Bondable Lingual Spur Therapy to Treat Anterior Open Bite

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BONDABLE LINGUAL SPUR THERAPY TO TREAT ANTERIOR OPEN BITE

by

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ABSTRACT
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The purpose of this study was to evaluate the effect of bondable lingual tongue spurs (BLTS; Tongue Tamers®, Ortho Technology, Tampa, FL) on measures of overbite and incisor position in a sample of anterior open bite subjects who had either a digit-sucking habit or an anterior tongue posture problem. Patient acceptance of the spurs was also evaluated.

BLTS were placed on all maxillary and mandibular incisors of 12 subjects (mean age 13.9 years) with anterior open bite. Dental casts and lateral cephalometric radiographs were taken pre-treatment (T1) and after 6 months of lingual spur treatment alone (T2). Overbite and overjet of the anterior teeth were measured and compared on pre- and post-treatment study models. Differences in the cephalometric analyses between T1 and T2 were also assessed. Questionnaires were completed to evaluate the subjects' acceptance of the spurs.

A statistically significant increase in overbite was found on all 6 anterior teeth measured on the study models. This observation was corroborated by the statistically significant increase in anterior overbite (1.38 ± 0.89mm; $P<0.001$) and uprighting of the upper and lower incisors observed on cephalometric radiographs. Overjet was not affected by the treatment. BLTS were well tolerated by the subjects. Eleven of 12 subjects adjusted to the spurs in 2 weeks or less.

Bondable lingual tongue spur treatment, in subjects with either digit-sucking habits or tongue posture problems, resulted in a significant reduction of anterior open bite and incisor proclination by successfully keeping pressure away from the anterior teeth. The spurs were placed in one appointment were well tolerated by patients.

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Elissa Joy McRae, DDS

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CHAPTER 1

INTRODUCTION

Anterior open bite correction has historically been problematic for orthodontists. The cause of open bite is thought to be multifactorial involving altered function and vertical growth.[1-15] This can be associated with a previous or current sucking habit. Other potential causes include genetics and naso-pharyngeal obstruction, which may be secondary to mouth breathing.[1-7] The obstruction may be due to anatomic blockage, allergies, or adenoid or lymphatic tissue hyperplasia.[1-7] Mouth breathing could also be habitual, which would necessitate a compensatory anterior inferior tongue posture to breathe.[1] More recently, this anterior tongue posture, as opposed to a tongue thrust (short duration), has been thought to be a significant factor in the etiology and high relapse incidence of anterior open bite.[1,4,6]

Anterior tongue rest posture is an etiologic factor that has largely been overlooked in both conventional orthodontic treatment and in surgical treatment.[1,2,9] Anterior tongue thrust is not significant clinically due to the short duration of the thrust. In fact, studies have shown that persons who place the tongue tip forward when they swallow usually do not have more tongue force against the teeth than those who keep the tongue tip back; the pressures may actually be even lower.[6] A tongue thrust lasts approximately one to three seconds maximum and occurs roughly 1000 times per day during swallowing.[1,6] This accounts for less than one hour out of an entire 24 hour period, and therefore, would not affect tooth position. On the other hand, if a patient has an anterior resting posture of the tongue, the long duration of this pressure, even if it is very light pressure, could affect tooth position, both vertically and horizontally.[6] Because teeth are normally in occlusion less than 60 minutes per day, mandibular and tongue rest posture are a dominant factor in tooth position, especially overbite.[1] Failure to correct infantile-like anterior tongue

posture subsequent to orthodontic and /or surgical treatment might be a primary reason for relapse of anterior open bite.[1,2,9]

An active digit-sucking habit results in many of the same problems as an anterior tongue posture problem. Thumb-sucking is the earliest and most common habit in children; it affects almost 45% of the young population of the world from birth through adolescence.[16] Prolonged finger-sucking may cause: reduced vertical growth of the frontal parts of the alveolar processes which creates an anterior open bite; proclination of the upper incisors as a result of the horizontal force created by the finger which can create excess overjet; anterior displacement of the maxilla for the same reason; anterior rotation of the maxilla, resulting in an increased prevalence of posterior crossbite in the deciduous dentition; possible retrusion of the mandible and retroclination of the lower incisors.[16,17] Self-correction of the malocclusion is likely if the habit is discontinued before the age of four.[16] When the sucking habit stops, the anterior open bite will usually spontaneously correct due to increased growth of the alveolar processes, provided that the patient is still growing[17] and does not additionally have an anterior tongue posture problem.

Poor stability of anterior open bite correction has been well documented in the literature. Lopez-Gavito et al[7] reported more than 35% of anterior open bite patients treated with conventional orthodontic appliances relapsed at least 3mm at ten years post-treatment (n=41). A more recent article by Remmers, et al[8] confirmed the poor long-term stability of open bite correction. They reported that 71% (n=52) of anterior open bite patients achieved a positive overbite at the end of treatment, however, 44% of patients had an open bite at 5 years post-treatment. A 20-40% relapse rate has been reported for

anterior open bite malocclusions treated with maxillary surgical impaction.[1,18,19] A more reliable treatment for this condition is desirable.

Correction of a functional habit during anterior open bite treatment may lead to higher long-term stability. In 1990 Huang, et al[2] researched the effect of crib therapy on the stability of anterior open bite treatment. Thirty-three anterior open bite patients participated in the study and 31 achieved bite closure; all patients who achieved a positive overbite during treatment maintained it post-treatment. They concluded that the stability of anterior open bite correction may be related to correcting an anterior tongue posture problem. These results were confirmed by Justus in 2001 when he utilized a maxillary lingual arch with spurs to arrest anterior tongue posture and maintain long-term stability of open bite correction.[1] Huang, et al[2] and Justus[1] believe the stability of open bite correction will improve once the habits that are a factor in their etiology are eliminated.

Besides conventional orthodontics, orthognathic surgery, or habit altering appliances that treat anterior open bite malocclusions, other modalities have been used like temporary anchorage devices[15], clear removable appliances[14], and multi-loop edgewise archwire techniques[12]. One way to discover if the tongue posture problem is a primary cause of the anterior open bite is to use a habit correcting appliance prior to initiating conventional orthodontic therapy to see if the bite begins to close on its own. The authors are aware of only one other study that analyzed the isolated effects of a banded spur appliance.[9]

Some clinicians are wary of using a banded type of spur appliance due to anticipated negative patient and/or parent reactions. Information has been reported on pain and serious injuries having been inflicted on children by habit appliances.[20] That author concluded fixed (banded) intraoral habit appliances are cruel and inflict pain and suffering on children out of all proportion to their necessity.[20] Because of this, the authors hoped to achieve increases in overbite similar to those achieved with the banded appliances[1,2,5,9,11,21] using bondable lingual tongue spurs, (BLTS, Tongue Tamers®, Ortho Technology, Tampa FL) a much simpler appliance inserted in a single appointment (Figure 1). No studies have been published that evaluate the ability of this bondable type of appliance to eliminate a digit-sucking habit or to correct an anterior tongue posture problem and begin closing an anterior open bite malocclusion.

The purpose of this study was to twofold:

1). To evaluate the effect of bondable lingual tongue spurs on measures of overbite and incisor position in a convenience sample of anterior open bite patients recruited from Marquette University School of Dentistry who had either a digit-sucking habit or an anterior tongue posture problem.

2). To evaluate patient acceptance of the spurs via questionnaire.

