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Changes in Lip, Cheek, and Tongue Pressures After Rapid Maxillary Expansion Using a Diaphragm Pressure Transducer

Nazan Küçükkeleş, DDS, PhD;[a] Cenk Ceylanoğlu, DDS[b]

ABSTRACT

The purpose of this study was to investigate the changes in pressures that are exerted to maxilla by the tongue, lip, and cheek before and after expansion and during the retention period. Twelve patients (five males, seven females) with maxillary transverse deficiencies were randomly selected. The first pressure measurements were made before expansion using a diaphragm pressure transducer. The second measurements were made right after the maxillary expansion procedure, which lasted about 20 days. The expansion devices were replaced with retention devices, and measurements were made at the end of the first, second, and third months of retention. Pressure values on the buccal side of upper first molar and incisor increased significantly right after expansion but started decreasing during retention. The values at the end of the third month of retention were similar to the preexpansion values ($P < .05$). Tongue pressures on the lingual side of the upper first molar and upper incisor decreased significantly with expansion but started increasing after the expansion procedure. Even at the end of the third month of the retention period, the values were not similar to the preexpansion values ($P < .05$). These values show that the cheeks and lips almost adapt to the new position of dental arches at the end of the third month, whereas tongue adaptation took comparatively longer.

KEY WORDS: Transducer, Pressure, RME.

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INTRODUCTION Return to TOC

Relapse after rapid maxillary expansion (RME) has been investigated over a long period. There is evidence that the midpalatal suture remineralizes at the end of the third month of the retention period; however, a relapse tendency has been observed up until six to nine months after completion of rapid maxillary expansion.[1,2]

The causes of this tendency were summarized in the literature as follows.

- High stress accumulated between the articulations of the craniofacial complex.
- Tension produced in the palatal mucosa.
- Imbalance between the buccal and lingual pressures, which is created as a result of maxillary expansion.[3–8]

There are few studies related to changes in lip, tongue, and cheek pressure due to the arch expansion,[2,9,10] and the adaptation period required by these soft tissues is still a question of debate. Our aim in this study was to investigate the changes in the pressures that are exerted on the maxillary arch by the tongue, lip, and cheek immediately after RME and at the end of the first, second, and third months of retention.

MATERIALS AND METHODS Return to TOC

The study group consisted of 12 subjects (seven girls, five boys) whose ages ranged between 13 and 20, with a mean age of 16.5 years. They all required RME as a part of their treatment planning. Panoramic, lateral, and posteroanterior cephalometric films were taken initially. Patients were informed about the measurements and asked to sign an informed consent.

An EPL BO diaphragm pressure transducer (Entran, Fairfield, NJ), connected to a digital strain indicator, was used to measure lip, cheek, and tongue pressures exerted on the maxillary dental arch.

The pressure transducer was calibrated by using a pressure chamber, which had a pressure manometer. The transducer was placed in the pressure chamber passing through a rubber bolt, and air pressure was increased slowly up to 1000 g/cm^2 (Figure 1). The values of the transducer were recorded on every 20 g/cm^2 display of the manometer, and the gage factor of the strain indicator was calibrated so that one digit on the monitor of the strain indicator corresponded to 1 g/cm^2 of pressure.

To attach the transducer during recordings, a molar band, which incorporated a buccal cleat and a lingual hook, was adjusted to a randomly selected upper first molar of each patient (Figure 2). Moreover, an acrylic stent with buccal and lingual hooks was prepared for the most prominent upper central incisor to hold the transducer during anterior recordings (Figure 3).

Recording method

The transducer was ligated to the hooks and cleats during the recording procedures, and recordings were made on the buccal and lingual sides of the first upper molars and central incisors (Figure 4). During the measurements, the patients were seated in a dental chair with their heads in natural head position. Recordings were made during rest position and when swallowing 10 ml of water. For dynamic evaluation of the lips and cheek, the pressures created during pronunciation of the vowel U and the tongue pressures created during pronunciation of the consonant N (en) were also recorded. To maintain the thermal compensation, the transducer was placed in the mouth and allowed to reach mouth temperature at least for 10 seconds before recordings were made. Then the cheeks were held away from the transducer by using a mouth mirror, the monitor was zeroed, and the cheek was released. For the assessment at rest position, the patients were asked to count to 20 and relax (in Turkish, the last letter of 20 is the “e” vowel, which keeps the patient in rest position). During recording of the rest position, five readings were taken, and the average of the five readings was used. Maximum values were recorded for the other measurements.

