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DOI: 10.2478/aoj-2013-0016

The impact of spur therapy in dentoalveolar open bite

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Aim: A longitudinal case-control study, designed to analyse the isolated effect of attached palatal spurs in patients displaying a dentoalveolar anterior open bite, is presented.
Methods: Thirty-one patients (mean age of 13.3 years ± 3.17 years) underwent a standardised treatment protocol with fixed anterior spurs for 8.3 months. Lateral cephalograms and plaster casts were analysed before (T1) and after spur therapy (T2). The data were tested using paired *t*-tests with a significance level of $p < 0.05$.
Results: The cephalometric analysis showed significant elongation of the height of the maxillary (mean +1.22 mm) and the mandibular (mean +1.39 mm) alveolar processes, as well as uprighting of the lower anterior teeth. The plaster cast analysis showed an increase in maxillary intermolar width (mean +0.98 mm) and a decrease in intercanine distance (mean -0.96 mm). The mandibular anterior width and dental arch length reduced. Overall, spur therapy resulted in a significant increase in overjet and overbite.
Conclusion: The use of spurs produced a resolution of the open bite in all patients. Therefore, spurs could be considered an effective mechanism for the management of anterior open bite in selected adolescent patients.
(Aust Orthod J 2013; 29: 145-152)

Received for publication: June 2012
Accepted: July 2013

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Introduction

An open bite is defined as a lack of vertical overlap or contact of the upper and lower incisors in any sagittal relationship.[1] The prevalence of an open bite in the mixed dentition ranges from 17% to 36.3%.[1,2] A tendency for vertical self-correction seen as a spontaneous increase in overbite has been reported in patients from 7 to 12 years of age.[3]

However, the treatment of patients with a persistent open bite remains an orthodontic challenge. The aetiology is frequently multifactorial but three possible causal factors have been identified: (1) dyskinesia, (2) the function and size of the tongue and (3) a vertical growth pattern with or without an anterior inclination of the maxilla.[4] A correlation has been reported between the orofacial musculature and facial structure which suggests a causal relationship between incorrect tongue position and an anterior open bite.[6] Furthermore, a digit-sucking or lip habit can produce a malocclusion characterised by an anterior open bite. If a sucking habit persists beyond the time that the anterior permanent teeth erupt, an open bite with proclined incisors may result.[5] Due to the many aetiological factors, multiple treatment strategies have been directed at eliminating the cause or correcting the dentofacial effects in order to improve the occlusion and masticatory function.[7-9]

An anterior resting tongue posture has been identified as a leading factor related to an anterior open bite and relapse after orthodontic or combined surgical-orthodontic therapy.[5,10,11] The management of tongue position is considered essential for successful treatment and various treatment approaches have been reported. Functional orthodontic appliances, vestibular shields, tongue cribs or myofunctional therapy have been applied with varying success.[10,12-16]

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Rogers first described therapy of incorrect tongue posture by employing palatal spurs.[17] Spur use was based on the premise that incorrect tongue posture could not been consciously and continuously controlled by the patient. Therefore, the modification of tongue posture could only be successful with considerable effort which was made more difficult by the duration of the dysfunction. By the application of palatal spurs, a nociceptive reflex is reportedly triggered, in order to avoid the cause of induced discomfort.[15] The avoidance act sets in motion a learning process and the neuromuscular establishment of a changed resting tongue posture.

Despite previous reports of spur therapy, few studies have examined their effectiveness in managing anterior tongue posture and improving an anterior open bite.[10,14,18] In addition, published papers are case studies or individual reports which do not permit scientifically-grounded conclusions.[10] Therefore, the aim of this prospective, longitudinal study was to determine, in patients presenting with an anterior open bite, the effect of palatal spurs on the craniofacial and dentoalveolar complexes.

