Lip pressure at rest and during function in 2 groups of patients with different occlusions

Domizia Di Fazio,a Luca Lombardo,b Antonio Gracco,b Pasquale D’Amico,a and Giuseppe Sicilianic
Ferrara, Italy

Introduction: The influence of the forces exerted by the perioral musculature on the position of the teeth has been the object of many scientific studies. Of the forces from the soft tissues, those from the tissues in the passive resting state are believed to be more important than forces exerted on the teeth during various functions such as speech and swallowing. The aims of this study were to measure upper lip pressure at rest and during swallowing in 2 groups of patients with different occlusions and to evaluate any differences among the groups.

Methods: Fifty subjects were divided into 2 groups according to occlusal and skeletal patterns: Class I and Class II. Both groups were divided into 2 subgroups according to age: young patients (9-17 years) and adult patients (18-35 years). A force-sensing resistor device (Datalog, Flexiforce low type, Biometrics Ltd, Gwent, United Kingdom) with a transducer thickness of less of 1 mm was used for the measurements. The sensor was positioned on the midline between the maxillary incisors with a thin layer of soft wax. Labial pressure measurements were made with the lips at rest and during swallowing saliva. Results: The average resting lip pressure was 24.59 ± 2.55 g/cm²; during swallowing, the mean pressure was 24.87 ± 2.45 g/cm². No significant difference was found between lip pressure at rest and at function or between the two groups with different occlusions and skeletal patterns. There was a significant correlation between lip pressure and age.

Conclusions: In healthy patients, (1) upper lip pressure does not change at rest and during swallowing, (2) upper lip pressure was similar in the 2 groups (Class I, 24.33 g/cm²; Class II, 24.61 g/cm²), and (3) lip pressure was higher in adults than in young subjects. Further studies are needed to measure the pressure of the lower lip and to evaluate whether there are differences in labial pressure between subjects with labial competence and incompetence. (Am J Orthod Dentofacial Orthop 2011;139:e1-e6)

The influence of the forces exerted by the perioral musculature on the position of the teeth has been the object of several scientific studies.1-3 The force plays a role in guiding tooth eruption and maintaining dental arch form and stability. Most authors accept, as a basis, the equilibrium theory of tooth position.2,4 The lips, cheeks, and tongue are the most important environmental determinants of tooth position. The forces from the tongue have consistently been found to be greater than those from the lips.1 However, the teeth are in an equilibrium position because the forces are equal on them over time from all directions, regardless of the strength of the muscle that is applying the force.

Of the forces from the soft tissues, those from the tissues in the passive resting state are believed to be more important than forces exerted on the teeth during various functions such as speech and swallowing. Forces that act on incisors during function are of short duration, but it has been postulated that forces operating longer than 4 to 6 hours per day can produce movements in a relatively short time.5 The question is raised: is there any difference between resting lip pressure and dynamic labial pressure?

The main function of the lips, oral competence, is controlled by the orbicularis oris muscle.6 The orbicularis oris muscle is a concentric, sphincter-like muscle around the mouth that closes, withdraws, and protrudes lips. Its action is analogous to the orbicularis oculi around the eye. The main function of the lips during swallowing is to maintain oral competence. Briefly, the upper lip closing movement is performed by the orbicularis oris muscle, and the lower lip closing movement is performed by the mentalis and orbicularis oris muscle.
In some patients with maxillary protrusion or severe Class II Division 1 malocclusion, lip incompetency and muscle imbalance are observed.\textsuperscript{7-9} Posen\textsuperscript{8} described a device for measuring the strength of the lips called the pommeter (perioral muscle meter). He found that the subjects with bimaxillary protrusion had low lip strength, compared with Class I and Class II Division 2 patients. Posen reached that conclusion with the pommeter, which is different from the force-sensing resistor sensors that we used in this study.

The question is whether there are any differences in labial pressure among subjects with different occlusions. The aims of this study were to measure upper lip pressure at rest and during swallowing in 2 groups of patients with different occlusions and to evaluate any differences among the groups.

