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Tongue to palate contact during speech in subjects with and without a tongue thrust

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SUMMARY The aims of this study were to determine the location and movements of the tongue on the palate during pronunciation of Persian consonants and selected words in subjects with and without a tongue thrust (TT). Ten patients with a TT and 10 control subjects, 9–13 years of age, matched for age, gender, ethnicity, type and severity of malocclusion, with no history of orthodontic treatment, surgery, or systemic disease were selected. Maxillary alginate impressions were taken to construct upper removable appliances with 12 electrodes. Fine wires connected the electrodes to a specially designed electropalatovision (EPU) device. The removable appliance was inserted in the upper arch and then the Persian consonants and some selected words were pronounced by both groups. An electromechanical marker was included on each electrode which showed the tongue movements on the palate. Tongue movements, the quantity of the tongue contacts, and the location of the tongue were compared using *t*- and Chi-square tests.

In the TT group, the tongue had more contact with the palate on six electrodes ($P < 0.001$). When pronouncing the consonants, the tongue made contact anteriorly on the palate in the TT group. The quantity of tongue contacts with the palate was similar in both groups. During pronunciation of selected words, the contact points of the tongue to the palate were similar in both groups.

Introduction

Various dentofacial and functional malocclusions affect normal speech. Non-physiologic function of the tongue has been considered an important aetiological factor of malocclusions. The tongue is an important organ contributing to deglutition, speech, growth and development of the jaws, and alignment of the teeth in occlusion (Graber, 1972). The effect of the tongue on growth of the jaws and development of the occlusion is a result of its pressure on the teeth and other areas during rest and function (speech, deglutition, respiration, etc; Graber, 1972).

The number of tongue movements and the contact point of the tongue with the palate are different in the pronunciation of consonants and words. These can be affected by tongue malfunction. Tongue thrust (TT) is a type of malfunction where, in deglutition, the tongue is positioned between the upper and lower anterior teeth or thrusts with pressure behind the upper anterior teeth. This abnormal pressure can exist during speech and in the rest position (Jablonski, 1982). The prevalence of a TT has been reported to be 48 per cent in 10- to 12-year-old students in Tehran (Eslamian and Behzadi, 1995) and 39–80 per cent in the United States (Rogers, 1961; Hanson *et al.*, 1969). The prevalence of a TT decreases from 10 to 12 years of age (Eslamian and Behzadi, 1995), when development of the occlusion takes place. The detrimental effects of TT can affect the occlusion, resulting in an anterior open bite (Straub, 1960; Ricketts, 1969; Moyers, 1988; Huang and Justus, 1990; Rodrigues, 1990), protrusion (Straub, 1960; Rock *et al.*, 1988; Rodrigues, 1990), spacing of the upper and lower anterior teeth (Sassouni and Forest 1971; Lebrun, 1985; Melsen *et al.*, 1987), a posterior crossbite (Ghafari *et al.*, 1988), anterior lisping (Graber, 1972), or problems in the pronunciation of some consonants (S, Z, T, D, L, and N) which are pronounced with tongue and alveolar approximation (Teanech and Fogel, 1974). These conditions have been detailed in various studies (Graber, 1972; Moyers, 1988).

The purpose of this investigation was to determine tongue location and movements on the palate during the pronunciation of the Persian alphabet and selected words in subjects with and without a TT.

Subjects and methods

This study was undertaken on 9- to 13-year-old patients (12 girls and 8 boys) with a TT and normal deglutition but without a history of orthodontic or surgical treatment, or systemic disease. They were matched with a control group for age, gender, ethnicity, and type and severity of malocclusion.

An electropalatovision (EPV) device using direct current with 12 electromechanical markers was designed and constructed (Figure 1).