Materials and methods

Thirty-one patients (16 female and 15 male) were recruited. All patients were of Caucasian origin with a mean age of 13.3 years ± 3.17 years (Table I) and were treated in the Department of Orthodontics of the Dental Clinic, University of Wuerzburg, Germany. The Declaration of Helsinki and the ethical standards established by the Institutional Review Board were followed and maintained during treatment. The study was conducted after informed and written consent from each participant.

The inclusion criteria identified an anterior open bite, or a relatively small overbite (≤ 2 mm), in combination with an anterior resting tongue posture, a visceral (infantile) swallowing pattern or a tongue thrust. Exclusion criteria were a lateral or anterior crossbite, a persistent digit habit, previous orthodontic or myofunctional therapy, and patients with a cleft lip and palate or with a craniofacial syndrome.

Treatment protocol

All patients underwent palatal spur therapy using a fixed appliance for a mean duration of 8 months ± 3 months (Figures 1a-f). The length of therapy was determined by the criteria described by Haung et al.[14] and Meyer-Marcotty et al.[18] who recommended that spurs be placed for at least 6 months or until a positive anterior overbite was achieved. No other appliance was used during the observation and treatment period.

Table I. Mean age in years (Y) and standard deviation (SD) of the study group.

Study group	N	Y	SD
All	31	13.33	3.17
Female	16	12.75	2.92
Male	15	13.58	3.16

The spur appliance consisted of a 0.9 mm palatal arch, fixed to the upper first molars. Pointed spurs, approximately 3 mm long, were soldered to the anterior and/or lateral tooth area, at a 45° downward angle and inclined towards the occlusal plane. As therapy progressed, the position and angulation of the spurs were varied according to individual postural tongue changes and to establish new sensory stimuli.

Method

In order to analyse dentoalveolar spur effects, plaster casts of the 31 patients were taken prior to treatment (T1) and immediately after therapy (T2). Craniofacial effects were assessed via lateral cephalograms but, because 5 patients had no film after treatment, they were excluded from the study, which left 26 cephalograms for assessment. The cephalograms were taken on the same machine (Orthopos DS Ceph®, Siemens, Erlangen, Germany) according to a standardised procedure, which assured consistency of imaging. The cephalometric analysis comprised 13 measurements (7 angular and 6 linear) related to 20 landmarks according to Rakosi (Figures 2a-b).[19] Additionally, measurements of the alveolar and basal height of the maxilla and mandible according to Beckmann et al. were used to analyse changes in the anterior dentoalveolar regions (Figure 2c).[20] The radiographic analysis was performed by the same investigator using the fr-win® software (Computer konkret AG, Dental Software, Falkenstein) to minimise variability.

Manual measurements of the plaster casts using a caliper with an accuracy of 0.1 mm were performed by