It was hypothesized that the spurs would serve as a reminder to the patients to discontinue their habit and allow for a subsequent increase in overbite and uprighting of the incisors from a reduction in tongue and/or digit pressures to the dentition. It was also hypothesized that the spurs would be well-tolerated since their size and shape are similar to that of a standard orthodontic bracket.

Figure 1: Comparison Photographs

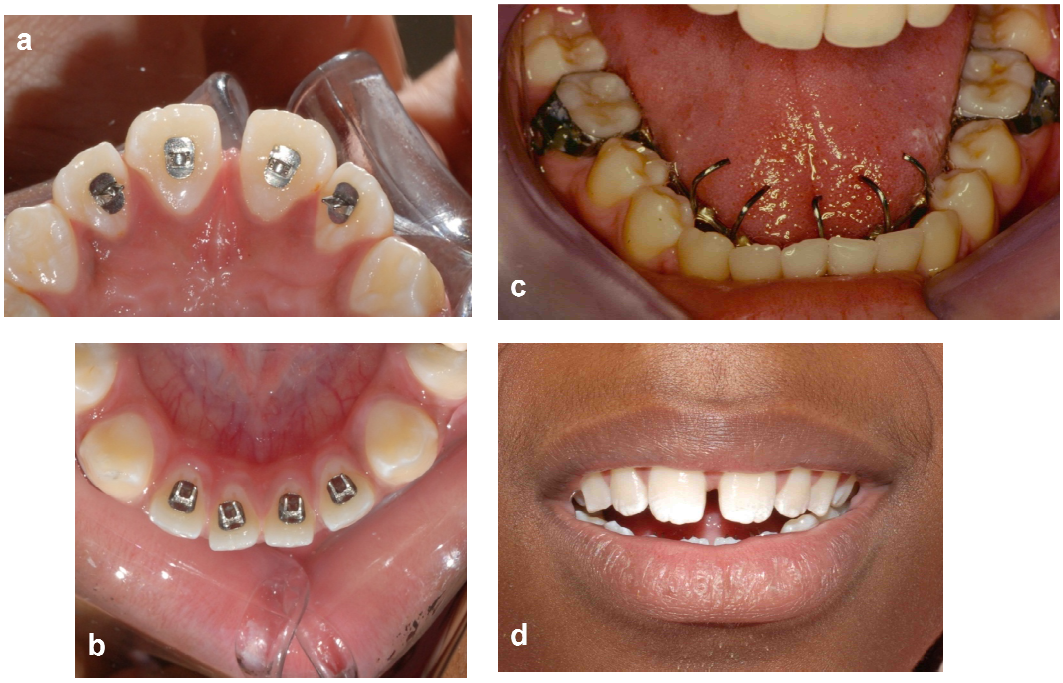

Figure 1: a and b. Examples of the BLTS used in this study bonded to the maxillary and mandibular incisors. c. An example of a banded type of spur appliance used to correct anterior tongue posture or digit-sucking habits. d. The same subject as in photograph a and b with 8 spurs bonded to the incisors. Note how esthetic these bonded spurs are in comparison to the banded spur appliance depicted in photograph c.

CHAPTER 2

MATERIALS AND METHODS

Subject Selection

Study protocol and consent forms were approved by the Institutional Review Board at Marquette University. Patients who were screened, selected for comprehensive orthodontic treatment at Marquette University post-graduate orthodontic clinic, and who met selection criteria were invited to participate. Inclusion criteria were: (1) end-to end anterior occlusion or anterior open bite (zero to negative overbite on at least one anterior tooth); (2) clinical signs of anterior tongue posture or a sucking habit (by observation); and (3) male or female patients within the age range of 7-18 years. Patients were excluded from the study if they had immediate dental needs/gross caries or if their maxillary lateral incisors had not yet erupted.

Informed consent/assent/parental permission was obtained from all patients who met inclusion criteria and information regarding the purpose, procedures, and risks of the study were given. A 6 month study period was chosen based on previous research with banded spur or crib appliances which found that duration to be sufficient for habit correction and a subsequent increase in overbite.[1,9,21] Fourteen patients consented to participate in the study and had the spurs bonded. Twelve subjects completed the 6 months of spur treatment. Two subjects were lost to follow-up and excluded from data analysis. The average age of the sample at bonding was 13.9 years with a range of 7.1-17.2 years. Nine subjects were female, and 3 were male. All patients had anterior tongue posture; three subjects had a digit-sucking habit in addition to a suspected anterior tongue posture problem. Subjects were informed about their habit and how it could affect their dentition. Proper tongue posture was reinforced at each visit (superior-posterior). The average number of days in spurs was 189 with a range of 176-210 days (Table 1).

Table 1. Patient Demographics

Pt #	Gender	Bonding Date	Debond Date	# Days in Spurs	Age at bonding date
1001	female	1/12/2009	7/23/2009	192	9.9
1002	female	2/17/2009	9/2/2009	197	15.8
1003	female	3/24/2009	9/30/2009	186	16.2
1004	female	4/3/2009	10/12/2009	189	7.1
1005	male	4/17/2009	10/20/2009	183	15.3
1006	female	5/11/2009	12/11/2009	210	15.2
1007	male	5/12/2009	12/1/2009	199	17.2
1008	male	5/13/2009	11/17/2009	184	12.3
1009	female	6/1/2009	12/7/2009	186	14.0
1010	female	6/4/2009	12/4/2009	180	12.4
1011	female	6/10/2009	12/16/2009	186	15.8
1012	female	6/18/2009	12/14/2009	176	16.0

Average # days in spurs: **189.0 days**
Average age of subjects : **13.9 years**

Table 1. Patient Demographics: Patient/subject identification number, gender of subjects, date spurs were bonded, date spur therapy was complete, number of days in spurs, and age of the subjects when the spurs were bonded.

Placement of the Bondable Spurs

Bondable Lingual Tongue Spurs (BLTS) were placed on the ligual surface of the maxillary and mandibular incisors, in the center of the crown of the tooth or as close to the center as the occlusion permitted. The spurs were bonded with either a 35% phosphoric acid etch, Transbond™ XT light cure adhesive primer, and Transbond™ XT composite resin or Transbond™ plus self-etching primer and Transbond™ XT composite resin. The subjects were instructed to try to remove and discard the spur from their mouth should one come debonded while eating. If swallowed, the BLTS would most likely make its way through the digestive tract. Risk of aspiration is very small; however, a chest radiograph would have been provided to the subject should this have potentially occurred (not necessary in this study). Out of the 112 spurs initially bonded, 19 debonded. If a spur came debonded multiple times, 35% phosphoric acid etch in addition to self-etching primer were used to rebond the spur; no further debonds occurred with this method. This method of rebonding was used because a recent study obtained significantly higher bond strengths using both acid etch and a self-etching primer.[22] Subjects were followed on a monthly basis for 6 months without any other intervention.

Records and Data Collection

The same clinician bonded the spurs and gathered all subsequent clinical data. Pre-treatment records consisted of maxillary and mandibular impressions, a wax bite, intra- and extra-oral photographs, lateral cephalometric and panoramic radiographs (T1, standard orthodontic records), and a thorough clinical evaluation. The subjects were recalled on a monthly basis to assess via questionnaire how well they were tolerating the

spurs, to re-emphasize the importance of breaking their habit, to make clinical measurements evaluating progress, to take intra-oral photographs, and to rebond any spurs that may have debonded. After 6 months of treatment, the spurs were removed and final records were taken. Post-treatment records (T2) were the same as pre-treatment, except the panoramic radiograph was not re-taken. At the end of the 6 month habit correction treatment period, a comprehensive orthodontic treatment plan was made for each patient to address any remaining malocclusion.

