Turkish Journal of Medical Sciences

Volume 42 | Number 5 Article 18

1-1-2012

The effect of early loss of anterior primary tooth on speech production in preschool children

MELEK DİLEK TURGUT

GÜLSÜM AYDAN GENÇ

FİGEN BAŞAR

MERYEM UZAMIŞ TEKÇİÇEK

TÜBİTAK

Original Article

Turk J Med Sci
2012; 42 (5): 867-875
© TÜBİTAK
E-mail: medsci@tubitak.gov.tr
doi:10.3906/sag-1104-41

The effect of early loss of anterior primary tooth on speech production in preschool children

Melek Dilek TURGUT[1], Gülsüm Aydan GENÇ[2], Figen BAŞAR[3], Meryem UZAMIŞ TEKÇİÇEK[1]

Aim: Early childhood caries (ECC) is a progressive dental caries in children that may cause premature loss of the anterior primary teeth. In this study, the aim was to investigate the effects of primary anterior tooth loss and removable dentures on the speech of children with ECC.

Materials and methods: Included in the study were 15 patients with ECC who required extraction of the primary anterior teeth and needed dentures (case group), and 15 healthy children (control group). The articulation of the control group was evaluated once and that of the case group was evaluated before and after extraction, before and after dentures, and at the follow-up exam. The errors of both groups and those among the case group for 5 periods were compared statistically.

Results: It was found that tooth loss did not influence articulation. However, dentures temporarily effected articulation of the [s], [ʃ], and [z] speech sounds.

Conclusion: It was concluded that although dentures may cause articulation disorders, children have an ability to compensate for the differences and articulate speech sounds correctly.

Key words: Early childhood caries, articulation disorders, speech

Introduction

Speech is described as an act of producing speech sounds for putting thoughts into words for communication (1). Speech sounds (phones) are divided into the categories of vowels and consonants with respect to their production in the vocal tract, their acoustic transmission, and their auditory reception (2). Speech sound disorders include problems with articulation (making sounds) and phonological processes (sound patterns) (3).

Phonological disorders implicate a language disorder, whereas articulation disorders imply speech disorders (4,5). Phonological disorders involve the linguistic aspect of speech production, which affects multiple speech sounds. On the other hand, articulation disorders involve the motor component of speech and are characterized by incorrect production of the speech sounds (6,7). Articulation disorders can be divided into functional and organic disorders. Organic disorders include physical factors like cleft palate, hearing impairment, and neurological dysfunction. However, functional disorders are caused without any pathological condition and speech sounds may be omitted, substituted with other speech sounds, or distorted (6,7).

In the Turkish language, it is difficult to determine the exact number of phonemes since it may differ depending on the criteria used (8). Eker (8) reported that although there have been a number of studies concerning the Turkish phonemes, the majority

Received: 19.04.2011 – Accepted: 29.09.2011

[1] Department of Pediatric Dentistry, Faculty of Dentistry, Hacettepe University, Ankara - TURKEY
[2] Department of Ear, Nose, and Throat and Head and Neck Surgery, Section of Audiology, Faculty of Medicine, Hacettepe University, Ankara - TURKEY
[3] Department of Ear, Nose, and Throat and Head and Neck Surgery, Section of Audiology, Faculty of Medicine, Ondokuz Mayıs University, Samsun - TURKEY
Correspondence: *Melek Dilek TURGUT, Department of Pediatric Dentistry, Faculty of Dentistry, Hacettepe University, Ankara - TURKEY*
E-mail: melekturgut@yahoo.com

of them approximated the number of phonemes to those of letters. The Turkish consonant phonemes (and their prominent allophones) are /b/, /c/ ([$d_{3,3}$]), /tʃ/, /d/, /f/, /g/ ([ɟ, g]), /g/, /h/, /k/ ([c, k]), /l/ ([l, ɬ]), /m/, /n/ ([n, ŋ]), /p/, /r/ ([r, ɾ, ɹ]), /s/, /ʃ/, /t/, /v/ ([v, w]), /j/, /z/, and /ʔ/. The Turkish vowel phonemes (and their prominent allophones) are /a/ ([a, aː, a]), /e/ ([e, eː, e]), /ɯ/, /i/ ([i, iː]), /o/, /œ/, /u/ ([u, uː]), and /y/ (Tables 1 and 2) (8-10).