After the preexpansion measurements, a Hyrax-type of expansion appliance was inserted, and the patients were instructed to turn the screw twice a day (Figure 5). Expansion was continued until the lingual cusp of the upper first molar was in contact with the buccal cusp of the lower molars. The mean duration of expansion was 21.8 days (ranging between 13 days and 28 days) and the mean amount of expansion was 7.8 mm (ranging between five mm and 13 mm).

The retention appliance consisted of two transpalatal bars passing between molar and premolar bands and was inserted right after removal of the Hyrax device after the expansion procedure. The retention appliance was constructed from 0.9 mm stainless steel wire, and it included a buccal cleat and a lingual hook on the molar band (Figures 6 and 7). Measurements were made with the retention device in the mouth and were repeated at the end of first, second, and third months of retention. The original stent was used for recording in the incisor area during the measurements. All the measurements were carried out by the same investigator.

For the assessment of the method error, measurements of 10 randomly selected patients were repeated one hour after the first measurements and the first and second measurements, were evaluated with *t*-tests. There was no significant difference between measurements. The data in this study were also evaluated using *t*-tests.

RESULTS Return to TOC

On the buccal side of central incisors

Pressure values during rest position increased significantly after RME and started decreasing by the end of the first month of retention. At the end of the third month, the values decreased to a level almost equal to their preexpansion values (Table 2). In one patient, the values kept increasing until the end of the first month of retention. In two patients, the values did not decrease to the preexpansion values.

During swallowing, the pressure values increased to significantly higher values in 11 patients after RME and started decreasing by the end of the first month of retention. By the end of the third month, there was no significant difference between preexpansion and third month values ($P < .05$). During the pronunciation of U, there was a slight but significant increase in values after RME, and the values returned to preexpansion levels by the end of the third month (Table 2).

On the buccal side of first molars

In rest position, the cheek pressure increased significantly ($P < .05$) in all the patients and started decreasing by the end of the first month of retention. There was no significant difference between preexpansion and third month values (Table 2).

During swallowing, the pressure values increased significantly and started decreasing by the end of the first month. At the end of the third month, the values were still higher than the preexpansion values, although the difference was not significant. The pressure values did not have a significant change after expansion in only one patient.

During the pronunciation of U, the values increased significantly, started decreasing by the end of the first month, and returned almost to the preexpansion values (Table 2).

On the lingual side of central incisors

During rest position, the pressure values decreased significantly after RME and started increasing by the end of the second month of retention. At the end of the third month, there was no significant difference compared with the preexpansion values (Table 2). In one patient, the values increased after RME, started decreasing by the end of the first month but did not return to the preexpansion values. In two patients, the values were still low at the end of the third month.

During swallowing, the pressures decreased significantly ($P < .05$) after RME and started increasing at the end of the first month of retention. The values kept increasing until the end of the third month and returned almost to their preexpansion values (Table 2). Furthermore, in two patients, the third month values increased to higher levels than the preexpansion values.

During the pronunciation of N, the values decreased significantly after RME and increased to the preexpansion values starting from the first month. There was no significant difference between preexpansion and third month values (Table 2). One patient did not show any adaptation after RME.

On the lingual side of first molar

After expansion, there was a slight decrease in pressure values during rest position, but it was not significant. Then the values started increasing to the preexpansion values in the following three months (Table 2).

During swallowing, there were significant changes between preexpansion and postexpansion values ($P < .05$). The values started increasing after the first month of retention, but the difference was still significant at the end of the second month. At the end of the third month, the difference was not significant, but the values were still low and the pressures had not yet reached the preexpansion values (Tables 1 and 2). The pressure values of two patients kept decreasing until the end of the third month after expansion. The values of two patients increased to higher levels compared with the preexpansion values.

During the pronunciation of N, the pressure values did not show a significant change before and after expansion or at the end of the third month of the retention period (Table 2).