Overbite and overjet were measured from the models on each individual anterior tooth position (canine to canine) using the same reference points pre- and post-treatment. Measurements were made utilizing the same digital caliper and were repeated 3 times for each tooth. The average was then calculated for each set of measurements. The lateral cephalometric radiographs were traced using Dolphin Imaging 11 software (Patterson Dental, Chatsworth, CA) by the same trained clinician. The variables that were assessed cephalometrically are listed in Table 2.

Examiner reproducibility was verified on 5 sets of models and cephalometric radiographs that were measured on 2 occasions, one month apart. The intraclass correlation coefficient[23] (ICC 3.1; Shrout & Fleiss 1979) was used for assessments and showed excellent (ICC>0.98) reproducibility for the measurements made on models. Higher variability was observed for cephalometric measurements. An acceptable to high level of reproducibility (ICC>0.80) was achieved on all variables.

The descriptive data analyses included mean values and standard deviations (SD) for all variables at baseline (T1), final examination (T2), and the difference T2 – T1.

Table 2. Cephalometric Variables used in This Study

Overbite (mm)	vertical distance between the tips of the upper and lower central incisors in relation to the occlusal plane
Overjet (mm)	horizontal distance between the tips of the maxillary and mandibular central incisors
Upper facial height to lower facial height ratio, UFH:LFH	distance nasion to anterior nasal spine (N-ANS) to distance anterior nasal spine to menton (ANS-Me)
U1 - SN (°)	angle formed between the long axis of the maxillary incisor to the SN plane
U1 - NA (°)	angle formed by the intersection of the maxillary incisor long axis to the plane between points N and A
U1 - NA (mm)	perpendicular distance from the tip of the maxillary incisor to the plane between points N and A
L1 - NB (°)	angle formed by the intersection of the mandibular incisor long axis to the plane between points N and B
L1 - NB (mm)	perpendicular distance from the tip of the mandibular incisor to the plane between points N and B
IMPA (°)	angle formed by the intersection of the mandibular incisor long axis to the mandibular plane

Student's paired *t*-test was used to evaluate the statistical significance of the difference between means obtained at T1 and T2.

The questionnaire consisted of 5 questions and also had space for additional patient comments (Figure 2). The variables assessed in the first four questions were speaking, eating, esthetics, and pain to the tongue. An ordinal rating scale was used to quantify the effect of the spurs on these variables: 1 (easy), 2 (neutral), 3 (difficult). The 5^{th} question on the survey asked how long it took for the patients to adjust to having the spurs on the backs of their teeth. Possible answers were: 2 days or less, 1 week, 2 weeks, and longer. Frequencies of responses were tabulated. The answers to questions 1 through 4 were analyzed statistically using the paired-sample Sign Test. A P-value of 0.05 was considered statistically significant. Statistical computations were performed using the SPSS 17.0 (SPSS Chicago, IL) software package.

Figure 2. Sample Questionnaire

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Patient Questionnaire

Please rate the following questions on a scale of 1-3:

1 = easy

2 = neutral

3 = difficult

1). How has it been adjusting to the spurs in terms of **speaking**?

2). How has it been adjusting to the spurs when **eating**?

3). How has it been adjusting to the spurs **aesthetically** (appearance)?

4). How has it been adjusting to the spurs in terms of **pain (to your tongue)**?

Please circle an answer to the following question:

5). **How long** did it take you to adjust to having the spurs on the back of your teeth?

2 days or less **one week** **two weeks** **have not adjusted yet**

5). Additional comments? (optional)

CHAPTER 3

RESULTS

Model measurements

A statistically significant increase in mean overbite was observed on all anterior teeth (Table 3). Central incisors showed the highest mean change, followed by lateral incisors and canines (Figures 3 through 8). The range of minimum change to maximum change was large, reaching from 2.37mm for the right canine to 6.38mm for the left central incisor. The upper right central incisor (UR1) showed the greatest increase in overbite: 1.71mm ($p < 0.002$) with an average of -1.08 pre-treatment (T1) and +0.63 post-treatment (T2). Overjet remained relatively constant during therapy; mean change over the 6 month observation period was not statistically significant for any assessed tooth. Based on model measurements, 11 of 12 subjects responded positively to the spur therapy.

Cephalometric measurements

Cephalometric data results are presented in Table 4. The number of variables analyzed was restricted to reduce the chance of false positives and other spurious findings resulting from multiple comparisons across related variables. Overbite increased on average by 1.38 ± 0.89mm ($P<0.001$). Mean baseline values were -2.2 at T1 and -0.82 at T2. A statistically significant uprighting of the upper (angle: U1 to SN and U1 to NA) and lower incisors (angle: L1 to NB and IMPA) was observed. In contrast, the decrease in protrusiveness/procumbency of the incisors (U1 to NA and L1 to NB in mm) was not statistically significant. Changes in overjet and facial height ratio were also not statistically significant.

Table 3. Model Analysis Results

Variable	T1		T2		Change (T2 - T1)		P	S
Overbite (mm)	**M**	**SD**	**M**	**SD**	**M**	**SD**		
UR3	0.5	2.26	1.09	2.09	0.58	0.62	0.008	**
UR2	-0.76	1.84	0.17	1.93	0.93	1.08	0.013	**
UR1	-1.08	1.81	0.63	2.17	1.71	1.57	0.003	***
UL1	-1.06	2.17	0.5	2.12	1.55	1.53	0.005	***
UL2	-0.99	1.64	0.06	1.42	1.06	1.29	0.016	**
UL3	0.95	2.02	1.8	1.46	0.84	0.71	0.002	***
Overjet (mm)								
UR3	0.85	1.27	0.86	1.19	0.01	0.38	0.958	n.s.
UR2	1.44	2.21	1.46	1.98	0.02	0.73	0.920	n.s.
UR1	2.97	2.32	2.68	1.92	-0.29	1.12	0.390	n.s.
UL1	2.79	2	2.63	1.69	-0.17	0.95	0.557	n.s.
UL2	1.57	1.73	1.55	1.4	-0.02	0.66	0.915	n.s.
UL3	0.69	1.02	0.58	0.82	-0.11	0.37	0.338	n.s.

Table 3. Model analysis results: mean value (M) and standard deviation (SD) at pre-treatment (T1) and post-spur therapy (T2); difference between T1 and T2; significance (S) for $p < 0.05$, results after paired T-test for normal distribution of the variables (n.s. not significant, * significant, ** highly significant, *** most highly significant).

