A study of the relationship of maximal perioral muscle pressure and tonic resting pressure using a pneumohydraulic capillary infusion system

By Erwin C. Lubit, BA, DDS; Mark A. Wallach, BS, DDS; and Ronald Schwalb, DDS

It is generally accepted that perioral musculature along with the tongue play important roles in the development of either a normal occlusion or a malocclusion. This philosophy has continuously appeared in the dental literature since 1873.[1-9]

While the general shape and position of the maxilla and mandible are genetically determined, the functional matrices play the primary morphogenetic role as to the final size, shape and position of these skeletal components.[10,11] Both normal and abnormal skeletal and dental relationships are stable when the total forces of the interacting functional matrices are balanced and in a state of equilibrium. These forces include the external perioral pressures, the internal tongue pressure, negative intraoral pressure created during swallowing, and respiratory function which influences the posture of the head, jaws and tongue.[6,12-14]

The muscles located circularly and radially around the mouth make up two muscular slings. The lower lip sling is formed by the superior portion of the buccinator and the orbicularis oris of the lower lip. The upper lip sling is formed by the inferior portion of the buccinator and the oribicularis oris of the upper lip. Frankel[8,15] maintained that when the orbicularis oris is not capable of producing a competent lip seal, and the postural balance between the two muscular slings is disturbed, the whole orofacial complex must compensate. Thus, open bite, Class II and Class III malocclusions can occur.

The conformation of the dental arch and the position of the individual teeth within the arches is dependent upon the enveloping musculature.[16] Aberration of the orofacial muscles result in an abnormal soft tissue guidance system altering the normal eruption path of the teeth. The form of the dental arches and tooth position within the arches are influenced by the resting musculature pressures of the lips and tongue more so than the functional pressures resulting from speech, mastication or swallowing. Thus, it is not the magnitude of the forces, but the duration of the forces, that is the more important

Abstract

The tonic (resting) and peak (maximum) lip pressures of 100 subjects were measured. The purpose was to evaluate the validity of the assumption that high peak pressures are indicative of high tonic pressures and vice versa. This paper describes the equipment and techniques devised to test these pressures. The results showed no statistically significant relationship whatsoever between tonic and peak lip pressures. We, therefore, suggest that maximum lip pressures not be used as a diagnostic aid in orthodontics.

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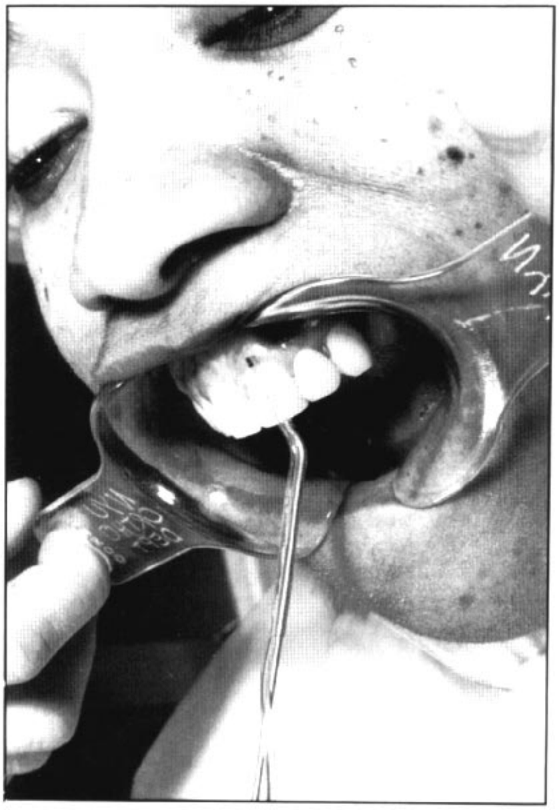
Key Words

Lip pressure • Oral muscular pressure • Pneumohydraulic capillary infusion system