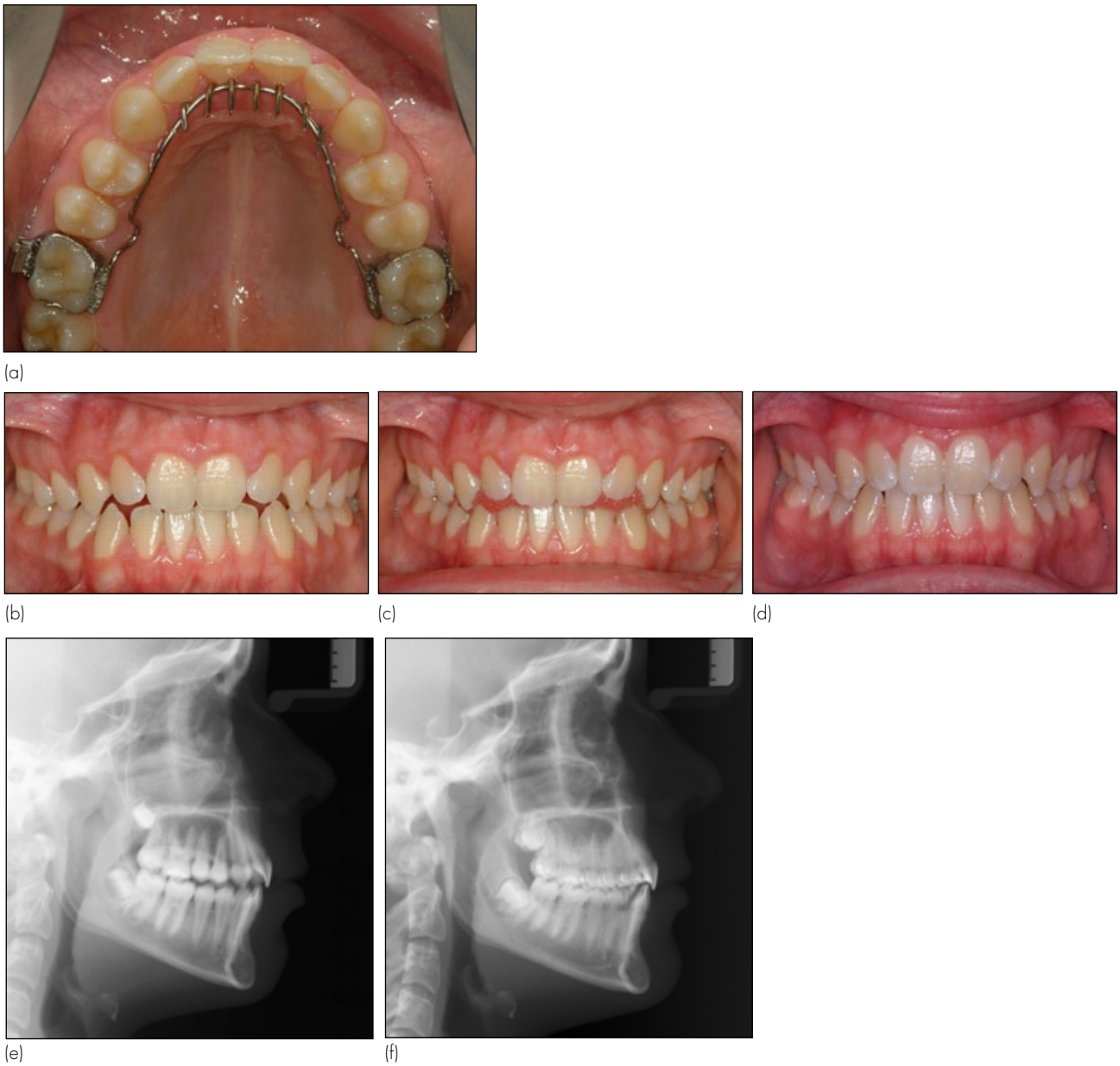


Figure 1. Patient treated exclusively with the Spur appliance.
(a) Spur appliance in situ; (b) Pretreatment (intra-oral frontal); (c) Pretreatment with tongue dysfunction; (d) Post-treatment (intra-oral frontal); (e) Pretreatment (Lateral cephalogram); (f) Post-treatment (Lateral cephalogram)

