest resting buccal pressures in the maxilla were recorded

in Class II div 2 subjects and lowest in Class III subjects. These findings were very similar to Howland and Brodies² results. This can be explained by the increased vertical growth pattern in Class III subjects (SN-GoMe = 39.13 ± 3.50) which has a weak muscular pattern. Buccal pressures in the mandible were highest in Class III subjects (39gm/cm²) and lowest in Class II div 1 subjects (18.77gm/cm²). These findings relate to the dentofacial morphology in Class III subjects who have a wider mandible and posterior cross bite with buccally placed molars.

The measurement of labial pressures during swallowing has rarely been discussed in previous literature, but we measured and found that labial and buccal pressures during swallowing was highest in Class II div 2 subjects for both upper and lower arch. These higher lip pressure readings can be explained by: (a) Short facial height and (b) Hyperactive mentalis muscle. While in the lower vestibule, highest resting values were of Class III group; however during swallowing the highest values were of Class II div 2 group. Increased buccinator activity in low angle population may be the answer to this controversy.

Outer speech pressures were measured when the subject pronounced the "U" sound. The values fell in between those measured for resting and swallowing, correlating with previous findings of Kato et al.²⁵

Lingual Pressure

In our study mean lingual pressures on the upper incisors were always higher in all classifications than the labial pressures. These findings agree with those of Winders,¹⁴ Proffit,^{15,16} & Lear and Moorrees,¹⁷ who reported lingual forces to be higher than the buccal forces.

In the lower incisal region tongue pressures were all smaller than the outer pressures. In the lower jaw the resting tongue pressures were greatest in Class I subjects and lowest in Class II div 1 subjects, agreeing with the results of Archer et al.²⁶ Generally tongue pressures in the mandible in all classifications

except Class I, were lower than the resting tongue pressures on the maxillary teeth.

Our study revealed that in the upper arch Class I subjects exhibited the highest recordings for swallowing (138.15gm/cm²), while in the lower arch Class II div 2 individuals had the greatest pressure values during swallowing. In all groups tongue pressures were higher than the outer pressures during swallowing in mandibular incisor and molar area. In the maxilla tongue pressures were also higher than the outer pressures during swallowing except that Class II div 1 subjects showed greater buccal pressures at the molar area. We found swallowing pressures at the upper molar area higher than the upper incisors in all malocclusions except Class II div 1, agreeing with findings of Thuer & Ingervall.²⁷

Recordings for pressure were also recorded while the subjects pronounced the "EN" sound. It was noted that generally the pressures while saying "EN" were higher at the upper molar area than the upper incisor, as also reported by Kato et al.²⁵ Speech pressures were greater than resting pressures but less than swallowing pressures, in accordance with findings of Thuer & Ingervall.²⁸

Comparison between Gender

Thuer & Ingervall¹³ found no correlation between lip pressures and gender. Mitchell et al,²⁹ Barlow and Muller,³⁰ Posen,³¹ all reported greater pressure values in males than in females. In our study a significant difference in perioral pressure was shown to exist between males and females of the same classification, pressure values of males being higher.

Barlow explained the difference in pressure between males and females as follows:

1. The fact that males generate significantly higher pressures is likely due to fundamental differences in the representation and distribution of contractile elements in the lower face.

2. A greater number of fibrils in the orbicularis oris muscle, resulting in greater number of actin-myosin cross bridges may

account for the higher forces observed in male adults.

3. Another factor to consider is the difference in mechanical advantage of certain perioral muscles in men and women.

Comparison of high angle with low angle subjects

In the present study we observed insignificantly greater pressures in low angle subjects. During swallowing values were significantly higher in low angle group in the incisor and molar areas. Proffit,³² Umemori,³³ Nanda³⁴ have reported that patients with a low mandibular plane angle have greater development of their perioral and masticatory musculature than high angle subjects.

It seems like the malocclusion types and the gender is affecting the buccal and lingual pressures. Still we do feel a need for further studies made on larger and well-defined groups to clear some differences.

Conclusions

- Mean pressures recorded were higher than previously reported in the literature.
- All classifications showed significant pressure differences.
- Upper lip pressures are related to incisor inclinations, overjet and skeletal morphology.
- Lower lip pressures are more related to skeletal morphology and facial height.
- Lingual pressures are generally higher than buccal pressures.
- Swallowing pressures are much higher than the resting pressures.
- Speech pressures fall in between the resting pressures and the swallowing pressures.
- Cheek pressures are higher than lip pressures.
- Anterior labial and lingual pressures differed from posterior buccal and lingual pressures in each classification.
- Males showed overall higher pressures than females.
- Low angle subjects showed insignificantly greater pressures than high angle subjects.

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