DISCUSSION Return to TOC

Several techniques have been described for the measurement of intraoral muscle forces and pressures. Lindeman and Moore[11] compared three different devices: strain gauges, load cells, and pressure transducers with respect to size, sensitivity, thermal compensation, factory uniformity, reliability, and validity, and they found the pressure transducer (EPL) to be the superior pressure-measuring device. They also concluded that the lips could exert a fluid pressure on the pressure-measuring device, so measurements should be made with pressure and not force-sensing devices. Moawad et al[10] compared the reliability and precision of a beam-type transducer and a diaphragm pressure transducer. They reported that the diaphragm pressure transducer was more precise and reliable. In another important study, Thüer et al[12] pointed out that the measurements of the resting pressures have to be made within an area of zero mm to two mm from the tooth surface. According to these criteria, the EPL diaphragm pressure transducer was found to be the most suitable device for the measurements in our research.

The head position of the patients is also an important question in pressure measurements of the teeth and alveolar process. According to Ingervall and Thüer,[13–15] the pressures are slightly greater with the head in extended than in the natural head position. So, considering their findings, we have recorded the pressure values in natural head position.

Moawad et al[10] recorded the pressures before and after one week of simulated dental arch expansion and concluded that the midline lip pressure decreased significantly after one week. Soo and Moore[14] measured the lip pressures before and after eight months of lip bumper therapy and concluded that the resting and speaking lip pressures showed significant increases one month after lip bumper placement, and then the pressure decreased to near or below pretreatment levels. The authors considered this an adaptive response. Similar to these studies, we found an adaptation at the end of the third month of retention on the buccal side.

Conversely, Halazonetis et al[2] recorded the cheek pressures after RME and found that during the three-month to four-month period of stabilization of the appliance, the pressures remained at the postexpansion levels, and no adaptation of the soft tissues occurred. Because the expansion appliance was not removed during the measurements, the tongue pressures were not examined in their study. One of the most important aspects of our study was the replacement of the expansion device by a retention device, which allowed adequate space for tongue adaptation thus making it possible for us to evaluate tongue adaptation.

In this study, some negative pressures were recorded on the lingual side similar to the previous studies reported by Thüer et al.[12,15] The authors reported that these negative pressures were undetected because the methods they used could not detect negative pressures.

Although the differences between preexpansion and third month values were not statistically significant, the mean values of the tongue pressures on the molar region in the rest and swallowing position did not fully reach the initial levels by the end of the third month of retention. According to Proffit,[16] the normal soft tissue functions are of short duration and therefore of little importance for tooth position. On the other hand, the resting forces on the teeth, because of their practically constant duration, are considered to have the greatest influence on the position of the teeth. So, it may be a good idea to follow adaptation of the tongue for a longer period (Figures 8 and 9).

On the other hand, in 1965, Zimring and Isaacson[17] studied the forces produced by RME appliances and found that the facial skeleton and maxillary articulations are the main resistance to expansion, not the midpalatal suture. In their study, the maximum loads on the patients ranged from 16.6 pounds (7.53 kg) to 34.8 pounds (15.8 kg) during treatment, and these forces were gradually dissipated almost to zero during the retention period of six weeks.

CONCLUSIONS Return to TOC

Because the tongue, lip, and cheek pressures have a tendency to return almost to their initial values at the end of the third month of the retention period and because previous studies showed that the RME forces disappear at the end of the sixth week and the midpalatal suture remineralizes in the third month after RME, the cause of long-term relapse needs to be researched elsewhere.

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TABLES Return to TOC

TABLE 1. Means and Standard Deviation Values of Pressures (gr/cm^2) Recorded Before and After Expansion and at the End of the First, Second, and Third Months of Retention

	Preexpansion		Postexpansion		First Month		Second Month		Third Month	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Buccal 1 rest	15.2	11.5	25.1	16.5	22.1	14	18.6	11.4	16.8	10.7
Buccal 1 swallow	49.3	26.5	66.1	35.1	59.1	27.8	57.5	28.4	52.6	25.4
Buccal 1 U	18.5	23.6	28.3	26.1	24.9	21.7	25.1	25.9	22.4	21.5
Buccal 6 rest	11.6	4.9	20.8	8.2	14.1	4.9	12.3	4.2	12.6	4.6
Buccal 6 swallow	72.3	41	107.4	48.2	91.9	47.5	89.7	51.2	80.4	49.8
Buccal 6 U	22.3	15.6	33.6	19.9	28.6	18.5	26.8	18.3	22.2	12.8
Lingual 1 rest	15.7	13.6	9	6.5	10	6.8	11.1	7.2	13.9	12
Lingual 1 swallow	84	40.3	58.9	34.3	68.7	32.3	74.4	33.6	85.9	41
Lingual 1 N	71.3	51.6	55.9	36.9	55.2	35.4	57.4	35.1	66	42.3
Lingual 6 rest	16.1	12.9	10	6.1	11.1	6.7	12.1	6.9	12.8	8.4
Lingual 6 swallow	173.2	77.1	112.7	32.7	105.3	24.2	122	30.2	145	74
Lingual 6 N	63.1	32.6	60.1	30.8	59.9	27.5	58.5	24.4	61.6	27.8