To control the device and the location of the electrodes, the upper orthodontic appliance was first tested intraorally by one author (LAP; Figure 2). The effect of saliva, the location of the electrodes, the site of the output wires, and the current intensity were assessed. The voltage was subsequently adjusted to a level to permit improved meter movements

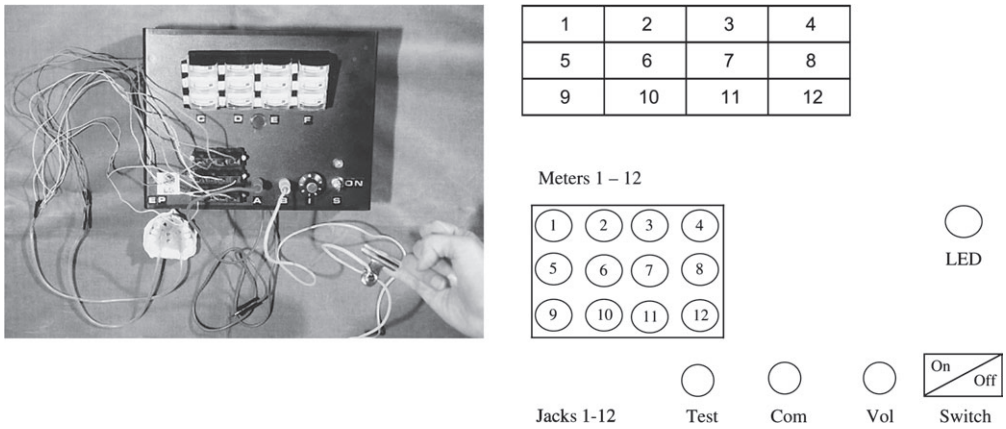

Figure 1 Photograph (left) and diagram (right) of electropalatovision device. Meters 1–12: show the rows of markers; Jacks 1–12: for connecting the output wires to the device; Test: contact Jack; Com: contact Jack to subject's body; Vol: voltage for regulating the current; Led: light-emitting diode lamp; Switch: on/off of the device.

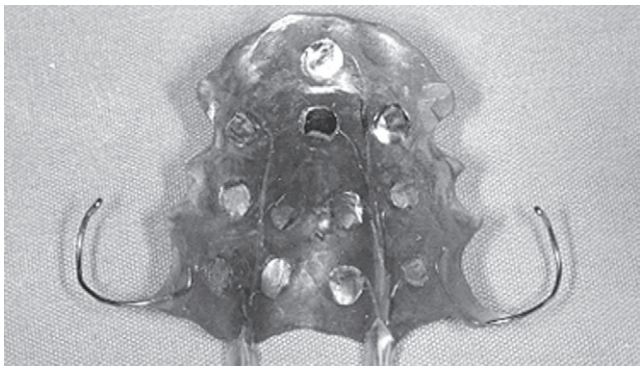

Figure 2 The upper removable appliance.

without damage to the tongue. To eliminate the effect of saliva, after pronouncing each consonant and word, the upper removable appliance was taken out and dried with a piece of cotton gauze. Each consonant and word was repeated consecutively four times at normal speed to enable the meters to be read exactly. The meters were installed in four rows of three allowing each row of markers to be read separately during pronunciation of each consonant and word.

The movement of the marker was recorded on a continuous scale from 0 to 100. Once recording commenced, contacts of the tongue to the palate were recorded. The intensity of the contacts was recorded as follows: 25 low, 50–75 moderate, and 75–100 high.

For 20 patients, 10 with TT and 10 with normal deglutition (six girls and four boys in each group) upper alginate impressions were taken and a removable appliance constructed using self-cured acrylic. The 12 electrodes (Figure 2) were the output wires that came from behind the right and left upper sulcus and exited from the corners of the mouth. After insertion and adjustment of the appliance in the upper arch, all the Persian consonants (32 letters) and selected words, 'Sad, Farsad, Siose, Sarakhs, Madreseh, Kakavand, and Leilazpour', were pronounced four times at moderate speed. The pronunciation of the consonants lasted 1 second, and the words 2–3 seconds. After each pronunciation, the appliance was removed and dried. This process was repeated three times for each individual. If the constants or words were spoken too quickly, the patient was asked to moderate the speed or the process was stopped.

The number of tongue movements or tongue contacts on the palate was studied using the EPV device. The 12 wires, which were attached to the electrodes of the upper appliance, were inserted in the EPV device. The electrodes were identified as C1, C2, C3, D1, D2, D3 E1, E2, E3, F1, F2, and F3 (Figure 3).