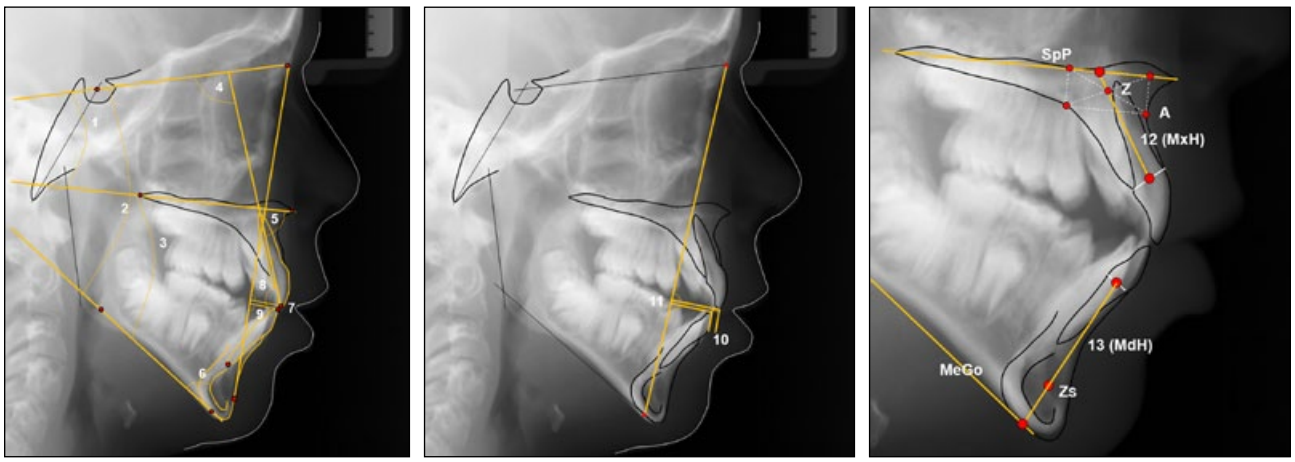
the same investigator. In total, 8 measurements were included in the cast analysis (Figures 3a-b). Intra-arch measurements comprised the anterior and posterior width of the dental arches, the length of the dental arch, and the maxillary and mandibular intercanine distances.

Statistical data analysis

Statistical analysis was conducted using SPSS software, Version 14.0 for Windows (SPSS Inc. Chicago, IL, USA). The distribution of the data was tested using the Kolmogorov-Smirnov test, which indicated a normal distribution. The collected data were analysed using paired *t*-tests to reveal differences between T1 and T2. The significance level was set at $p < 0.05$.

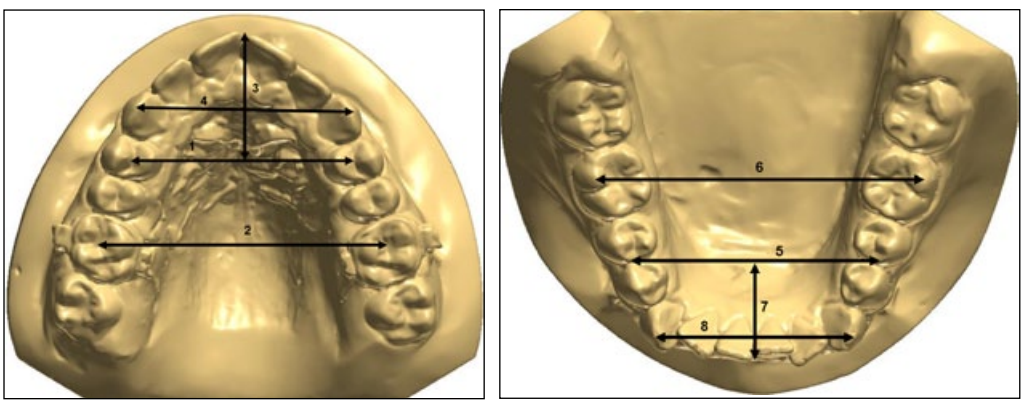
Method error

The same investigator retraced 10 randomly-selected cephalograms and remeasured 10 plaster casts after a period of 6 weeks. The method error was calculated



(a) (b) (c)

Figure 2. (a) Craniofacial complex: 1 = NSL-NL (°); 2 = NSL-ML (°); 3 = NL-ML (°); 4 = U1_NSL (°); 5 = U1_NL (°); 6 = L1_ML (°); 7 = Interincisal angle (°); 8 = U1_NPog (mm); 9 = L1_NPog (mm)
(b) Occlusion: 10 = Overjet (mm); 11 = Overbite (mm)
(c) Alveolar and basal height of the maxilla and the mandible. Measurement of maxillary (MxH) and mandible (MdH) alveolar height according to Beckman et al.[20] 12 = MxH (mm); 13 = MdH (mm)



(a) (b)