TABLE 2. Mean Differences and the Comparison of the Preexpansion Values (gr/cm^2) With the Postexpansion and First, Second, and Third Month Retention Values

	Preexpansion–Postexpansion		Preexpansion–First Month		Preexpansion–Second Month		Preexpansion–Third Month	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Buccal 1 rest	9.9**	5.9	6.9**	5.6	3.4**	3.5	1.7	3.0
Buccal 1 swallow	16.6**	13.7	9.7**	9.7	8.2**	7.8	3.2	8.0
Buccal 1 U	9.9**	8.4	6.4*	8.4	6.6**	11.1	3.9	8.4
Buccal 6 rest	9.3**	6.6	2.5*	2.9	0.7	2.2	1.0	3.1
Buccal 6 swallow	35.1**	28.1	19.6*	26.1	17.4*	18.6	8.1	16.8
Buccal 6 U	11.3**	12.8	6.2	14.6	4.5	17.5	−8.33	10.6
Lingual 1 rest	−6.7*	8.0	−5.7**	7.7	−4.7*	8.0	−1.8	5.2
Lingual 1 swallow	−25.2**	16.6	−15.4**	13.0	−97*	13.8	1.8	10.2
Lingual 1 N	−15.4**	22.3	−16.1**	24.4	−13.9*	25.2	−5.3	22.9
Lingual 6 rest	−6.1	12.0	−5.1	11.7	−4.0	9.5	−3.3	9.0
Lingual 6 swallow	−60*	79.9	−67.9**	62.2	−51.2*	63.1	−28.2	55.3
Lingual 6 N	−3.1	27.3	−3.3	27.7	−4.7	15.3	−1.5	14.3

* $P < 0.05$, ** $P < 0.01$

FIGURES Return to TOC

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FIGURE 1. The calibration of the transducer by using a pressure chamber

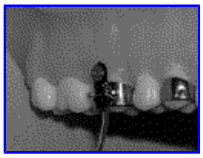

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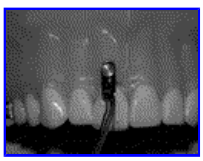
FIGURE 2. The application of the diaphragm pressure transducer to the molar band buccally. (The distance from the tooth surface is less than two mm)



Click on thumbnail for full-sized image.

FIGURE 3. The application of the diaphragm pressure transducer to the central incisor buccally

Click on thumbnail for full-sized image.

FIGURE 4. The application of the diaphragm pressure transducer to the molar band lingually

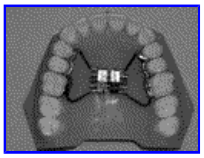


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FIGURE 5. Hyrax-type expansion appliance

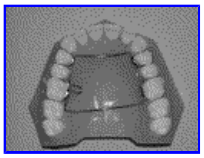

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FIGURE 6. Retention appliance constructed from 0.9 mm stainless steel wire with lingual hook and buccal cleat.

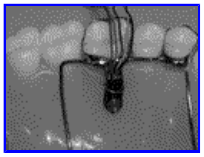

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FIGURE 7. The application of the diaphragm pressure transducer to the lingual hook of the retention appliance.

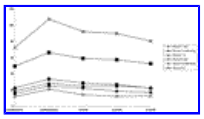

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FIGURE 8. The graph of buccal pressures before and after expansion and during retention periods (g/cm^2)

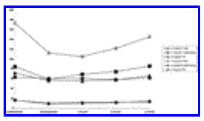

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FIGURE 9. The graphs of lingual pressures before and after expansion and during retention periods (g/cm^2)

[a]Professor, University of Marmara, Istanbul, Turkey

[b]Research Assistant, University of Marmara, Istanbul, Turkey

Corresponding author: Nazan Küçükkeleş, DDS, PhD, Belediye sitesi, A1, Blok No: 7 80600, 2. Ulus, Istanbul, Turkey (E-mail: nazles@turk.net)