Figure 3. UR1 Individualized Overbite Results

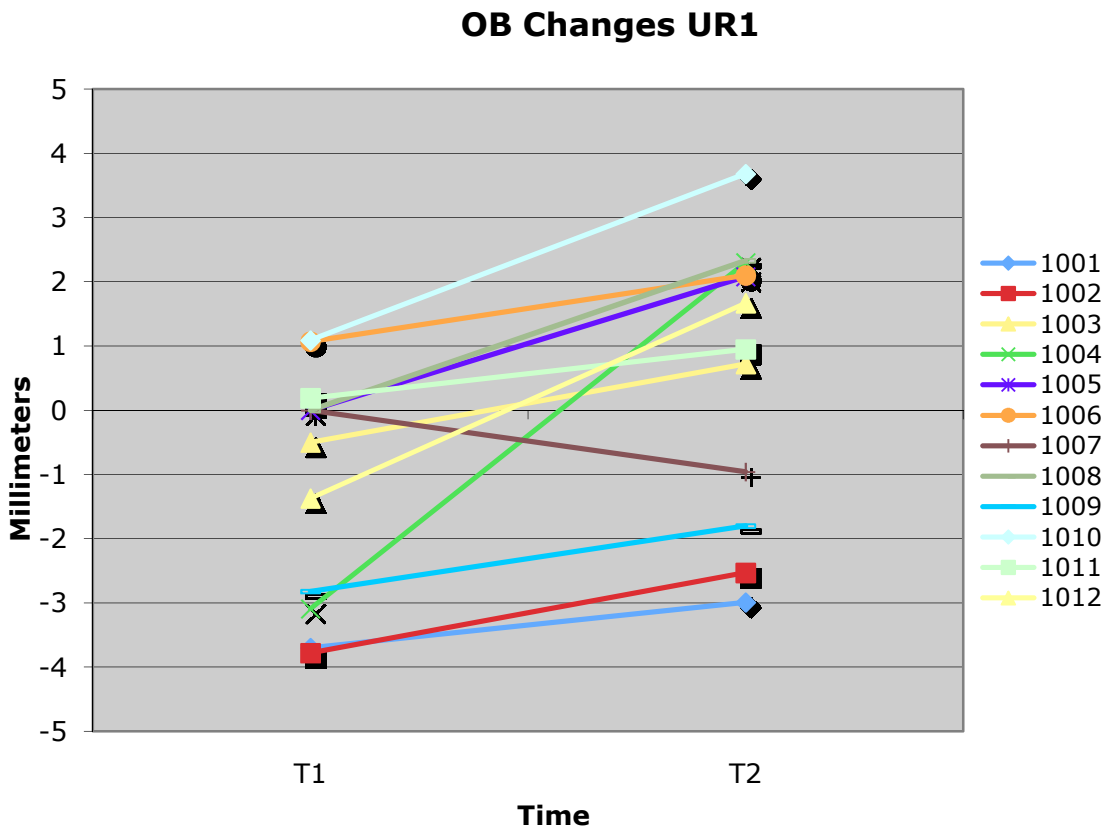

Figure 3: UR1 Overbite Results – Upper right central incisor (UR1): Individualized graph of changes in the overbite in patients (n = 12) measured at the upper right central incisor as obtained from the model analysis results. Note all patients except one had positive treatment results. One patient had a dramatic improvement (same patient as Figure 11).

Figure 4. UL1 Individualized Overbite Results

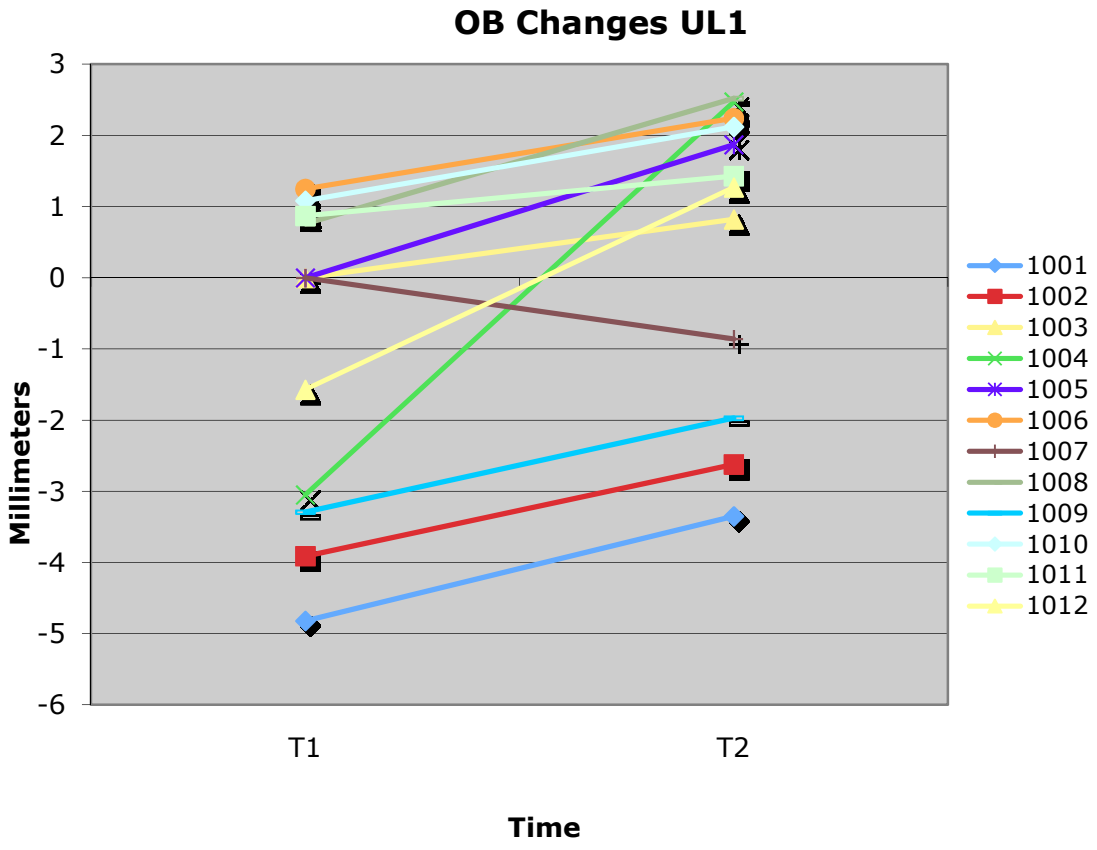

Figure 4: UL1 Overbite Results – Upper left central incisor (UL1): Individualized graph of changes in the overbite in patients (n = 12) measured at the upper left central incisor as obtained from the model analysis results.

