European Journal of Orthodontics 33 (2011) 139–142
doi:10.1093/ejo/cjq042
Advance Access Publication 27 July 2010

Altered oral sensory perception in tongue thrusters with an anterior open bite

Sridhar Premkumar*, Srinivasan Avathvadi Venkatesan** and Sivaram Rangachari***
*Department of Orthodontics, Government Dental College and Hospital, **Institute of Neurology, Madras Medical College and Hospital and ***Private Practice, Chennai, India

Correspondence to: Dr Sridhar Premkumar, B-3, Block-2, Jain Ashraya Phase III, 31, Arcot Road, Virugambakkam, Chennai-600 092, India. E-mail: dr_premsridhar@yahoo.co.in

SUMMARY The aim of this study was to evaluate oral sensory perception in patients with an anterior open bite (AOB) and associated tongue thrusting activity. This study was performed in the Department of Orthodontics, Government Dental Hospital, Chennai, on 30 subjects (16 females and 14 males) aged from 12 to 17 years with an AOB associated with a tongue thrust and in a control group of 100 subjects (53 females and 47 males aged from 12 to 17 years) with a normal occlusion and no oral habits. Stereognosis and two-point discrimination (2PD) were employed for evaluation of oral sensory perception. Statistical comparison was undertaken using a Student's *t*-test.

Stereognostic ability was altered in children with an AOB associated with a tongue thrust (t = 15.2, probability of occurrence $P < 0.01$). The mean oral stereognostic score in the control group was 31.8 and in tongue thrusters 25.3. The AOB group also showed a diminished 2PD threshold at the tip of the tongue [control group 1.08 mm, tongue thrusters with an AOB 1.64 mm ($t = 7.3$, $P < 0.01$)]. This finding highlights the fact that the tongue plays a vital role in oral sensory perception. Oral stereognostic tests and 2PD as diagnostic tools are valuable in the evaluation of oral sensory perception.

Introduction

Maturation of motor expression is intimately correlated with local maturation of sensory experience as well as with progressive development of higher levels of brain function, which is termed 'encephalization' (Bosma, 1963). Therefore, correct maturation of orofacial function requires a normal sensory motor feedback mechanism. Normal function is the common denominator joining the individual parts of the orofacial system into a dynamic integrated system (Graber, 1997). Function is the result of the sensory motor reflex mechanism, which comprises sensory feedback and the resultant motor response. Since a delicate equilibrium exists between sensory input and motor activity, disturbances in one part of the system do not remain isolated but affect the whole system.

An incorrect sensory motor feedback mechanism leads to stomatognathic dysfunction. In subjects with pernicious oral habits, such as tongue thrusting, motor activity is altered and adaptational tongue positional changes take place leading to malocclusions, such as an open bite, crossbite, protrusion of teeth, and deepening of the palate. It is logical to assume that sensory perception could be altered in conditions with faulty motor functions, such as a tongue thrust. A review of the orthodontic literature reveals that this particular aspect of sensory motor feedback mechanism has been poorly investigated. It is therefore essential that a study of oral sensory perception is carried out to investigate clinically useful information on local sensory perception, which more readily evokes associated motor functions. Colleti *et al.* (1976) and Dahan (1992) indicated that an investigation of oral sensory perception among tongue thrusters with an open bite would be productive in order to extend the present knowledge in this area. The purpose of this study was to investigate the current evidence on oral sensory perception that is thought to contribute to sensory motor reflex mechanism.

Subjects

Prior to the start of this study, a mini-mental state test (Table 1) was completed to assess the intelligence/awareness of the patients (Epstein *et al.*, 1997). Those who scored less than 24 points out of a maximum of 30 in the mini-mental state test were excluded. One hundred subjects (53 females and 47 males) with normal occlusion and no history of pernicious oral habits and 30 subjects (16 females and 14 males) with an anterior open bite (AOB) and an abnormal tongue posture during swallowing participated in this study. The experimental subjects exhibited open vertical separation between the incisal edges of maxillary and mandibular anterior teeth with contact in the posterior segments. Their ages ranged from 12 to 17 years. The control and experimental groups were selected from children who belonged to the same local Dravidian population. Neither group had a history of previous orthodontic treatment or trauma to the teeth or jaws.