There was a specific meter for each electrode on the device; the contact of tongue to the electrode was shown by the movement of indicators. Every indicator was distinguished by a special code and each word was recorded using a special code. The number of tongue contacts on the electrodes was recorded. After recording the contact points and the number of tongue movements, the data in the two groups were compared by *t*- and Chi-square tests for the quantity and intensity of the tongue contacts.

Results

The Persian consonants and their analogues in English, which are pronounced between tongue and palate and teeth, are shown in Table 1. The pronunciation of the English analogues is described according to Hornby (1992). No analogue was found for 'gh', which is pronounced as 'r' in the French language. In Persian, consonants such as T, C, and Z are pronounced between the tongue, teeth, and palate. In English, they are pronounced between the tongue and the teeth. The tongue contact with the palate in pronouncing some of the consonants in the two groups is shown in Figure

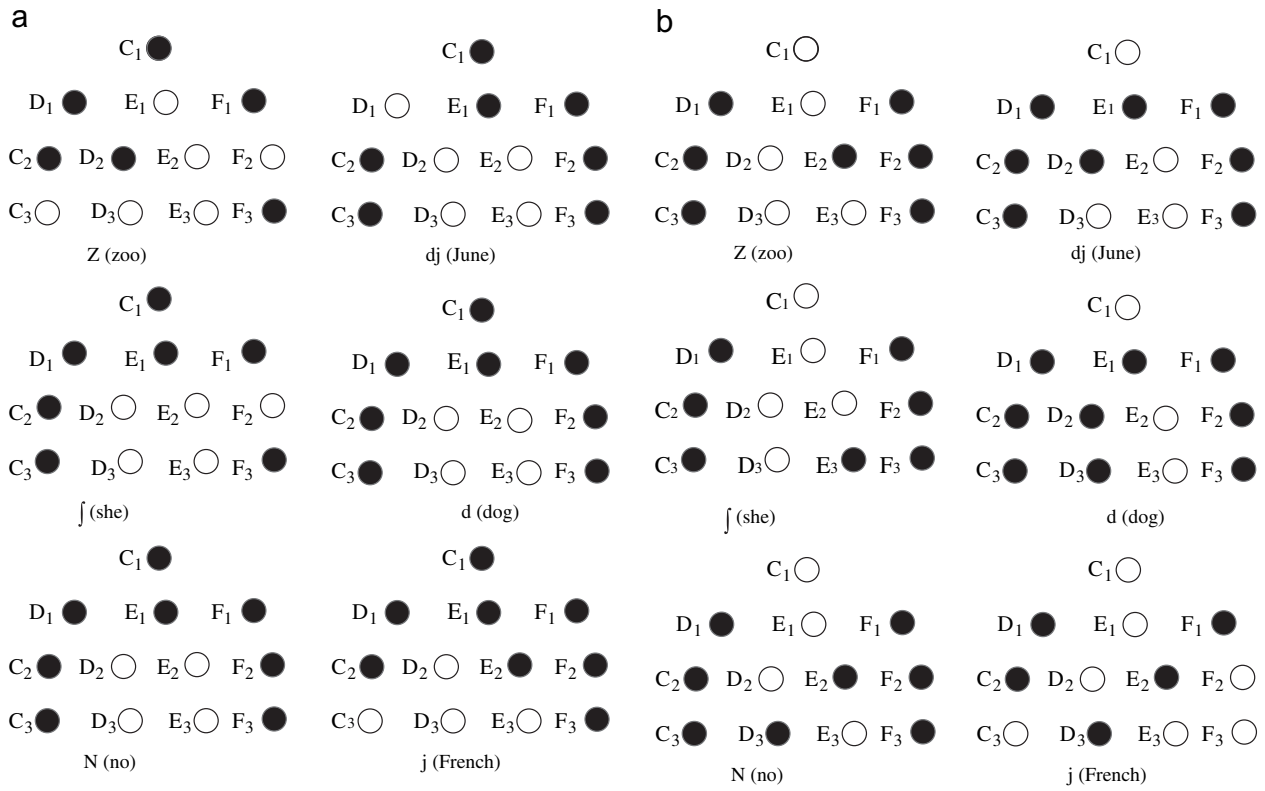

Figure 3 The location of tongue contacts with the palate in pronouncing six consonants in a tongue thrust (a) and control (b) subject.