Figure 5. UR2 Individualized Overbite Results

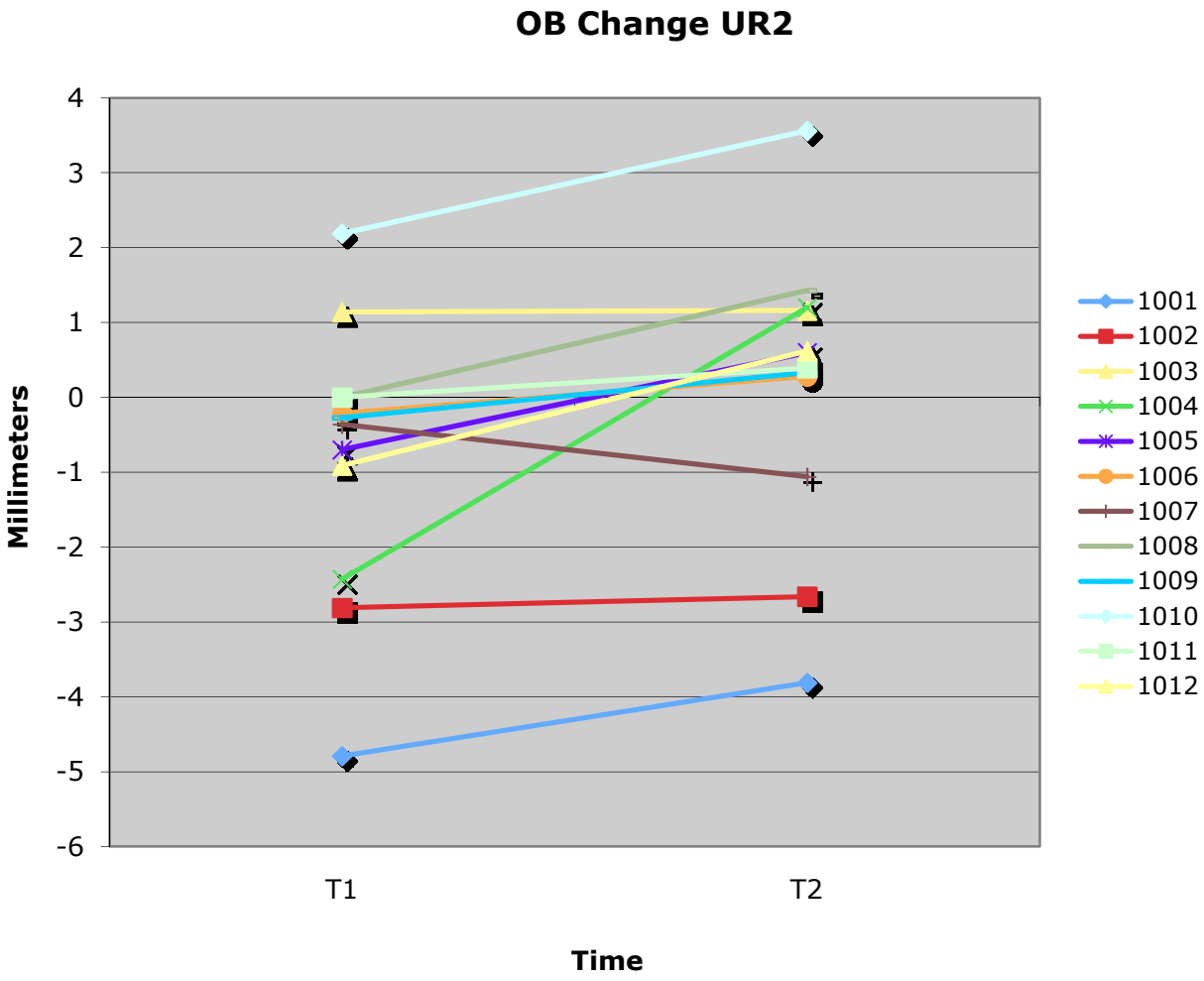

Figure 5: UR2 Overbite Results - Upper right lateral incisor (UR2): Individualized graph of changes in the overbite in patients (n = 12) measured at the upper right lateral incisor as obtained from the model analysis results.

Figure 6. UL2 Individualized Overbite Results

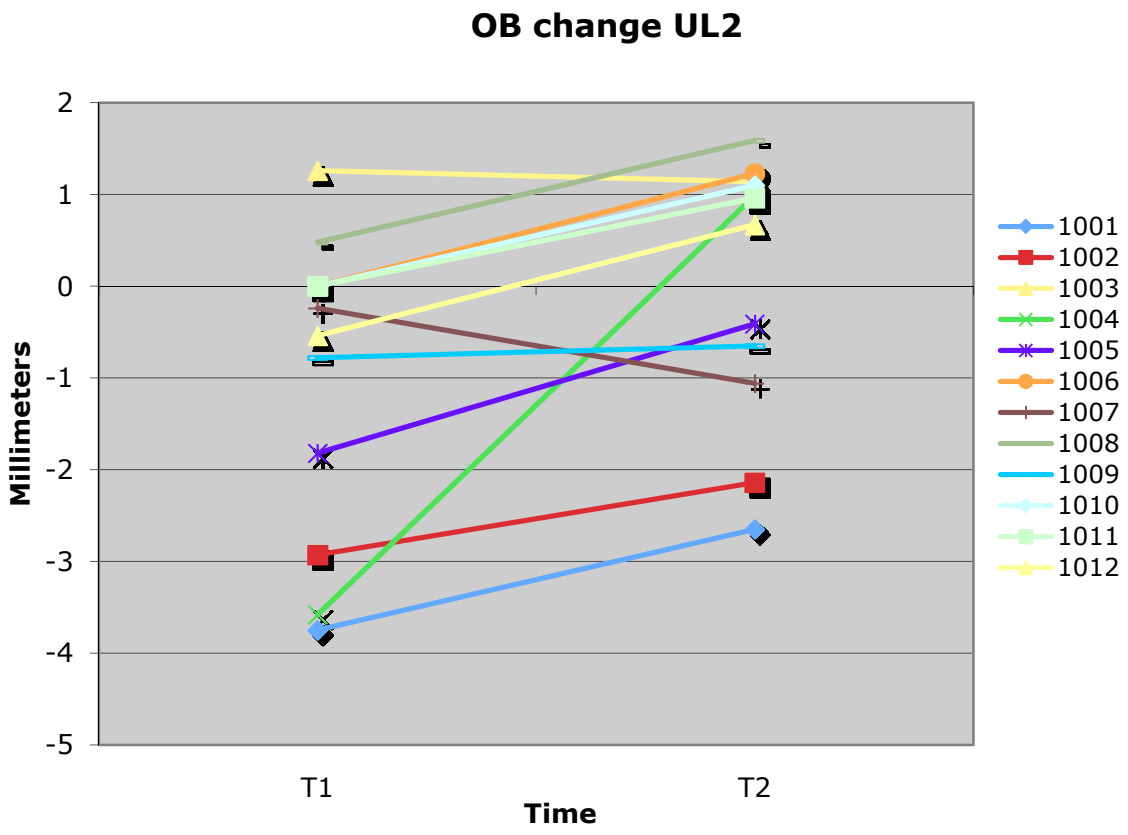

Figure 6: UL2 Overbite Results – Upper left lateral incisor (UL2): Individualized graph of changes in the overbite in patients (n = 12) measured at the upper left lateral incisor as obtained from the model analysis results.