Table 1 Mini-mental state examination.

Orientation
1. What is the year, season, date, month, and day? (One point for each correct answer.)
2. Where are we? Country, county, town, hospital, and floor? (One point for each correct answer.)

Registration
3. Name three objects, taking 1 second to say each. Then ask the patient to repeat them. One point for each correct answer. Repeat the question until the patient learns all three.

Attention and calculation
4. Serial sevens. One point for each correct answer. Stop after five answers. Alternative, 'spell' words backwards.

Recall
5. Ask names for three objects in Question 3. One point for each correct answer.

Language
6. Point to a pencil and a watch. Have the patient name them for you. One point for each correct answer.
7. Have the patient repeat 'No, ifs, and or buts'. One point for each correct answer.
8. Have the patient follow a three-staged command. 'Take the paper in your right hand, fold the paper in half, and put the paper on the floor'. Three points.
9. Have the patient read and obey the following: close your eyes. (Write in large letters.) One point.
10. Have the patient write a sentence of his or her own choice. (The sentence must contain a subject and an object and make some sense.) Ignore spelling errors when scoring. One point.
11. Have the patient draw two intersecting pentagons with equal sides. Give one point if all the sides and angles are preserved and if the intersecting sides form a quadrangle.

Maximum score: 30 points.

Development of stereognostic forms

Stereognostic investigation was made with a set of five different plastic geometric configurations (circle, square, triangle, star, and clover). The pieces were 12 mm in diameter and 3 mm thick and corresponded to the procedure used by Berry and Mahmood (1966). The word stereognosis denotes the ability of an individual to identify not only the shape of an object but also texture and density (Botez *et al.*, 1985). Hence, in this study, the ability of the subject to discriminate the surface texture and density was also included. To evaluate the patient's ability to discriminate the surface texture, blocks of plastic of the same size (12 mm) and shape (square) with sides, which were smooth and rough were used. Metal pellets and thermocoles of same size (12 mm) and shape (square) were used to evaluate the density of the objects. The arms of the bow divider were connected by a pivot joint and with a side adjustment, which was used to assess two-point discrimination (2PD).

Procedure

Details of the test were explained to the patients by showing them the five different geometric configurations. Identical models were placed on the table in front of the patient.

The configuration was kept on the dorsal surface of the anterior part of the tongue (Figure 1a) with the patient's view obscured and he/she was asked to identify a duplicate from the identical objects placed on the table. A maximum of 30 seconds was allowed for identification of each form. The subject was then asked to roll the object against the hard palate (Figure 1b) and to identify the object by correlating it with the same model on the table. The subjects were thus tested for lingual and linguo-palatal sensation. Instructions were given to all the subjects to avoid placing the object between the teeth or lips at any given time. During evaluation, the individuals were informed that the objects