Early childhood caries (ECC) is described as a specific form of dental caries in children younger than 71 months. Frequent consumption of liquids with fermentable carbohydrates (particularly before/during sleeping) or prolonged breastfeeding have

Table 1. The Turkish consonant phonemes and their prominent allophones.

Orthography	Phoneme	Allophones	Remarks
b	b		
c	d͡ʒ	d͡ʒ	
		ʒ	Written as the letter j in orthography
ç	t͡ʃ	t͡ʃ	
d	d	d	
f	f	f	
g	ɡ	ɡ	
		ɟ	Palatal g (in Turkish: ince g)
ğ	ɣ	ɣ	
		▼ ▲	Sometimes the soft g lengthens the preceding vowel
h	h	h	
j			Not a phoneme in Turkish
k	k	k	
		c	Palatal k (in Turkish: ince k)
l	l	l	
		ɬ	Velarized l (in Turkish: kalın l)
m	m	m	
n	n	n	
		ŋ	Velar n
p	p	p	
r	r	ɾ	Tap r (in Turkish: tek çarpmalı r)
		r	Trill r (in Turkish: çok çarpmalı r)
		ɹ	Approximant r (in Turkish: yaklaşmalı r)
s	s	s	
ş	ʃ	ʃ	
t	t	t	
v	v	v	
y	j	j	
z	z	z	
‘	ʔ	ʔ	Glottal stop (in Turkish: gırtlak çarpması)

Table 2. The Turkish vowel phonemes and their prominent allophones (in the allophones column, the first one is the standard allophone).

Orthography	Phoneme	Allophones	Remarks
a	a	a	
		aː	Long a
		a̟	Front a (in Turkish: ince a)
e	e	e	
		eː	Long e
		e̞	Close e
ı	ɯ	ɯ	
i	i	i	
		iː	Long i
o	o	o	
ö	œ	œ	
u	u	u	
		uː	Long u
ü	y	y	

been reported to be the major factors involved in ECC (11). In cases of ECC, the aim is to restore all of the affected teeth with fillings. Nevertheless, extraction of nonrestorable teeth because of extensive caries may be required (12). After premature extraction of the primary anterior teeth, removable partial dentures have been used in order to reproduce a desirable esthetic appearance, to reestablish function, and to prevent abnormal speech and tongue habits (13) (Figure).

The effect of teeth on the articulation of speech sounds has been the concern of researchers because the consonant speech sounds categorized as labiodental ([f] and [v]), dental ([θ] and [ð]), and alveolar ([n], [t], [d], [s], and [z]) are formed with the aid of the anterior teeth (14). Therefore, studies regarding the effects of tooth loss are focused on the production of those speech sounds (15-17). A number of studies have been conducted to investigate the effect of removable partial dentures on the speech

Figure. A removable partial denture before (left) and after (right) insertion in the oral cavity.