Figure 3. Plaster cast analysis.
(a) Maxilla: 1 = Anterior width of dental arch (mm); 2 = Posterior width of dental arch (mm); 3 = Anterior length of dental arch (mm); 4 = Intercanine distance (mm)
(b) Mandible: 5 = Anterior width of dental arch (mm); 6 = Posterior width of dental arch (mm); 7 = Anterior length of dental arch (mm); 8 = Intercanine distance (mm)

according to Dahlberg.[21] No significant difference was found between the first and second measurements on the radiographs. The method error was 0.38 – 0.68 mm in the plaster cast analysis and 0.45 – 0.97° and 0.18 – 0.89 mm respectively, in the cephalometric analysis (Table II and III). Therefore, good reproducibility was established and accepted for each parameter.

Results

Cephalometric analysis

The results of the cephalometric analysis are shown in Table IV. Spur therapy caused no statistically significant influence on the maxilla or on the mandible in the vertical dimension (inclination of the jaws). The maxillary (NSL-NL) and the mandibular (NSL-ML) measurements were almost normal at T1 and T2 according to the Rakosi analysis. The inter-basal angle (NL-ML) slightly increased at T2, but without statistical significance.

The sagittal position of the upper anterior teeth did not significantly alter following spur therapy (U1_NSL/ U1_NL). In contrast, the lower anterior teeth uprighted at T2. The angulation of the lower incisors to the mandibular plane (L1-ML) decreased significantly ($p < 0.001$) as did the distance between

Table II. Cephalometric analysis: method error of measurements according to Dahlberg.[21]

Variable		Method error of measurements
Inclination of the jaw bases		
1	NSL-NL (°)	0.81
2	NSL-ML (°)	0.46
3	NL-ML (°)	0.92
Dental analysis		
4	U1_NSL (°)	0.45
5	U1_NL (°)	0.89
6	L1-ML (°)	0.97
7	U1-NPog (mm)	0.18
8	L1-NPog (mm)	0.28
9	Interincisal angle (°)	0.9
Occlusion		
10	Overjet (mm)	0.24
11	Overbite (mm)	0.20
Height of the alveolar processes		
12	MdHab (mm)	0.73
13	MxHab (mm)	0.89

Table III. Plaster cast analysis: method error of measurements according to Dahlberg.[21]

Variable		Method error of measurements
Maxilla		
1	Anterior width (mm)	0.38
2	Posterior width (mm)	0.57
3	Anterior length (mm)	0.66
4	Intercanine distance (mm)	0.41
Mandible		
5	Anterior width (mm)	0.68
6	Posterior width (mm)	0.48
7	Anterior length (mm)	0.57
8	Intercanine distance (mm)	0.42
Occlusion		
9	Overjet (mm)	0.36
10	Overbite (mm)	0.20

the lower incisor to NPog (L1-NPog: $p = 0.012$). Additionally, a significant increase in the interincisal angle was observed ($p = 0.005$).

Overjet, as well as overbite, increased significantly during therapy (overjet: $p = 0.009$; overbite: $p = 0.014$). In contrast with the insignificant changes in the inclination of the jaws, the cephalometric evaluation of maxillary and mandibular anterior alveolar height (according to Beckmann[20]) showed significant vertical development (alveolar height of the mandible MdH: $p = 0.001$; alveolar height of the maxilla MxH: $p = 0.005$).

Plaster cast analysis

The results of the plaster cast analysis are shown in Table V. The maxillary intermolar width increased significantly ($p = 0.013$), whereas intercanine distance significantly decreased during the study ($p = 0.024$). Anterior mandibular width and the length of the dental arch significantly decreased (anterior width: $p = 0.024$; length of the dental arch: $p = 0.003$).

Discussion

The impact of palatal spur therapy was longitudinally analysed in a group of Caucasian subjects possessing an anterior open bite. The effects on the dentofacial complex and the alveolar and basal heights of the maxilla and the mandible were assessed on pre- and post-treatment lateral cephalograms. Furthermore, the morphological changes in the dental arches were measured on plaster casts. Overall, an increase of overjet and overbite was found during spur therapy.