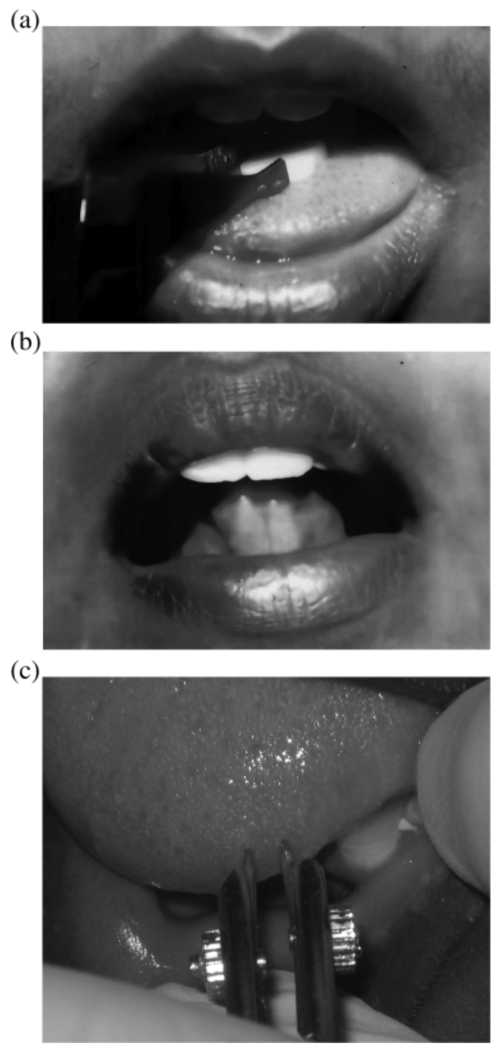

Figure 1 Oral stereognosis testing for lingual (a) and linguo-palatal (b) sensation and testing for two-point discrimination (c).

would be presented at random and there were no good or bad grades in the test. All the different configurations were tested randomly and errors, if any, were recorded. Evaluation of surface texture and density were consecutively carried out in a similar manner after shape discrimination. An interval of 15 minutes was allowed between shape, texture, and density evaluation. Each configuration was presented only once. A score of 2 points was given for each correct identification; the maximum stereognostic score was 36.

A bow divider was used to assess the ability of an individual to recognize the duality of parts (Figure 1c). Tests were carried out at the tip, lateral border (right and left sides), and dorsum of the tongue. 2PD was always performed on the day after stereognosis testing to avoid patient fatigue. The minimum distance between the two points of the divider at which the subjects were able to perceive the two points were measured using a millimetric scale and the findings were recorded. A standard decreasing interval procedure was adopted.

The objective of sensory testing is to delineate the extent of sensory impairment. Duplication of tests of sensory function does not increase the amount of information obtained and as the patient's cooperation is lost, repetition becomes less and less informative. The first competent examination of a patient's sensory system is the one most likely to provide accurate information (Munro and Campbell, 2000). Hence, tests were carried out only once in this study by the same operator (SP) to eliminate bias. The results were tabulated and statistical analysis was undertaken using a Student's *t*-test.

Results

There was higher percentage of correct responses in the recognition of shape in the control group. The mean oral stereognostic score for the control group was 31.8. The highest number of errors occurred when differentiating the circle and clover shapes. The time taken by the controls to identify the particular shapes was shorter when compared with subjects with an AOB with a tongue thrust. The tongue thrusters with an AOB showed a significantly reduced stereognostic score:mean score 25.3, which was statistically significant at the 1 per cent level (Table 2, Figure 2). They also had difficulty in identifying triangular from square shapes. Error in discriminating surface texture was also noted. In addition, tongue thrusters showed poorer ability in manipulation of forms. They tended to move the shapes over their tongue (side, back, and middle), while the control group used mostly the tongue tip to aid identification. The two-point threshold of the control group was found to be more acute at the tip of the tongue with the threshold decreasing postero-laterally (Figure 3). The two-point thresholds were found to be 1.08 mm at the tip of the tongue, 2.04, 2.99, and 4.04 mm antero-posteriorly at the dorsum of the tongue, and 3.01, 4.02, and 4.97 mm antero-posteriorly at the lateral border of the tongue. Tongue thrusters also displayed a similar pattern of 2PD, but the threshold at the

Table 2 Comparison [mean and standard deviation (SD)] of oral sensory perception between the controls and tongue thrusters with an anterior open bite

	Controls		Tongue thrusters		'*t*' value	*P*
	Mean	SD	Mean	SD		
Stereognosis	31.8	1.9	25.3	2.5	0.73	**
Two-point discrimination						
a. Tip of the tongue	1.08	0.35	1.64	0.43	7.3	**
b. Dorsum of the tongue						
D1	2.04	0.59	2.25	0.55	1.62	NS
D2	2.99	0.88	3.28	0.48	1.72	NS
D3	4.04	1.1	4.2	0.3	0.78	NS
D	3.02	1.3	3.34	0.75	1.28	NS
c. Lateral border of the tongue						
LB1	3.01	0.86	3.0	0.24	0.06	NS
LB2	4.02	1.0	4.0	0.16	0.16	NS
LB3	4.97	1.17	5.0	0	0.14	NS
LB	4.0	1.54	4.0	0.39	0	NS