**MATERIAL AND METHODS**

Fifty subjects were divided into 2 groups according to occlusal and skeletal patterns: group 1, 25 patients (9 male, 16 female) with Class I skeletal pattern and Class I occlusal relationship, and group 2, 25 patients (12 male, 13 female) with Class II skeletal pattern and Class II Division 1 or Division 2 dental pattern. Subjects with increased overjet (>7 mm) were excluded. The groups were further divided into 2 subgroups according to age: subgroup A, young patients aged 9 to 17 years (mean age, 13 years), and subgroup B, adults aged 18 to 35 years (median age, 27.5 years).

To evaluate the occlusal and skeletal patterns of each subject, the usual orthodontic documentations, including extraoral and intraoral photos, dental casts, and profile x-ray cephalograms, were made. All landmarks were identified and digitized by 1 investigator using Dolphin Imaging Software (version 10.5, Dolphin, Imaging and Management Solutions, Chatsworth, CA, USA). McLaughlin’s cephalometric analysis was chosen for this purpose.\textsuperscript{10}

The inclusion criteria were no permanent teeth lost; no missing or supernumerary teeth; no history of orthognathic surgery or previous orthodontic treatment; no congenital craniofacial anomalies; no occlusal canting or other asymmetric skeletal patterns; no Class III skeletal and dental pattern; no overjet greater than 7 mm; no labial incompetence, oral breathing, and sucking habits; no hypodivergent or hyperdivergent patients; no patients whose upper lip and maxillary incisors were not in the correct positions for the sensor; and no patients in treatment with drugs influencing the tone of the muscles.

A force-sensing resistor device (Datalog, Flexiforce low type, Biometrics Ltd, Gwent, United Kingdom) with a transducer thickness of less of 1 mm was used for the measurements. The sensor was 20 cm long, 3 cm wide, and ultraflexible so that it was comfortable in the mouth (Fig 1). It was reliable for a wide range of temperatures: -28°C to 216°C, including the mouth’s temperature (37°C); this allowed minimized temperature-induced errors. The sensor was positioned on the midline between the maxillary incisors with a thin layer of soft wax about 0.5 mm thick. A data logger (Biometrics Datalog II of NexGen Ergonomics, Units 25 and 26, Biometrics) (Fig. 2, A) and DataLog Display and Analysis Software (Fig 2, B) were used for data acquisition.

Lip pressure measurements were made with the lips at rest and during swallowing saliva. The measurements were performed 3 times for 4 minutes each, at 5-minute intervals. During recording, each subject was asked to swallow at minutes 1, 2, 3, and 4. All measurements were made by the same operator (D.D.).

To achieve natural head position, the subjects were seated in front of a mirror.\textsuperscript{11,12} They were asked to look into the mirror image of their eyes, after tilting their head up and down with decreasing amplitude until they relaxed. The mirror was positioned 200 cm in front the subject.

**Statistical analysis**

The means of the 3 measurements and the standard deviations were calculated. Because of the sample size, we used the Friedman test to study systematic differences between lip pressure at rest and during swallowing.
of the 50 patients. The Mann-Whitney test was used to test for any differences between groups 1 and 2, each comprising 25 subjects with a different occlusion. For the assessment of the method error, measurements of 10 randomly selected subjects were repeated 1 week later, and Dahlberg’s formula was calculated as $\sqrt{\sum d^2 / 2n}$. The method error calculated was about 1.410628 g/cm².

**RESULTS**

The average resting lip pressure was 24.59 g/cm² ± 2.55 59; during swallowing, the mean pressure was 24.87 g/cm² ± 2.45 (Table I). No significant difference was found between lip pressure at rest and at function (Table II).

Table III shows the mean labial pressure values of the Class I and Class II groups. No significant difference was found between the 2 groups with different occlusions and skeletal patterns: Class I and Class II, as shown in Table IV.

Because no significant difference was found between the 2 groups, the data were divided into 2 subgroups to study labial pressure and age: group A, 27 young patients, 9 to 17 years old; and group B, 23 adult patients, 18 to 35 years old. Table V shows the average labial pressures of these groups.

The Wilcoxon test was used to test differences between the 2 groups, with the results shown in Table VI.

All results of this study are summarized in Figure 3.