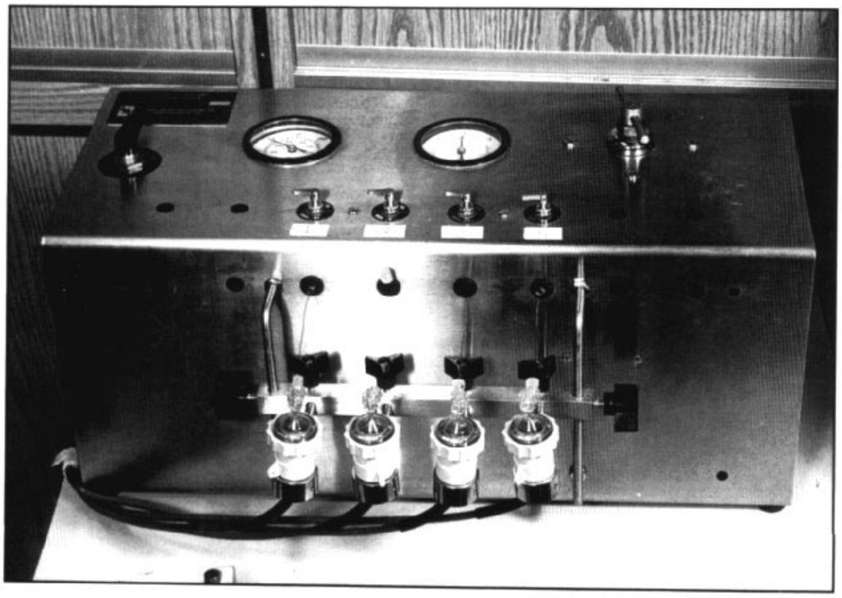


Figure 1
A water infused catheter in a subject's mouth. The darkened sensory tip is located in the middle of the gingival margin of the left central incisor tooth. The sensory lumen faces the lip.

Figure 2
Pneumohydraulic infusion pump with four pressure transducers. Pressure from the upper lip is transmitted to the transducers where they are converted into electrical signals.

influence on tooth position.[6,14] Measuring tonic (resting) lip forces is more significant than measuring maximum lip pressure. Though both have been studied, a direct relationship between the two has never been proven.

Various methods of measuring perioral and tongue forces have been described in the literature. Werner[17] described a closed air-filled manometer system. A simple pressure dynamometer was used by Friel,[18] Faigenblum,[19] and Posen.[20,21] Luffingham,[22] Savage,[23] and Mooney et al.[24] used electronic pressure sensitive transducers. Electromyography was used by Gustafusson et al.,[25] and Lowe et al.[26] Bardach et al.[27] used a hydraulic transducer system. Strain gauge pressure transducers were used by Gould,[28,29,30] Proffit,[14,31] and Archer.[32]

Mooney et al.[24] quantified lip pressures into three types: resting, tensing and peak pressures. Resting pressure exists when the lips are in a normal relaxed condition. Tensing pressure occurs during certain functional activities such as mastication, deglutition and speech. The peak pressure is obtained when one is contracting the labial musculature in a grimace-like posture, which is a sustained contraction.

Posen[20,21] designed a simple dynamometer which he called a pommeter. He used it to measure the maximum holding force of the orbicularis oris muscle on a wafer and considered this a test of maximum perioral muscle tension. He assumed that when the maximum tonicity of the lips was high, then the tonic lip pressure was high. When the maximum tonicity of the lips was low, then the tonic pressure was low. The following experiment addresses the validity of this inference.

Materials and methods

The equipment and technique described herein has gradually evolved over many years, with the aid of several postgraduate residents at NYU College of Dentistry.

This experiment used a pneumohydraulic capillary infusion system and a newly designed catheter system.

Catheters continuously infused with water from a pneumohydraulic infusion pump,* transmitted pressure from the upper lip to pressure transducers #223-651.** The transducers converted the pressures into electrical signals. Couplers #9853C** received the electrical signals from the transducers and transmitted these signals to power amplifiers #461D,** where the

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power of the signals was increased before the physiological dynograph recorder #511A,** made a permanent quantitative record (Figures 1, 2, 3). Both the motor function (peak pressure) and tonic function (resting pressure) of the lips were recorded.

Our system used two hollow plastic tubular catheters. Each catheter had a diameter of 1.7 millimeters, with a circular opening of 0.838 millimeter, located 0.45 millimeter from the closed end. The area surrounding the circular opening was stained to allow easy visualization of the target point. The two catheters were glued together, keeping the circular lumens on the same side and in a perfect reference plane. A six-inch brass wire with a diameter of 1.4 millimeters was inserted into a 1½ inch long hollow plastic tubing. It was attached to the catheters 12 millimeters from the closed end, thus it did not interfere with placement of the catheters or add extra bulk under the lip. The long free end of the brass wire was inserted into a metal wire holder that was attached to a universal ball joint mounted on a movable metal arm (Figure 4), allowing easy and accurate positioning of the catheters for pressure readings.