Table 1 The location of tongue contacts with the palate in Persian consonants pronounced between the tongue, palate, and teeth.

Persian consonants	English analogues	Control group (n = 10)	Tongue thrust group (n = 10)
Te, Ta	t (tea)	C1 C2 C3 D1 E1 E2 F1 F2 F3	C1 C2 C3 D1 D2 E1 F1 F2 F3
Ce Se Sa	s (So)	C1 C2 D1 E2 F1 F2 F3	C1 C2 D1 F1 F2 F3
Che	t ʃ (chin)	C2 C3 D1 D2 E1 F1 F2 F3	C1 C2 C3 E1 F1 F2 F3
De'	d (did)	C2 C3 D1 D2 E1 E2 F1 F2 F3	C1 C2 C3 D1 E1 F1 F2 F3
Je'	dj (June)	C2 C3 D1 E2 F1	C2 D1 E1 F1 F3
She'	ʃ (she)	C2 C3 D1 E2 F1 F2 F3	C2 C3 D1 F1 F3
K	k (cat)	C2 C3 E2 F2 F3	C2 D3 F1 F3
G	g (got)	C2 D1 E1 E3	C2 D3 F1 F3
Le'	l (leg)	C1 C2 D1 E2 F1 F2 F3	C2 D1 E1 F1 F3
Ne'	n (no)	C2 C3 D1 E2 F1 F2 F3	C2 C3 D1 E1 E2 F1 F2
Ye'	j (yes)	C2 C3 E2 F1 F2 F3	C2 F3
Ze'-Za	z (zoo)	C2 C3 D1 E1 F1 F2 F3	C1 C2 D1 F1 F3
Ghe'	re' (French language)	E2 E3	C2 F3
Khe'	ch (German Language)	F2 F3	C2 F1 F3

3a,b. In the pronunciation of all the Persian consonants (A-Ye) in the TT group, the contacts were more at F3, F1, E1, D1, C2, and C1 (i.e. six electrodes); this means that tongue movements were more anterior in the TT group (Figure 4a) than in the group without a TT (Figure 4b). The difference between the groups was significant ($P < 0.001$; Table 2).

In pronunciation of the selected words (in speech), most contacts were at F3, F1, and D1 with no significant difference between the groups. The mean number of tongue contacts to the palate during pronunciation of the words was similar in both groups; 1.8 ± 0.2 in subjects with a TT and 1.9 ± 0.3 in those without a TT.

The intensity of the tongue contacts on the palate was the same in both groups. Chi-square analysis did not show any differences between the groups (Table 3).

Discussion

It is interesting that some electrodes, especially those towards the posterior of the hard palate, were contacted so rarely.

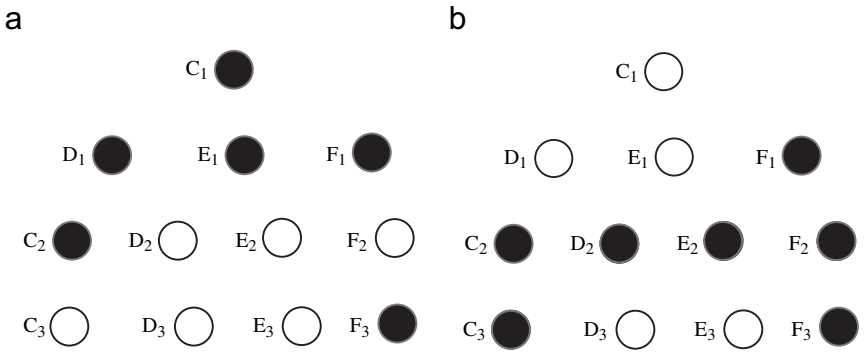

Figure 4 The location of tongue contacts with the palate in (a) the 10 subjects with a tongue thrust and (b) the 10 subjects in the control group.