No other appliance was used which allowed an isolated determination of the impact of treatment. Meyer-Marcotty et al. previously described a standardised spur therapy protocol which was adopted in the present study.[18] The analysis of the pretreatment lateral cephalograms showed a tendency towards a skeletal open bite in all patients. In addition, the underlying skeletal growth pattern appeared consistent with patients characterised by an anterior open bite.[22] The cephalometric analysis conducted during the present study showed a clinically insignificant increase in the vertical position of the maxilla and mandible. A slightly increased inter-basal angle was without statistical significance and so, no clinically significant vertical effect on the maxilla and the mandible could be ascribed to the spur therapy.

Table IV. Cephalometric analysis; mean value (M) and standard deviation (SD) at the study times T1 and T2; difference (Δ) between T1 and T2; significance (S) for $p < 0.05$; results after the *t*-tests for paired random samples for normal distribution of the variables (n.s. not significant, *significant, ** highly significant, *** most highly significant.

Variable		T1		T2		Δ(T2-T1)		S	
		M	SD	M	SD	M	SD	p	
Inclination of the jaws									
1	NSL-NL (°)	5.84	2.90	6.04	3.14	0.20	2.05	0.623	n.s.
2	NSL-ML (°)	35.73	5.87	36.36	6.13	0.63	2.33	0.181	n.s.
3	NL-ML (°)	29.89	5.30	30.31	5.59	0.42	2.23	0.342	n.s.
Dental analysis									
4	U1_NSL (°)	104.85	6.77	104.07	8.05	-0.78	5.03	0.439	n.s.
5	U1_NL (°)	69.31	6.63	69.90	7.98	0.59	4.89	0.543	n.s.
6	L1-ML (°)	90.59	7.16	86.73	7.40	-3.87	4.57	0.000	***
7	U1-NPog (mm)	7.22	3.14	7.44	3.56	0.22	2.01	0.583	n.s.
8	L1-NPog (mm)	4.04	2.44	3.12	3.16	-0.92	1.74	0.012	*
9	Interincisal angle (°)	128.83	7.31	132.87	9.86	4.03	6.67	0.005	**
Occlusion									
10	Overjet (mm)	3.16	1.98	4.31	2.29	1.15	2.07	0.009	**
11	Overbite (mm)	-0.35	1.88	0.64	1.98	0.99	1.91	0.014	*
Height of the alveolar processes									
12	MdH (mm)	31.97	4.31	33.36	4.43	1.39	1.92	0.001	***
13	MxH (mm)	20.54	3.93	21.66	2.95	1.12	1.84	0.005	**

paired *t*-tests

Table V. Plaster cast analysis; mean value (M) and standard deviation (SD) at the study times T1 and T2; difference (Δ) between T1 and T2; significance (S) for $p < 0.05$; results after the *t*-tests for paired random samples for normal distribution of the variables (n.s. not significant, * significant, ** highly significant, *** most highly significant).

Variable		T1		T2		Δ(T2-T1)		S	
		M	SD	M	SD	M	SD	p	
Maxilla									
1	Anterior width (mm)	36.48	3.01	36.20	2.99	-0.27	1.14	0.206	n.s.
2	Posterior width (mm)	47.07	3.47	48.05	3.36	0.98	1.99	0.013	*
3	Anterior length (mm)	18.20	2.02	18.38	2.18	0.19	1.24	0.423	n.s.
4	Intercanine distance (mm)	34.11	1.97	33.15	2.99	-0.96	1.99	0.024	*
Mandible									
5	Anterior width (mm)	35.66	2.69	35.15	2.36	-0.51	1.15	0.024	*
6	Posterior width (mm)	48.75	2.78	49.01	2.69	0.26	1.22	0.262	n.s.
7	Anterior length (mm)	15.50	2.37	15.00	2.09	-0.51	0.83	0.003	**
8	Intercanine distance (mm)	27.16	2.04	26.67	1.88	-0.49	1.53	0.111	n.s.
Occlusion									
10	Overjet (mm)	3.41	1.99	4.13	2.08	0.73	1.70	0.029	*
11	Overbite (mm)	0.48	1.94	1.77	1.54	1.30	2.11	0.003	**