of adult patients (18,19). In children, this topic has been generally investigated among children with cleft palate. The prostheses used among children with cleft palate were found to be beneficial in improving speech (20). In healthy children, regarding the effect of the anterior teeth, pioneer investigations were conducted by Bankson and Bryne (16) and by Snow (17). Bankson and Bryne (16) evaluated children before and after exfoliation of the primary anterior teeth. They found a statistically significant relationship between the production of [s] and the presence of teeth (16). Snow (17) evaluated the relationship between the articulation of consonant speech sounds ([f], [v], [ð], [θ], [s], and [z]) and the primary maxillary incisors. In that study, the author found that children with intact primary maxillary incisors articulated speech sounds correctly (17). However, in those studies, it was also reported that in some children, [s] speech sound production was not related to the presence of the anterior teeth (16,17). Riekman and el Badrawy (15) later reported that articulation of the [s] and [z] speech sounds could be affected only if extraction of the primary maxillary anterior teeth was done before 3 years of age. They suggested that at those ages, loss of the teeth permits too much air to escape and prevents the correct production of those speech sounds (15). However, to the best of our knowledge, there has been no study investigated the effect of both early primary anterior tooth loss and removable partial dentures in children. Thus, the purpose of the current study was to investigate whether early primary anterior tooth loss and removable partial dentures affect articulation in preschool children with ECC. The null hypothesis was that early tooth loss and/or denture use may cause permanent articulation errors.

Materials and methods

The present study was planned as a case-control study. Selection criteria of the case group included at least one primary maxillary incisor that needed to be extracted. Uncooperative children during the test procedures and those unable to use dentures were excluded from the study. The mother tongue of all of the subjects was Turkish, and they had no medical problems and had normal hearing. No evaluation was made regarding the articulations of the patients before the commencement of the study. None of the patients had previously received speech therapy. In the beginning of the study, a total of 33 children, 3-5 years of age and diagnosed with ECC, participated in the case group. Nevertheless, 11 patients before extraction, 6 patients after extraction, and 1 patient after insertion of the dentures failed to keep appointments. Thus, a total of 15 patients, 3-5 years of age (156.42-260.71 weeks of age, mean age of 199.87 ± 34.49 weeks), were included in the case group. The control group consisted of 15 children, 3-5 years of age (160.77-278.09 weeks of age, mean age of 227.39 ± 40.68 weeks), with intact anterior teeth.

The aim and clinical procedure of the study were explained and informed consent was obtained from the children's parents. The study was approved by the local ethics committee of Hacettepe University, Ankara, Turkey.

In the first step of the study, the age and sex of the patients were recorded. In the second step, articulations of the patients were evaluated by one speech therapist who was experienced in the speech therapy of preschool children. Articulation was assessed using a standardized articulation test (Ankara Articulation Test, Ankara Artikülasyon Testi, AAT) (21) and by talking about a subject that the child was interested in. The speech sound of the soft g ([g]) was not included in the test, as there is no word beginning with this letter in the Turkish language. The remaining consonants were tested in the initial, medial, and final word positions according to the following errors (7,22,23).

Phonological errors:

1. Omission: absence of a required speech sound in a word.

2. Substitution: replacing a speech sound with the correct speech sound.

3. Addition: adding an extra speech sound next to the articulated speech sound.

Articulation errors:

1. Distortion: inaccurate production of a speech sound.

Interdental lisping: a type of distortion characterized by production of sibilant consonants with the tongue tip placed too far forward (against the teeth or between the teeth); most common lisps involve [s] and [z].

2. Mass effect: a type of distortion because of a mass in the mouth, without any articulation error.

In the present study, lisping corresponded to strident lisping, whereas mass effect implied distortion caused by the mass of the dentures.

The errors of the patients in the control group were evaluated once, whereas in the case group, this was done 5 times:

1. Before extraction of the primary teeth.

2. After all of the extractions were completed and hemorrhage control was established.

3. Before insertion of the dentures (2 weeks after extraction).

4. Just after insertion of the dentures.

5. At 1 week after insertion of the dentures (follow-up appointment).

Since the patients were very young, acoustic analyses could not be performed due to cooperation problems.

Statistical analysis

SPSS 15.0 for Windows was used for the statistical analysis. The Shapiro-Wilk test of normality was used to check whether the age distribution was normal among the groups. Since the age distribution was normal, Student's t-test was used to compare the difference between the case and control groups according to age. The difference in the errors of the case and control groups with respect to sex was evaluated using Fisher's exact test. The differences regarding the errors of the case and control groups were evaluated using Fisher's exact and Kolmogorov-Smirnov tests. The differences in the articulation of the case group with respect to each evaluation period were assessed using the marginal homogeneity test. Moreover, the speech sounds that caused statistically significant differences were also determined using the marginal homogeneity test. For all of the tests, $P < 0.05$ was considered statistically significant.