**$P < 0.01$; NS, not significant.

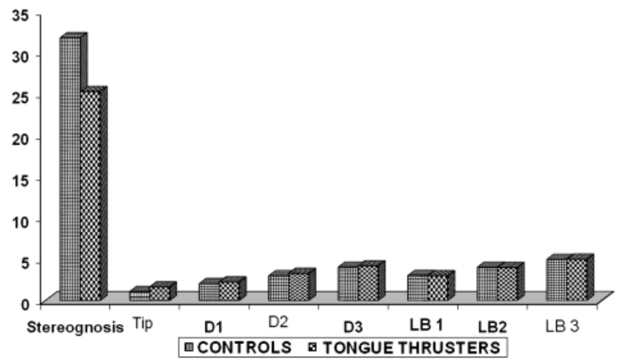

Figure 2 Graphical representation of the comparison of oral stereognosis and two-point discrimination between the control group and tongue thrusters with an anterior open bite.

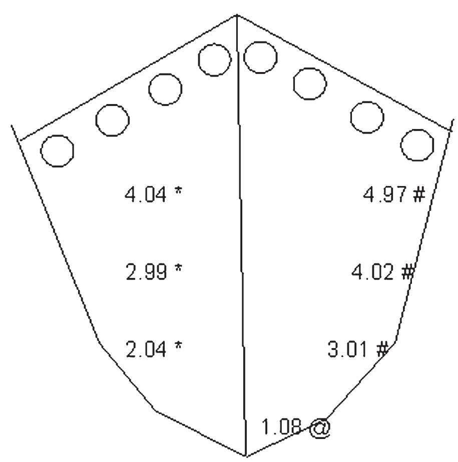

Figure 3 Spatial distribution of two-point discrimination thresholds in the control subjects. Each number represents the mean threshold in millimetres. The results for the lateral border and dorsum are the average of the right and left sides. * dorsum of tongue; # lateral border of the tongue; @ tip of the tongue.

tip of tongue was decreased (1.64 mm) when compared with the control group.

Discussion

Lingual tactile sensation serves unique functions, such as providing sensory information for suckling in new borns, and mastication, swallowing, and speech in adults. There exists a highly developed sensory motor feedback mechanisms, which make it possible to attain such functions of the mouth (Chuang, 1979). The fundamental concern with sensory motor function involved during motor function, coupled with a general interest in oral sensation, led many investigators (Chauvin and Bessette 1974; Berry and Mahmood, 1966; Leung *et al.*, 2002; Ikebe *et al.*, 2007) to extend the exploration of tactile perception to form and 2PD.

Only a few studies have been conducted on oral stereognosis pertaining to oral habits (Colleti *et al.*, 1976; Dahan and De Westerlink, 1980). The results from the present study show that individuals with an AOB associated with a tongue thrust showed a statistically significant inferior ability to perceive shapes and texture. The mean oral stereognostic score was 25.3 in tongue thrusters when compared with 31.8 in the control group. Litvak *et al.* (1971) found that in the partial absence of anterior teeth in dentulous subjects, the stereognostic score was reduced. Such a reduced score could correlate with that obtained in the present study for subjects with an AOB.

Two-point thresholds reflect the density and receptor field size of the mechanoreceptors at the test site. Kawamura and Wessberg (1990) and Ringel and Ewanowski (1965) found the tip of the tongue to be the most spatially acute site with sensitivity decreasing with distance postero-laterally. The current findings are in agreement with those reports. Grossman (1967) also stated that the threshold for detection of forms and 2PD demonstrate a spatial gradation of the sensitivity of the oral mucosa, with the greatest acuity in the lips and at the tip of the tongue. This is due to the progressive decrease in the sensory nerve terminals from the anterior to the postero-lateral part of the tongue.