Our previous research showed that tonic pressures were consistantly below 20 centimeters of water, while peak pressures ranged from 200 to 340 centimeters of water. Thus, we calibrated the dynograph for one catheter to record pressures up to 20 centimeters of water, while the other catheter recorded pressures up to 320 centimeters of water. Charting was done on graph paper divided into 40 boxes. Each box on the tonic pressure graph was equivalent to 0.5 centimeter of water. Each box on the peak pressure graph was equivalent to eight centimeters of water. With the controls on the pneumohydraulic infusion pump, we were able to activate one catheter at a time without disturbing the catheters or changing their position.

Our procedure was to seat a subject in a dental chair with the Frankfort horizontal plane parallel to the floor. The chair was then raised or lowered so that the open lumens of the catheters were level with the transducer heads. There is about a one inch vertical leeway, up or down, from this position, before atmospheric pressure differences affect the calibration. The upper lip was elevated and the joined catheters were positioned in the mouth by adjusting the swinging arm and ball joint assembly. The target point was the middle of the attached gingiva over the maxillary left central incisor with the lumen facing the lip (Figure 1). With the catheters properly positioned, final adjustments were

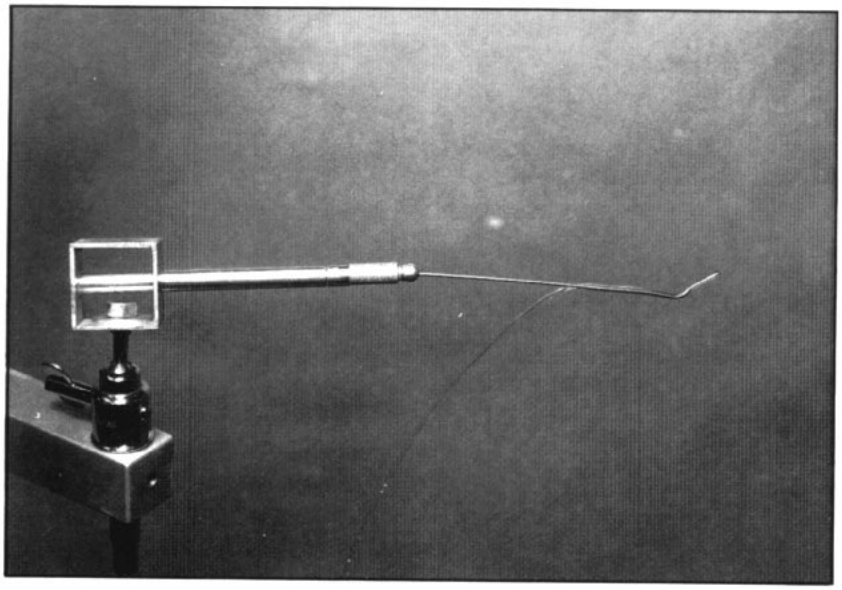
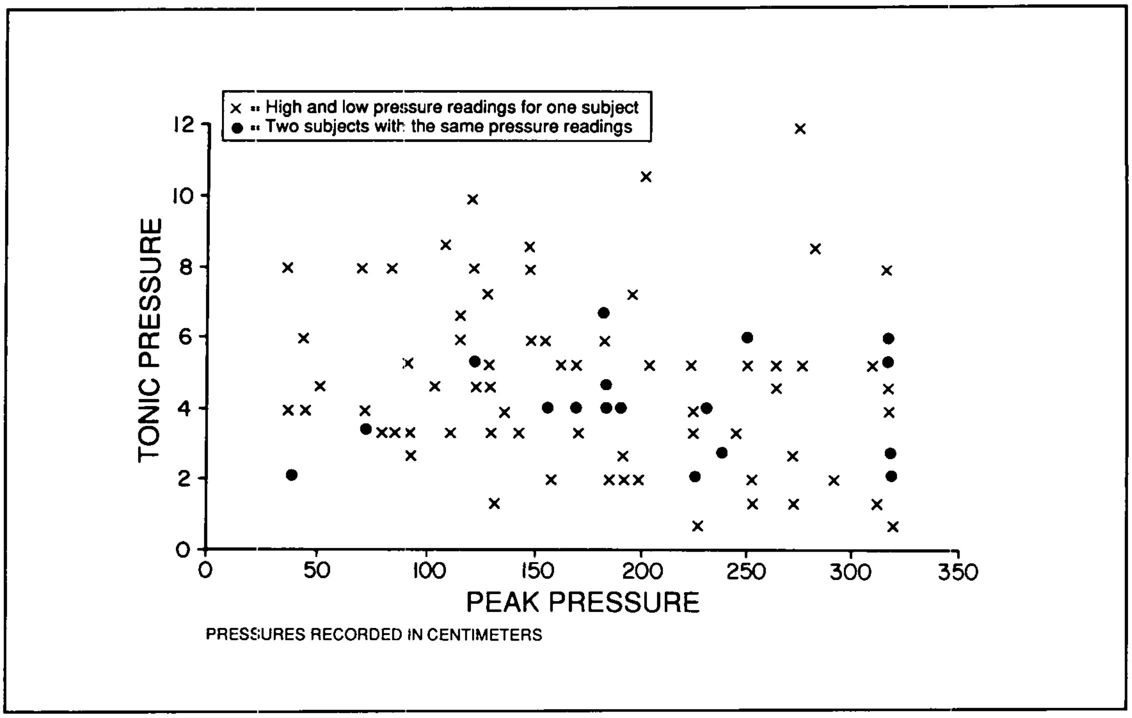