Results

The ratio of the number of boys to girls in the case and control groups was 8/7 and 9/6, respectively. The distribution of the number of the patients in the case group with respect to age (weeks) was as follows: 2 patients of 156.42 weeks, 7 patients of 165.11-199.88 weeks, and 6 patients of 212.91-260.71 weeks. The distribution of the number of patients in the control group with respect to age (weeks) was as follows: 5 patients of 160.77-186.84 weeks, 6 patients of 234.64-256.36 weeks, and 4 patients of 265.05-278.09 weeks.

The mean ages of the case and control groups were 199.87 ± 34.49 and 227.39 ± 40.68 weeks, respectively. There was no statistically significant difference with respect to age between the 2 groups ($P = 0.055$).

In all of the patients (n = 15/group), 20 consonants were analyzed in each evaluation period. The data showing the distribution of 300 consonants in each evaluation period are shown in Table 3.

a. Errors with respect to sex in both groups

No statistically significant difference was found in the errors of the control group with regard to sex ($P = 0.999$). Similarly, there was no significant difference in the case group with respect to sex in any of the evaluation periods ($P = 0.569$, $P = 0.569$, $P = 0.282$, and $P = 0.608$ for before extraction, after extraction, before dentures, and follow-up appointments, respectively). Statistical analysis was not available for the period after the denture appointments.

b. Common errors in both groups

The numbers of errors in the case and control groups with respect to the evaluation times are shown in Table 3. In the case and control groups, the most common error was the substitution error. Mass effect was found to be predominant after the insertion of the dentures, but it had disappeared by the time of the follow-up appointment.

c. Comparison of the errors of the 2 groups

There was no significant difference when a comparison was made in the errors between the case group before extraction and those of the control group ($P = 0.427$).

d. Errors with respect to number of extracted teeth in the case group

The distribution of the number of extracted teeth was as followings: 1 tooth (3 patients), 2 teeth (2

Table 3. The number and percentage of errors in both the case and control groups.*

Evaluation time	Normal	Distortion	Substitution	Omission	Mass effect	Interdental lisping	Addition
			Case group				
Before extraction	276 (92.0)	1 (0.3)	20 (6.7)	3 (1.0)	-	-	-
After extraction	273 (91.0)	1 (0.3)	23 (7.7)	1(0.3)	-	2 (0.7)	-
Before denture	277 (92.3)	2 (0.7)	18 (6.0)	2 (0.7)	-	1 (0.3)	-
After denture	232 (77.3)	7 (2.3)	28 (9.3)	2 (0.7)	30 (10.0)	1 (0.3)	-
Control time	282 (94.0)	1 (0.3)	14 (4.7)	2 (0.7)	-	1 (0.3)	-
			Control group				
	282 (94.0)	-	15 (5.0)	2 (0.7)	-	-	1 (0.3)

*Numbers indicate the number of errors; parentheses indicate the percentage of errors.

patients), 3 teeth (6 patients), and 4 teeth (4 patients). Nevertheless, no statistical comparison could be made regarding the relationship between errors and the number of the extracted teeth because of the relatively small number of cases.

e. Errors after tooth extraction in the case group

There was no significant difference when a comparison was made between the errors of the case group before and after tooth extraction (P = 0.317).

f. Errors before and after the insertion of the dentures in the case group

There was no significant difference regarding errors of the case group before extraction and before insertion of the dentures (P = 0.904). However, a statistically significant difference was found in the articulation of the [s], [ʃ], and [z] speech sounds when a comparison was made of speech before and after insertion of the dentures (P < 0.05). The most common error was the mass effect, with a percentage of 20%.

g. Comparison of the errors after dentures and at the follow-up appointment in the case group

There were significant differences regarding the articulation of the [s], [ʃ], and [z] speech sounds at the follow-up appointment compared to the after denture evaluation (P < 0.05). The articulation errors of the speech sounds [s], [ʃ], and [z] before and after dentures and at the follow-up appointment are shown in Table 4. There was no significant difference with regard to the errors of the case group at the follow-up appointment compared to those of the control group (P = 0.999). Moreover, no statistically significant difference was found in the errors of the case group before extraction and at the follow-up appointment (P = 0.264).