The oral stereognostic scores in this study were not influenced by gender, in agreement with the findings of Kumin *et al.* (1984). A high score in oral perception indicates that the patient is in receipt of accurate information from his/her sensory feedback. The presence of a tongue thrust might affect tongue discrimination, a skill that probably reflects sensitivity and mobility of the tongue. This coupled with the fact that there is absence of tooth contact in the anterior region due to the open bite could lead to decreased sensory perception. The impaired oral sensory mechanism among tongue thrusters with an AOB could reflect a combined motor and sensory deficit. The possibility that variations among tongue thrusters exist is supported by the observation that four subjects in experimental group achieved the same low number of errors as the control group.

Conclusions

The present study showed that oral sensory perception is impaired in subjects with an AOB associated with a tongue thrust. The findings also confirm that form, size, and surface characteristics of the test pieces have an effect on the findings. It is evident that a healthy natural dentition with balanced soft tissue function offers good oral stereognostic ability. It remains to be determined whether oral sensory perception can improve with training and correction of an AOB. The study has highlighted the efficacy of oral stereognostic tests and 2PD as diagnostic tools in evaluation of oral sensory perception. The findings also confirm the role of the tongue in stereognosis, which involves both sensory perception and motor ability of manipulation of forms.

References

Berry D C, Mahmood M 1966 Oral stereognosis and oral ability in relation to prosthetic treatment. British Dental Journal 120: 179–185

Bosma J F 1963 Maturation of function of oral and pharyngeal region. American Journal of Orthodontics 49: 94–104

Botez M I, Botez T, Olivier M 1985 Handbook of clinical neurology. Volume 1 clinical neurophysiology. Elsevier Science Publisher, Philadelphia. p. 45

Chauvin J O, Bessette R N 1974 Oral stereognosis as clinical index. New York State Dental Journal 40: 543–546

Chuang C K 1979 Oral kinaesthesia and the sensory motor control of tongue and jaw movement. Journal of the Acoustical Society of America 66: 10–12

Colleti E A, Geffner D, Schlanger P 1976 Oral stereognostic ability among tongue thrusters with interdental lisp, tongue thrusters without interdental lisp and normal children. Perceptual and Motor Skills 12: 259–268

Dahan S J 1992 Perception and malocclusion an assessment of their interface with oral dysfunction. Journal of Japanese Orthodontic Society 51: 89–98

Dahan S J, De Westerlink A 1980 Oral stereognosis of the dysgnathic child, thumb suckers and non suckers. SSO Schweizerische Monatsschrift Zahnheilkunde 90: 129–132

Epstein O, Perkin G D, de Bono D P, Cookson J (eds) 1997 Clinical examination, 2nd edn. Mosby Publications, London, pp. 302–303

Graber T M 1997 Functional analysis. In: Graber T M, Rakosi T, Petrovic A G (eds). Dentofacial orthopedics with functional appliance, 2nd edn. Mosby Publications, St Louis, pp. 125–160

Grossman R 1967 Methods in determining oral tactile experience. In: Bosma J F (ed). Symposium on oral sensation and perception Charles C Thomas Publications, Springfield, pp. 564–578

Ikebe K, Amemiya M, Morri K, Matsuda K, Furuya-Yoshinaka M, Nakubi T 2007 Comparison of oral stereognosis in relation to age and use of complete dentures. Journal of Oral Rehabilitation 34: 345–350

Kawamura P, Wessberg G A 1990 Perioral somesthetic sensibility. Journal of Oral and Maxillofacial Surgery 48: 1181–1190

Kumin L B, Bell K, Forget K, Goodman M S 1984 Relationship of oral stereognostic ability to age and sex of children. Perceptual and Motor Skills 59: 123–126

Leung K C M, Pow E H, McMillan A S, Wong M C M 2002 Oral perception and oral motor ability in edentulous patients with stroke and Parkinson's disease. Journal of Oral Rehabilitation 29: 497–503

Litvak H, Silverman S I, Garfinkel L 1971 Oral stereognosis in dentulous and edentulous subjects. Journal of Prosthodontic Dentistry 25: 139–151

Munro J F, Campbell I N 2000 Macleod's clinical examination, 10th edn. Churchil Livingstone, Edinburgh, pp. 185–240

Ringel R L, Ewanowski S J 1965 Oral perception. 1. Two point discrimination. Journal of Speech Language and Hearing Research 8: 389–390