**DISCUSSION**

The thickness of the transducer had an influence on the measurements. Perioral soft-tissue pressure measurements are generally biased because of the displacement of tissue by the pressure-sensing device.14

To measure the forces, many devices have been designed; all had a different shape and thickness and, therefore, had a potential effect on the measurements.15-17 Weinstein et al4 demonstrated that the soft-tissue force would change and make the teeth move if the buccolingual dimension were increased. The transducer increased the tooth dimensions and influenced the tension of the muscles. Ho et al18 proved that the labial pressure exponentially increases when tissue displacement is greater than 1.5 mm. Therefore, the thickness of the transducer plays an extremely important role. Since our sensor was thin (1.4 mm), this effect was minimized.

The finding of large interindividual variations in this investigation is common in studies of muscle pressure. It would be difficult to control interindividual variations because of the varied functional responses among subjects. Thuer et al19 and Thuer and Ingervall20 pointed out that the variations were likely to be biologic and not because of recording difficulties. Luffingham21 also concluded that the variations probably arose from a change in subject behavior rather than methodologic difficulties. Bundgaard et al22 stated that similarities in occlusion and facial morphology do not account for similarities in functional pattern.

---

**Table I.** Mean lip pressure at rest and during swallowing

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Age (y)</th>
<th>Mean force (g/F) and SD at rest</th>
<th>Mean pressure (g/cm²) and SD at rest</th>
<th>Mean force (g/F) and SD at swallowing</th>
<th>Mean pressure (g/cm²) and SD at swallowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>9-35</td>
<td>17.46 ± 1.82</td>
<td>24.59 ± 2.55</td>
<td>17.64 ± 1.73</td>
<td>24.87 ± 2.45</td>
</tr>
</tbody>
</table>

---

**Fig 2.** A, Biometrics Datalog; B, Datalog display and analysis software.
The head position of the patients is also an important question in pressure measurements of the teeth and alveolar process. According to Ingervall Thuer and Thuer et al,24 the pressures are slightly greater with the head in extended than in the natural head position. So, considering their findings, we recorded the pressure values in natural head position.

For the measurement of static and dynamic labial pressure, the average labial pressure value in our study was 24 to 26 g/cm², corresponding to 24.51 N/m² × 10², in accordance with other studies,25-27 but much higher than the results of Hellsing et al,28 Thuer et al29 (2.6 g/cm²), and Ogushi et al30 (1.96 g/cm²). In their studies, Thuer et al29 and Ogushi et al30 measured perioral pressures by using the hydraulic-capillary infusion system, introduced in gastroenterology for esophageal intraluminal manometry.31 This system uses a catheter type of sensor with a small diameter and is expected to reduce the distance between the sensing portion and the tooth surface. However, few investigators reported using a hydraulic system in measurements of muscle pressure exerted on the dentition. The most common measuring device used is the strain gauge transducer. The different system for labial measurement might explain our different results compared with the above-mentioned studies.

The average pressure of the upper lip during swallowing, 24.54 g/cm², is similar to the mean resting pressure, 24 to 26 g/cm². We found no significant difference of upper lip pressure at rest and during swallowing saliva. Our findings agree with those of Abrams32 and Proftt.2 Proftt2 showed that upper lip figures for swallowing and resting are essentially the same and concluded that there is no upper lip activity in swallowing in the groups studied (Australian aborigines and American whites). Abrams32 found no significant difference between static and dynamic pressures of perioral muscles and showed that lips and cheeks have no activity during swallowing saliva.

Our result can be explained, considering the function of the lips during the mechanism of swallow. Deglutition consists of a sequence of muscle contractions that takes saliva or bolus from the mouth to the stomach. During the mouth phase of deglutition, the lips can remain

---

**Table II. Friedman test for differences between static pressure and dynamic pressure**

| Difference | 0.2831 | t ratio | 0.5716 |
| SE difference | 0.4954 | DF | 99.8346 |
| Upper confidence level difference | 1.2660 | P > |t| | 0.5689 |
| Lower confidence level difference | –0.6997 | P > |t| | 0.2845 |
| Confidence | 0.95 | P < |t| | 0.7155 |