Discussion

In the oral cavity, the organs that contribute to speech are the tongue, palate, alveolar processes, gums, lips, and teeth (18). In our study, no statistically significant difference was found in the articulation of speech sounds before and after extraction of the anterior teeth. This result can be attributed to some factors. The first may be related to the improved psychological status of the child. In detail, the adaptation of the child to the speech therapist at the second visit and the relief of pain after tooth extraction might have positive effects on the child. The second factor may be related to the compensation ability of the children for positioning of the tongue and lips, and adjustment of the air stream to articulate the speech sounds correctly (15,24-26). Nevertheless, the compensation of the children might have begun before extraction, since the extracted teeth had gross tissue loss and

Table 4. The errors of the speech sounds [s], [ʃ], and [z].*

Before dentures	After dentures	1 week follow-up
	[s]	
13 normal (86.6)	8 normal (53.3)	13 normal (86.6)
1 distortion (6.7)	2 distortion (13.3)	1 distortion (6.7)
1 interdental lisping (6.7)	1 substitution (6.7)	1 interdental lisping (6.7)
	3 mass effect (20.0)	
	1 interdental lisping (6.7)	
	[ʃ]	
14 normal (93.3)	8 normal (53.3)	15 normal (100.0)
1 substitution (6.7)	1 distortion (6.7)	
	3 substitution (20.0)	
	3 mass effect (20.0)	
	[z]	
14 normal (93.3)	9 normal (60.0)	14 normal (93.3)
1 substitution (6.7)	3 substitution (20.0)	1 substitution (6.7)
	3 mass effect (20.0)	

*Numbers indicate the number of patients; parentheses indicate the percentage of errors.

contained no or minor crown tissue. In the present study, the presence of an insignificant difference of the errors between the case group before extraction and the control group may also suggest an early compensation mechanism due to tissue loss.

In children with developmental disorders or syndromes demonstrating hypodontia or anodontia, partial or total dentures are used throughout their life. Nevertheless, partial dentures serve as an interim device in healthy children with limited primary anterior tooth loss due to trauma or caries (27). Despite their short-term usage, special emphasis should be placed on dentures because they improve speech and esthetics, and they prevent psychological disturbances and tongue habits (13,27). Therefore, replacement of lost primary anterior teeth is important, since dentures have a positive psychological impact even at preschool age, when esthetics becomes important (27).

The effect of the dentures was found to disappear after 1 week, which is consistent with the findings of studies performed on orthodontic patients of older age groups (28,29). Importantly, the results of our study clearly demonstrate the ability of children

to adapt and compensate for structural changes in articulation independent of age or appliance type.

Although the labial angulations due to the artificial anterior teeth showed errors in the [s] speech sound of some adult patients (19), to the best of our knowledge, there is no study regarding the effect of removable dentures in children in the contemporary literature. In a previous study, it was also reported that the speech sounds formed with the aid of lips, teeth, and the alveolar region are liable to be affected by removable dentures (19). In accordance with this knowledge, in the current study, a difference was found in the articulation of the [s], [ʃ], and [z] speech sounds. In the English language, the speech sounds [s] and [z] are categorized as alveolar speech sounds, whereas the speech sound [ʃ] is a postalveolar speech sound (14). In the Turkish language, although the speech sound [ʃ] is also considered to be a postalveolar speech sound, the speech sounds [s] and [z] are considered dental speech sounds (9).