Figure 7. UR3 Individualized Overbite Results

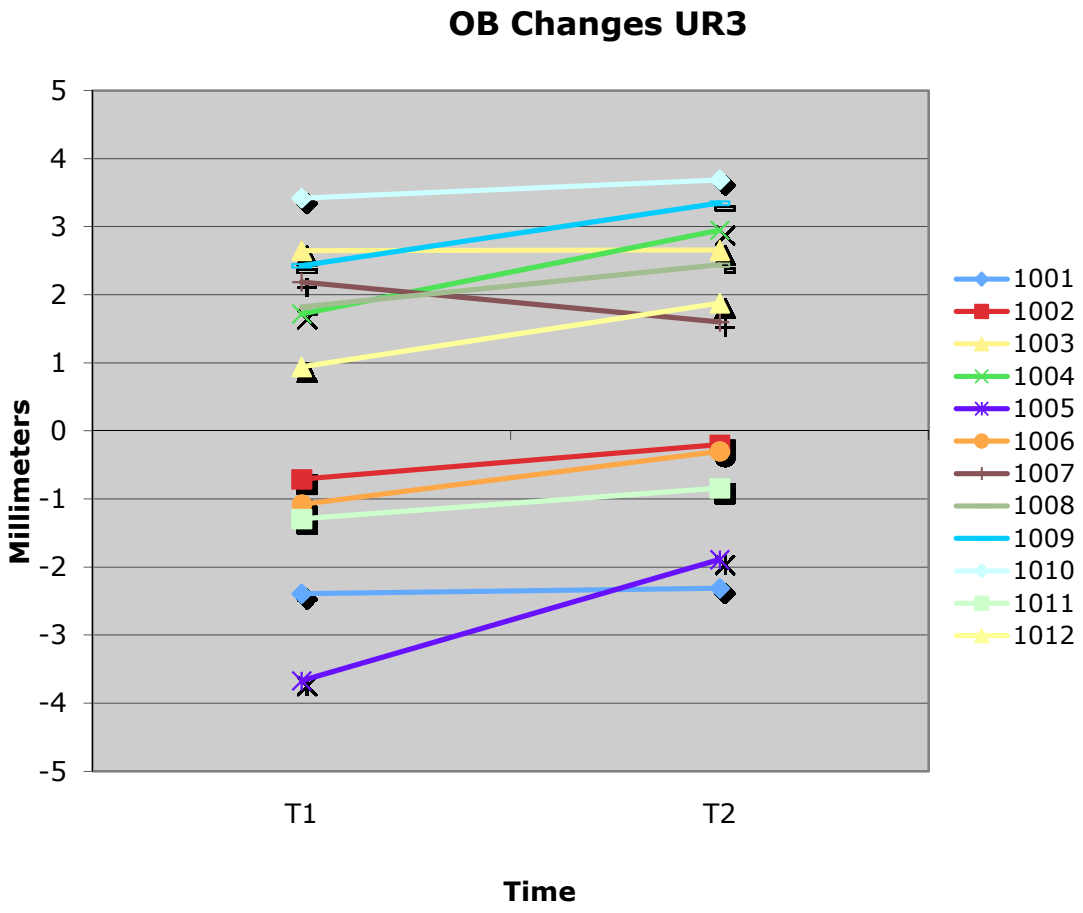

Figure 7: UR3 Overbite Results – Upper right canine (UR3): Individualized graph of changes in the overbite in patients (n = 12) measured at the upper right canine as obtained from the model analysis results.

Figure 8. UL3 Individualized Overbite Results

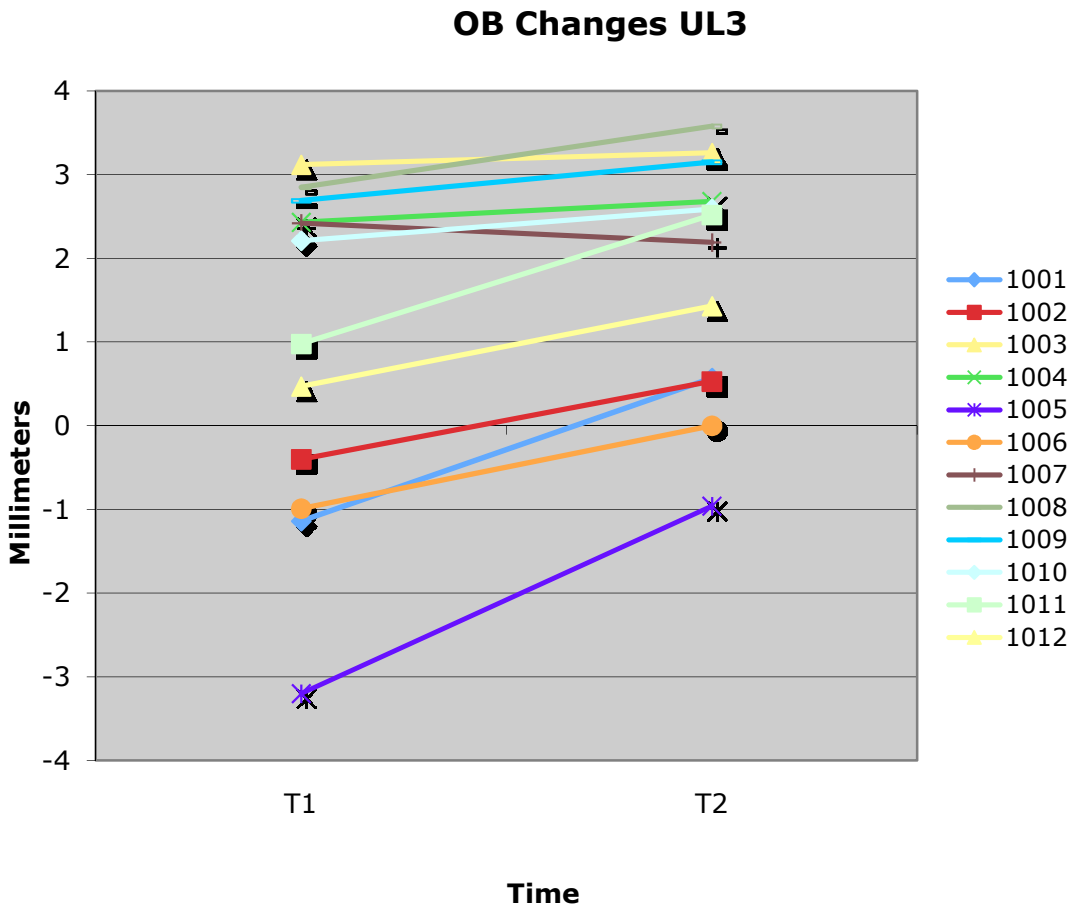

Figure 8: UL3 Overbite Results – Upper left canine (UL3): Individualized graph of changes in the overbite in patients (n = 12) measured at the upper left canine as obtained from the model analysis results.

Table 4. Cephalometric Analysis Results

Variable	T1		T2		Change (T2 - T1)		P	S
	M	**SD**	**M**	**SD**	**M**	**SD**		
Overbite (mm)	-2.19	1.48	-0.82	1.74	1.38	0.89	0.000	***
Overjet (mm)	3.42	2.13	3.85	1.90	0.43	1.13	0.210	n.s.
UFH : LFH (mm)	57.83	2.85	58.50	2.62	0.67	1.22	0.084	n.s.
U1 to SN (degrees)	111.01	4.36	109.19	4.87	-1.82	2.28	0.018	**
U1 to NA (degrees)	29.23	5.24	26.63	5.12	-2.60	2.43	0.003	***
U1 to NA (mm)	6.76	1.79	6.41	1.66	-0.35	1.50	0.436	n.s.
L1 to NB (degrees)	35.62	8.65	30.13	8.25	-5.49	3.09	0.000	***
L1 to NB (mm)	7.92	3.16	7.49	3.42	-0.43	0.77	0.081	n.s.
IMPA (degrees)	100.29	8.11	94.60	7.87	-5.69	3.05	0.000	***

Table 4. Cephalometric analysis results: mean value (M) and standard deviation (SD) at pre-treatment (T1) and post-spur therapy (T2); difference between T1 and T2; significance (S) for $p < 0.05$, results after paired T-test for normal distribution of the variables (n.s. not significant, * significant, ** highly significant, *** most highly significant).

Questionnaire

All subjects completed the questionnaires at the end of month 1 and 6. The tongue spurs were very well tolerated by subjects overall (Figure 9). All subjects agreed the spurs were an acceptable esthetic treatment approach. After only one month of therapy, the spurs were rated as either easy or neutral to tolerate in all categories except eating and pain to the tongue (Figure 10). By month 6, all subjects agreed the spurs were easy to accept in terms of esthetics. Most subjects felt that wearing the BLTS caused some minimal initial discomfort. This observation did not change substantially ($P=0.969$) over time. After spur placement, most subjects noted that the spurs interfered somewhat with eating. However, they adjusted quickly to the change; 11 of 12 subjects reported improvements with eating and pain to the tongue within the six month time period. Eleven of 12 subjects indicated that they adjusted to the spurs in two weeks or less. All patients adjusted to the spurs in less than one month; one patient adjusted in less than 2 days.