Table 2 The number of tongue contacts on the palate during pronunciation of the Persian alphabet in the control and tongue thrust (TT) groups.

Groups	Contact points												Sum
	C1	C2	C3	D1	D2	D3	E1	E2	E3	F1	F2	F3	
TT	30	53	38	35	4	4	17	4	2	33	18	53	291
Control	21	41	41	29	14	3	8	18	12	21	38	46	292
Total	51	94	79	64	18	7	25	22	14	54	56	99	583

Few sounds in Persian are linguo-palatal and even then the tongue is not very far back in the palate. Maddieson (1984) suggested that in most native Persian dialects, the only linguo-palatal consonant was J (Je), whereas 'k' and 'g' are velar consonants, i.e. the tongue contacts the soft palate.

In the present study, there was no significant difference between the TT and control groups in the number of tongue contacts, the location of contacts during speech, or the pronunciation of the words. However, during pronunciation of the consonants, significant differences were seen in the location and number of tongue contacts between the two groups ($P < 0.001$). In the TT group, the contact points of the tongue were more towards the anterior and lateral sides of the palate (behind the incisors, canines, and premolars). These findings show that the combination of consonants to words in speech reduces the difference in speech between the TT and control group. Although there was a difference in tongue movements when pronouncing the consonants between the two groups during speech, they were similar.

During pronunciation of the words, the contacts between the tongue and palate were mostly at the anterior and lateral parts of the palate in both groups, and the least contacts were in the midpalatal areas.

Most studies reported in the literature concern the assessment of tongue movements during deglutition, controlling tongue movements, and tongue movements during abnormal deglutition.

Shawker *et al.* (1983), who used ultrasound to study tongue movement, reported this method to be successful. Chiang *et al.* (2003) found that ultrasonography in combination with the cushion-scanning technique was a valuable tool in quantitative analysis of tongue movement during vowel articulation. Yokochi (1996) used videofluoroscopy to study the stages of incorrect deglutition and TT in 30 severely physically disabled children. Harden and McRydell (1984) studied changes in deglutition habits after treatment to correct TT and observed that normal deglutition was achieved.

Table 3 Contact intensity in pronouncing the consonants and words in individuals with and without a tongue thrust (TT).

Groups		Contacts' number		
		High moderate	Mild	Sum
TT	Number	227	186	463
	%	59.8	40.2	100
Control	Number	361	234	545
	%	60.2	39.3	100
Total	Number	638	420	1058
	%	60.3	39.7	100

Wasson (1989) introduced methods for correction of TT such as orthodontic and functional appliances, myofunctional therapy, and surgery. Lundquist *et al.* (1995) found electropalatography (EPG) to be a useful method to study tongue movements and Swedish 'S' production. Hardcastle *et al.* (1991) found EPG to be an important method in the

objective evaluation of treatment procedures. Schwestka-Polly *et al.* (1995) introduced electromagnetic articulography (EMA) to observe tongue movements and to detect the influence of spikes in orthodontic appliances to correct the tongue pattern in anterior open bite subjects. Horn *et al.* (1997) examined tongue function and movement in the midsagittal plane during speech using EMA. The distances and angles appeared favourable to describe the course of movement, whereas areas produced unfavourable results. Suzuki *et al.* (1981), who used palatography in patients with an anterior open bite to determine the articulatory specifications of the tongue, observed anterior tongue movement of tongue in all the patients.

Teanech and Fogel (1974) reported that in individuals with a TT, there is lisping in the pronunciation of S, Z, T, D, L, and N.

Difficulty in matching the TT and control groups (age, gender, ethnicity, type, and severity of malocclusion), repeating the consonants and words, patient co-operation, and exact control of the indicator of the EPV device resulted in a limited number of subjects. Further investigations should be performed on subjects who do not require orthodontic treatment, to enable the procedures to be repeated at regular intervals in order to avoid delays in patients' treatment.

Conclusion

During the pronunciation of letters in the Persian alphabet, the tongue made contact more anteriorly on the palate in individuals with TT (or tongue malfunction) than in those without a TT. On the other hand, during pronunciation of whole words, the contact points were located similarly on the palate whether the individuals exhibited a TT or not.

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