In our study, the distortion and substitution errors of these speech sounds were also observed, but the majority of the errors were caused by the mass effect of the dentures. During the articulation of consonants, the tongue comes into contact with the teeth, alveolar ridge, or hard palate. Therefore, artificial teeth or palate may cause a changed perception and may alter tongue movement or position (19). This condition was considered to be the cause of the errors after dentures in the present study.

Interestingly, there was no difference between girls and boys in our study, while it was commonly reported that boys had more articulation problems than girls (24,25).

It is reasonable to observe more articulation errors in a 3-year-old child compared to a 5-year-old child. However, the aim of the present study was to evaluate the effect of tooth extraction and/or dentures in children rather than the articulation errors with respect to age. The results revealed that articulation errors at the beginning remained constant at the end of the treatment and were not influenced by extraction or dentures. Since maturation and learning may decrease errors, no speech therapy was planned for those patients (16,26).

Each language has its own speech sounds, some of which may require special articulation (24). However, the phonetic alphabet makes studies comparable to each other, since the articulation of the speech sound is taken into consideration (13). In some studies conducted with different languages spoken around the world, specific articulation tests adopted for that language were used (24,25). Since the ages of the children in the current study were very young, the illustrated cards of a standardized articulation test, the AAT, were used to communicate with the children. In fact, the AAT determines the articulation age of children at the evaluation time rather than the error type (21). Since the aim of the present study was to determine the error types caused by early loss of the primary teeth and/or dentures, the illustrated cards were used for this purpose without using the scoring system of the AAT. In addition, the young age of the children also limited the patient number in the study due to the lack of cooperation of some children with the speech therapist and the dentist.

Within the limitations of this study, it can be concluded that preschool children have a compensation ability to articulate speech sounds correctly despite early primary anterior tooth loss. Removable partial dentures may temporarily affect the articulation of the [s], [ʃ], and [z] speech sounds. Therefore, the null hypothesis was rejected.

Acknowledgments

The authors would like to thank Mr Ian Hartley for language revision and Pınar Özdemir Geyik for the statistical evaluation of the manuscript. We would like to acknowledge our sincere thanks to Professor Mehmet Akif Kılıç for his valuable comments regarding the content of the manuscript.

References

1. Johnson NC, Sandy JR. Tooth position and speech—is there a relationship? Angle Orthod 1999; 69: 306-10.

2. Niemi M, Laaksonen JP, Aaltonen O, Happonen RP. Effects of transitory lingual nerve impairment on speech: an acoustic study of diphthong sounds. J Oral Maxillofac Surg 2004; 62: 44-51.

3. American Speech-Language-Hearing Association. Speech sound disorders: articulation and phonological processes. Rockville (MD): ASHA; c1997-2012. Available at http://www.asha.org/public/speech/disorders/SpeechSoundDisorders.htm.

4. Haynes WO, Pindzola RH. Diagnosis and evaluation in speech pathology. 5th ed. Boston (MA): Allyn & Bacon; 1998.

5. Bleile KM. Articulation and phonological disorders. London: Singular Publishing; 1996. p.62-4.

6. Roth FP, Worthington CK. Treatment resource manual for speech-language pathology. 2nd ed. Canada: Singular Thomson Learning; 2001.

7. Hegde MN. Hegde's pocket guide to assessment in speech-language pathology. 2nd ed. Canada: Singular Thomson Learning; 2001.

8. Eker S. Türkçenin sesbirimleri ve belirgin altsesbirimleri. In: Károly L, editor. Turcology in Turkey: selected papers. Szeged (Hungary): SzTE BTK Altajisztikai Tanszék; 2007. p.181-98.

9. Zimmer K, Orgun O. Turkish. In: Handbook of the International Phonetic Association. Cambridge: Cambridge University Press; 2000. p.154-156.