Figure 9. Patient Questionnaire Results

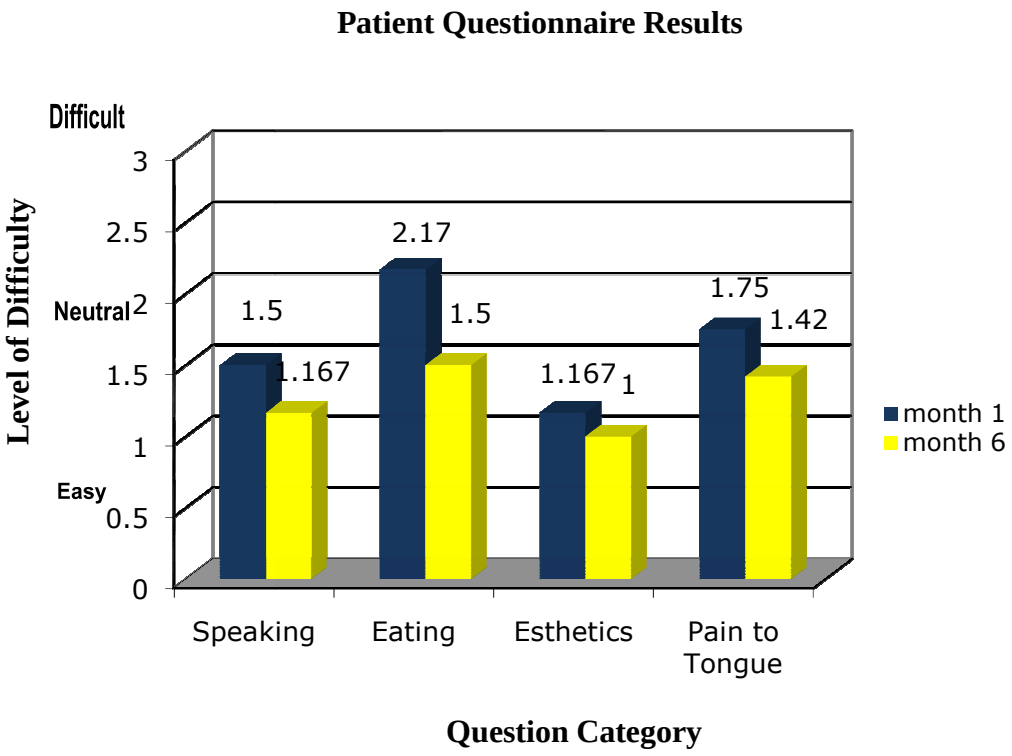

Figure 9: Patient Questionnaire Results: Mean spur acceptability ratings at the end of months 1 and 6 of spur treatment regarding four criteria: speaking, eating, esthetics, and pain to the tongue.

Figure 10. Questionnaire Response Frequencies

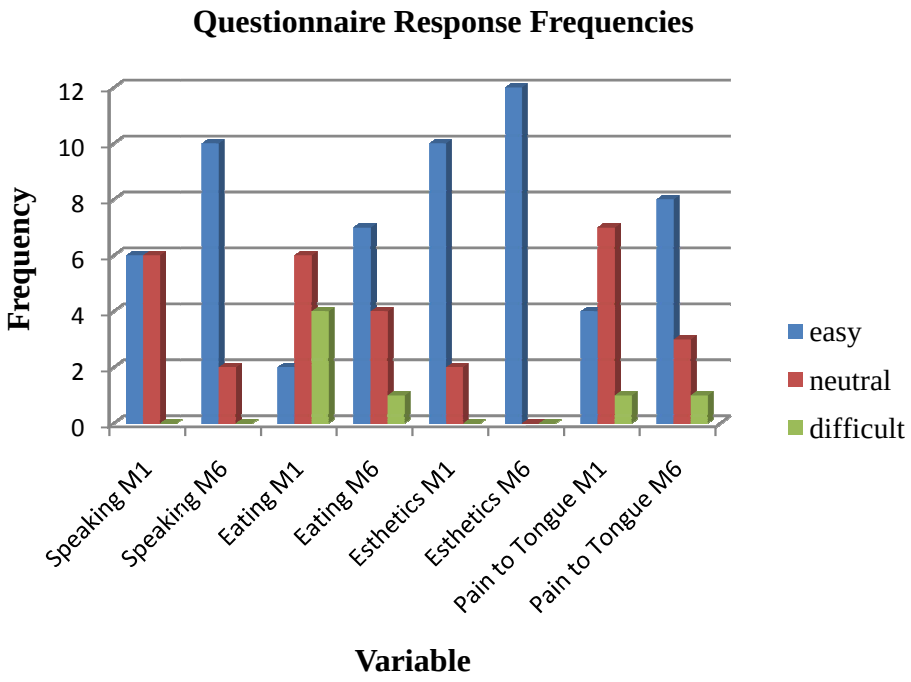

Figure 10: Questionnaire Response Frequencies – Comparison of the end of month 1 (M1) and the end of month 6 (M6) questionnaire responses to the 4 variables used to assess patient acceptance of the spurs: speaking, eating, esthetics, and pain to the tongue.

CHAPTER 4

DISCUSSION

This study evaluated the ability of bondable lingual tongue spurs to correct anterior tongue posture or a digit-sucking habit and allow a subsequent change in incisor position and overbite in a small sample of anterior open bite patients. Eleven of the 12 patients showed an increase in overbite during the 6 months of spur therapy alone.

A statistically significant increase in mean overbite occurred on all 6 anterior teeth without bonding spurs to the canines. This is possibly due to decreased tongue pressure exerted on the adjacent bonded teeth, which would allow for their uprighting and extrusion as well. Overjet remained relatively constant during therapy; there was no statistically significant change on any of the 6 anterior teeth. These results in overjet have not been achieved in any previous studies using banded tongue spur appliances,[1,2,9] possibly because the spurs were used in either the maxillary or the mandibular arch, but not both arches. Therefore, this finding was somewhat hypothesized because the spurs were placed on both the maxillary and mandibular teeth, allowing for similar uprighting/eruption of both arches, which would keep overjet relatively consistent. Another reason to explain the lack of incisor uprighting in the other studies is that the banded lingual arch spur appliances (maxillary or mandibular) could have been touching the incisor teeth, preventing them from uprighting in both arches.

There were 2 outlier subjects in this study, one with dramatic positive results (Figure 11) and one who obtained negative treatment results. The subject who had the dramatic positive result was 7.1 years of age, and was the youngest subject in the study. The next youngest subject in this study was 9.9 years old and already had her entire permanent dentition fully erupted including second molars. All other subjects in this

Figure 11. Before and After Spur Therapy Photographs: An Outlier Case

Figure 11: Pre- and post-treatment occlusions of a subject enrolled in the study that had both a finger-sucking habit and an anterior tongue posture problem. This subject was 7.1 years old.

study were 12 years of age or older. In the 7.1 year old subject, her dental age was also significantly more advanced than her chronological age. She was referred by her pedodontist to take part in this study. The pedodonist confirmed that her upper 4 incisors had been erupted for over a year and her root formation was almost complete. Her amount of anterior open bite had remained the same for the past year due to a thumb-sucking habit the patient was unable to quit on her own. For this patient, the spurs served as a gentle reminder to keep her fingers out of her mouth. Her digit-sucking habit was discontinued during the first month of tongue spur therapy, allowing her incisors to erupt into their proper positions during the rest of the study period. To remove all uncertainty regarding this case, the statistics were re-run removing her from the patient pool. Statistical significance was obtained with all the same variables when she was excluded from the data pool.