**Table III. Mean Lip pressure in Class I and Class II patients**

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Occlusion</th>
<th>Mean in g/cm² and SD at rest</th>
<th>Mean in g/cm² and SD at swallowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 25</td>
<td>Class I</td>
<td>24.33 ± 2.69</td>
<td>24.59 ± 2.60</td>
</tr>
<tr>
<td>Group 2 25</td>
<td>Class II</td>
<td>24.61 ± 2.46</td>
<td>24.94 ± 2.40</td>
</tr>
</tbody>
</table>

**Table IV. Mann-Whitney test to evaluate differences between Class I and Class II groups**

| Difference | 0.2796 | t ratio | 0.3828 |
| SE difference | 0.7103 | DF | 47.6424 |
| Upper confidence level difference | 1.7483 | P > |t| | 0.7035 |
| Lower confidence level difference | –1.1891 | P > |t| | 0.3518 |
| Confidence | 0.95 | P < |t| | 0.6482 |

**Table V. Mean labial pressure of young patients and adults**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Age (y)</th>
<th>Mean g/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>27</td>
<td>9-17</td>
<td>23.61 ± 2.37</td>
</tr>
<tr>
<td>B</td>
<td>23</td>
<td>18-35</td>
<td>25.47 ± 2.44</td>
</tr>
</tbody>
</table>

**Table VI. Wilcoxon test to evaluate differences between adults and young patients**

<table>
<thead>
<tr>
<th>Groups n</th>
<th>Score sum</th>
<th>Score mean</th>
<th>(Mean-Mean0)/Std0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult 23</td>
<td>701.000</td>
<td>30.4783</td>
<td>2.380</td>
</tr>
<tr>
<td>Young 27</td>
<td>574.000</td>
<td>21.2593</td>
<td>–2.380</td>
</tr>
</tbody>
</table>

S, 701; Z, 2.380; P > |Z|, 0.0173.
closed to ensure labial seal and avoid undesired spurt. Therefore, when there is oral competence, labial seal is ensured. The sample examined in this study consisted of healthy subjects with lip competence and no oral breathing and sucking habits.

In accordance with our findings, Lufngham\textsuperscript{21} found no difference in labial pressure during swallowing between the 3 groups with different occlusions, except for the subjects of Class II Division 1 with increased overjet. They had higher values of labial pressure during swallowing because of oral incompetence and no labial seal.

The second aim of our investigation was to study the differences in labial pressure between subjects with different occlusions. The average lip pressures were 24.33 g/cm\textsuperscript{2} in the Class I group and 24.61 g/cm\textsuperscript{2} in the Class II group. No statistically significant difference was found. This result was similar to other studies. Gould and Picton\textsuperscript{9} did not find any difference in labial pressure during swallowing between the 3 groups with different occlusions (Class III, Class II Division 1, and Class II Division 2), except for 10 subjects with Class II Division 1 with increased overjet. They had higher values of labial pressure during swallowing because of oral incompetence.

Our sample was divided in 2 subgroups according to age: young and adult patients. The mean labial pressures were 23.62 g/cm\textsuperscript{2} for young patients with Class I and Class II relationships and 25.47 g/cm\textsuperscript{2} for adult patients.

We found a significant difference (\(P > 0.01\)) between the 2 groups. Our data agree with those of Mitchell\textsuperscript{5} and Posen et al.\textsuperscript{7,8} They studied the perioral force in healthy patients and found that muscle force is higher in adults than in younger subjects. This result might be explained by the maturation of the orbicicularis muscle: its force and tone increase with age and growth.

**CONCLUSIONS**

The purposes of this study were to measure the force generated by the upper lip and to ascertain whether there are relationships between static and dynamic pressure, and between upper lip pressure and occlusion.

Our results indicate the following in healthy subjects with lip competence.

1. There is no significant difference between labial pressures at rest and during swallowing.
2. There is no significant difference in labial pressures between Class I and Class II patients.
3. There is a significant difference between subjects at different ages.

This study suggests that the average upper lip pressures on the central incisors were 24.11 g/cm\textsuperscript{2} during resting and 24.54 g/cm\textsuperscript{2} during swallowing. We evaluated only the pressure of the upper lip in healthy patients. Further studies are needed to measure the pressure of the lower lip and to evaluate whether there are differences of labial pressure between subjects with lip competence and incompetence.
REFERENCES