10. Kiliç MA, Yildirim I, Okur E, Oğüt F, Serbetçioğlu B. The effect of stimulus duration on perception of Turkish vowels in normal-hearing and hearing-impaired children. Int J Audiol 2006; 45: 675-80.

11. Adair SM. Epidemiology and mechanisms of dental disease. In: Pinkham JR, Casamassimo PS, Fields HW, McTique DJ, Nowak AJ, editors. Pediatric dentistry infancy through adolescence. 4th ed. St Louis (MO): Elsevier Saunders; 2005. p.199-205.

12. Koroluk LD, Riekman GA. Parental perceptions of the effects of maxillary incisor extractions in children with nursing caries. ASDC J Dent Child 1991; 58: 233-6.

13. Dean JA, McDonald RE, Avery DR. Management of the developing occlusion. In: McDonald RE, Avery DR, Dean JA, editors. Dentistry for the child and adolescent. 8th ed. St Louis (MO): Mosby; 2004. p.625-82.

14. UCL Division of Psychology and Language Sciences. Reproduction of the international phonetic alphabet. London: University College London; 2005. Available at http://www.langsci.ucl.ac.uk/ipa/ipachart.html.

15. Riekman GA, el Badrawy HE. Effect of premature loss of primary maxillary incisors on speech. Pediatr Dent 1985; 7: 119-22.

16. Bankson NW, Byrne MC. The relationship between missing teeth and selected consonant sounds. J Speech Hear Disord 1962; 27: 341-8.

17. Snow K. Articulation proficiency in relation to certain dental abnormalities. J Speech Hear Disord 1961; 26: 209-12.

18. Jindra P, Eber M, Pešák J. The spectral analysis of syllables in patients using dentures. Biomed Papers 2002; 146: 91-4.

19. Runte C, Lawerino M, Dirksen D, Bollmann F, Lamprecht-Dinnesen A, Seifert E. The influence of maxillary central incisor position in complete dentures on /s/ sound production. J Prosthet Dent 2001; 85: 485-95.

20. Pinto JH, da Silva Dalben G, Pegoraro-Krook MI. Speech intelligibility of patients with cleft lip and palate after placement of speech prosthesis. Cleft Palate Craniofac J 2007; 44: 635-41.

21. Ege P, Acarlar F, Turan F. Ankara Artikülasyon Testi (Ankara Articulation Test). Ankara: Ankara Üniversitesi Araştırma Fonu Yayını; 2004 (in Turkish).

22. Özbek M, Tulunoğlu İ, Özkan S, Öktemer M. Evaluation of articulation of Turkish phonemes after removable partial denture application. Braz Dent J 2003; 14: 125-31.

23. McCord JF, Firestone HJ, Grant AA. Phonetic determinants of tooth placement in complete dentures. Quintessence Int 1994; 25: 341-5.

24. Palviainen S, Laine T. The role of developmental stage of occlusion for articulatory disorders in speech among first-graders. J Clin Pediatr Dent 1990; 15: 33-8.

25. Pakhala R, Laine T, Lammi S. Developmental stage of the dentition and speech sound production in a series of first-grade schoolchildren. J Craniofac Genet Dev Biol 1991; 11: 170-5.

26. Gable TO, Kummer AW, Lee L, Creaghead NA, Moore LJ. Premature loss of the maxillary primary incisors: effect on speech production. J Dent Child 1995; 62: 173-9.

27. Kotsiomiti E, Arapostathis K, Kapari D, Konstantinidis A. Removable prosthodontic treatment for the primary and mixed dentition. J Clin Pediatr Dent 2000; 24: 83-9.

28. Sergl HG, Klages U, Zentner A. Functional and social discomfort during orthodontic treatment - effects on compliance and prediction of patients' adaptation by personality variables. Eur J Orthod 2000; 22: 307-15.

29. De Felippe NL, Da Silveira AC, Viana G, Smith B. Influence of palatal expanders on oral comfort, speech, and mastication. Am J Orthod Dentofacial Orthop 2010; 137: 48-53.