Figure 3
A four-channel physiological dynograph recorder. The amplified electrical signal is now permanently recorded upon the graph paper. One channel was used to record the tonic pressures, another for the peak pressures.

Figure 4
A long brass wire is attached to the catheters at one end and inserted into a wire holder at the other end. The wire holder is attached to a universal joint that is mounted on a movable metal arm.

Figure 5
A scattergram of tonic and peak lip pressures.



made to establish a correct base line on the graph. The subject's upper lip was then carefully draped over the catheters and recordings started.

The subjects were instructed to look straight ahead and relax, not to speak and to be as comfortable as possible. This was confirmed by a drop in pressure as recorded on the dynograph until a stable tonic pressure was reached and recorded. The subjects were then instructed to tense their lips in a grimace for peak pressure recordings. This was rehearsed prior to the recordings to insure that the patient's upper lip did not go below the plane of occlusion and dislodge the catheter. This was repeated five times. The subjects were instructed to tense for only five seconds, enough time to achieve maximum contraction without fatiguing the muscles. The readouts on the dynograph recorder were monitored by the one experimentor to insure that the subjects were relaxed and the catheters did not slip. Another observer verified the position of the catheters, by extraoral inspection and one intraoral inspection after the third cycle. This procedure was repeated on 110 subjects. Out of this group, 100 yielded results with a stable enough baseline reading to be judged accurate. Ten subjects couldn't seem to relax with the catheter in their mouth or could not keep their heads still, yielding a large discrepancy in their readings. Though quantitative accuracy was stressed, it was the relationship between high and low readings that concerned us. Small variations in numerical value were deemed insignificant.

Results

From the five readings obtained for maximum perioral pressure, the highest and lowest readings were excluded. These usually occurred at the beginning or end of the procedure and probably resulted from unfamiliarity with the required muscle action or fatigue. Dislodgement of the catheter assembly from the original site of placement also contributed to inaccuracy at the extremes of pressure. The baseline readings were judged separately by two researchers and their results were averaged. The variations in their interpretation (numerical) of the measurements were small.

The readings selected were listed in order. The lowest pressure and the highest pressure were listed separately. The difference between them for each subject was also recorded. The Pearson Correlation Matrix was used to give a numerical value to the linearness of data on a graph in which the numeral one is a perfect correlation. A numerical correlation value close to zero or below indicates that no linear relationship exists.

Our input consisted of the lowest tonic pressure readings accepted and the highest peak pressure readings deemed significant. We found our data to have a Pearson Correlation Coefficient of -0.146, indicating a complete lack of any statistically significant relationship, either direct or indirect, between the peak pressure and the tonic pressure of the lip in the same subject, in the same area. This was confirmed by graphing the data in which the "Y" coordinate represents tonic lip pressure and the "X" coordinate represents peak perioral pressure (Figure 5).

Conclusions

Since the results of our experiment on 100 patients showed no correlation between peak and tonic lip pressures, it would be wrong to clinically apply the results of maximum lip pressures to orthodontic therapy. Tonic resting pressures are the only measureable means of translating the muscle pressure into clinical application.

Summary

This study qualitatively assesses the relationship between two types of forces that are exerted on the dentition (resting and maximum forces) by the perioral musculature. It has been assumed that knowledge of the intensity of one gives knowledge of the intensity of the other by direct inference. This study has demonstrated the unreliability of this assumption.

Materials and methods must be developed to assess these low level (orthodontically significant) forces in a way convenient for the orthodontist, so these pressure readings might be used as a tool, indicating among other things arch stability and potential for relapse.

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