paired *t*-tests

Several dental parameters were significantly altered by therapy. Treatment resulted in uprighting of the lower incisors and a significant, concomitant increase in the inter-incisal angle. Furthermore, an increase in overjet and overbite was found. These measurements suggested an adaptation of the tongue and a reduction of its influence on the anterior teeth due to induced positional changes. Previous literature has described the tongue of patients wearing a palatal crib as occupying a more posterior and higher position in the mouth.[23] Moreover, the findings of a recent Magnetic-Resonance-Imaging-Study revealed that the tongue tip became positioned more posteriorly when a crib was placed.[24] Therefore, the spur-induced changes in tongue position likely produced adaptive dental changes, resulting in the uprighting of the lower incisors and the increase in inter-incisal angle and overjet. All patients showed a significant increase in anterior maxillary and mandibular alveolar height, leading to an improvement in overbite. By using Beckmann's[20] differentiated analysis, an elongation of the anterior dentoalveolar processes (increase in alveolar height) was shown. This could be interpreted as an alveolar adaptation independent of skeletal basal changes (inclination of the upper/lower jaws). Moreover, the increase in alveolar height, as previously demonstrated in skeletal open bite patients, is suggestive of a level of dentoalveolar compensation[25,26] in the production of a positive overbite.

The transverse analysis of the plaster casts showed a significant increase in maxillary intermolar width and a decrease in intercanine distance. Concurrently, mandibular anterior width and the length of the dental arch decreased. The arch changes may be explained by an induced alteration in resting tongue position and a resulting change in tongue pressure on the teeth. In a study by Taslan et al., resting tongue pressure was shown to increase significantly on the upper first molar and decrease on the lower incisors after the insertion of a crib appliance.[27] The effectiveness of crib therapy was described as the ability to redirect the resting posture of the tongue into a less influential position, resulting in a decrease in lingual pressure on the anterior teeth.[28] The results of Taslan et al. supported the hypothesis that the adaptive capacity of the tongue appeared responsible for the changes evident in the present plaster cast analysis. Therefore, spurs may be effective in adolescent patients with an anterior open bite or open bite tendency caused by tongue dysfunction.

Parker confirmed the successful use of spurs in open bite treatment but reported a traumatising effect on patients.[29] However, this unfavourable effect was contested by Haryett et al., who examined the psychological impact of various orthodontic appliances designed to discourage habits.[30,31] No orthodontic appliance, including spurs, caused psychological problems related to the management of habits. Moreover, spur therapy was shown to be the most effective treatment protocol. Clinical experience has confirmed that no patient treated with palatal spurs had the appliance removed early, nor were injuries to the tongue or the oral mucosa encountered. Justus explained the lack of deleterious effect by the adoption by the tongue, of a new resting posture dictated by a nociceptive or proprioceptive reflex.[15] This process began immediately upon placement of the spurs so that, despite the spurs' sharp ends, no soft tissue injuries occurred.

One limitation of the present study was the absence of a comparative control group. However, it is not unusual to commence research with a well-controlled prospective clinical trial (using no other appliance in a defined group of patients). Moreover, there are ethical considerations in the denial of therapy in a defined control group.

Conclusion

The treatment of open bite patients with fixed palatal spurs produced distinctive morphological changes in the dental arches. The main findings were:

1. An increase of overjet and overbite,
2. Uprighting of the lower incisors,
3. Elongation of maxillary and mandibular alveolar heights.

In summary, the use of palatal spurs created an increase in overbite in all patients. Therefore, it is concluded that spurs are effective in the management of a tongue-induced anterior open bite in carefully-selected adolescent patients.

Conflict of Interest

The corresponding author states that there is no conflict of interest.

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