The one subject who had negative treatment results in this study commented on his questionnaire that he “didn’t even know they (the spurs) were there”. This is a potential problem with the bondable lingual tongue spurs. Due to their small size, some patients may adjust too well to the spurs and not adopt a more posterior-superior tongue posture position. This patient was unable to re-train his tongue with the aid of these spurs, as exemplified by his final tongue spur therapy photo, depicting his continued anterior tongue posture (Figure 12). Because of this, that patient either continued to grow vertically, pushed his incisors more vertically with prolonged tongue pressure, or a combination of the two, which slightly increased his anterior open bite during the 6 month study period.

Figure 12. Post-Treatment Smile Photograph: An Outlier Case

Figure 12: Post-treatment smile photograph of the subject who had negative treatment results in this study. Notice that his anterior tongue posture problem was not corrected with BLTS therapy. This patient was 17.2 years old.

Besides the outlier cases previously mentioned, many other subjects in the sample attained visibly positive BLTS therapy results. A sample of other cases with visibly positive BLTS therapy results from this study are shown in Figures 13 through 15.

There has been only one published study that analyzed the isolated effect of a spur appliance. This study, conducted by Meyer-Marcotty, et al[9], utilized a banded maxillary spur appliance on 15 growing patients (mean age 13 years, 10 months). Not all patients had anterior open bite; 3 patients were classified as having a small overbite (less than or equal to 2mm). In approximately 9 months of treatment, they achieved bite deepening on 13 of the 15 patients with a mean overbite increase of 1.95mm, measured only by cephalometric evaluation. A similar increase in overbite was obtained in the present study, 1.71mm on the study models and 1.38mm on the cephalometric analysis. Because of these similar results, it is possible that bondable lingual tongue spurs may achieve similar increases in overbite as the more time consuming banded types of spurs appliances. Further research is needed to directly compare the effectiveness of these 2 appliances in increasing overbite in anterior open bite malocclusions.

A study by Araujo, et al[11], recently accepted for publication, addresses the issue of patient acceptance of spur treatment. The study evaluated both patient and parent reactions to orthodontic treatment of open bite patients with a banded lower lingual arch with spurs. Seventy-two patients and parents completed the questionnaires. The discomfort time noted with the banded appliance was up to 10 days in the majority of patients, which is similar to the results obtained in this study (2 weeks or less). However, because of the Tongue Tamers® small size, one would assume that patients would adjust more quickly to the bondable appliance. About 39 percent of patients in Araujo's study

Figure 13. Before and After Spur Therapy Photographs

Figure 13: Pre- and post-treatment occlusion photographs of a subject enrolled in this study that had both a digit-sucking habit and an anterior tongue posture problem. This patient was 16.0 years old.

Figure 14. Before and After Spur Therapy: Spacing and tongue posture

Figure 14: Pre- and post-treatment occlusion photographs of a subject enrolled in this study that had maxillary and mandibular spacing and an anterior tongue posture problem. This patient was 12.3 years old.

Figure 15. Before and After Spur Therapy: Crowding and tongue posture

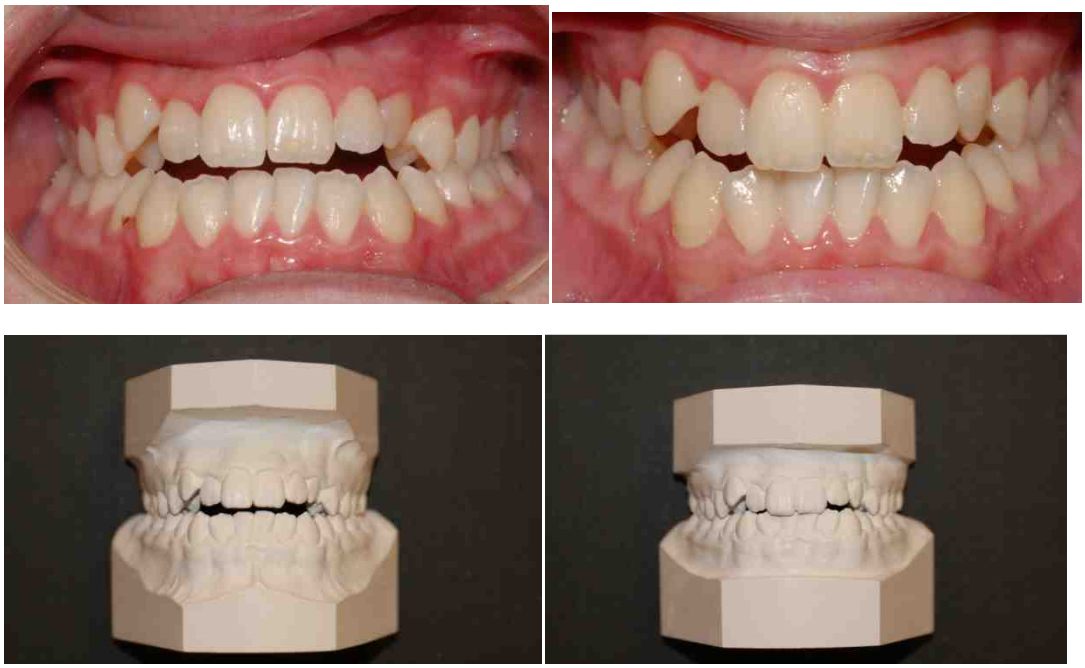

Figure 15: Pre- and post-treatment occlusion photographs of a subject enrolled in this study that had maxillary and mandibular crowding and an anterior tongue posture problem. This patient was 15.3 years old.

considered the procedure to be too aggressive, and the female patients tended to worry more about their friends' reaction to the appliance. Aggressiveness and esthetics were not problems with the bondable spurs. Speech and chewing difficulties were the most common functional problems reported with the banded appliance.[9] Justus[1] reported that it typically took his patients 2-3 weeks to adjust to his maxillary arches with spurs. He also thought speaking, swallowing, and eating were the most frequently reported impairments with his spur appliances. Speech did not seem to be significantly affected with the bondable spurs; eating and pain to the tongue were the most common difficulties, although the overall mean rating for these categories was neutral to easy. Once again, further investigation is needed to directly compare patient acceptance of these 2 types of spur appliances.

Many of the open bites were not completely closed in the 6 month study period. Further increase in overbite may have occurred if a longer treatment period was allowed. Of the 3 patients who had a digit sucking habit, 2 were highly motivated to quit, and the spurs served as a gentle reminder to keep their finger out of their mouth and excellent results were obtained (positive overbite). One of the 3 patients who had a digit-sucking habit in addition to anterior tongue posture was unable to completely discontinue the habit. In the subjects who struggled to quit their habit, whether it was a sucking habit or anterior tongue posture, the bite did not completely close. However, the overbite did increase slightly and uprighting was noted in the incisors cephalometrically. This could potentially be related to a reduction in the frequency of the habit.

The amount of uprighting of the incisors found in this study was surprisingly significant, especially in the mandibular incisors. The lower incisors uprighted almost 6

degrees in terms of the IMPA (mean values; T1 = 100.29 degrees, T2 = 94.60 degrees) and over 5 degrees for L1 to NB (mean values; T1 = 35.62 degrees, T2 = 30.13 degrees). It is known that proclining the incisors leads to an increase in arch length.[24] Figures 16 and 17 demonstrate either a decrease in spacing or an increase in crowding of the lower arches that was noticed in subjects in this study, probably due to the uprighting/retroclination of the incisors from the BLTS. Future research could measure the differences in arch length in patients treated with tongue spurs.

It could be argued that the results of this study may not be viewed as clinically significant. Statistical significance and clinical significance are not the same thing. Reports of statistically significant differences that may not be clinically significant are much more frequently encountered in the literature than clinically significant differences missed statistically.[6] Tests of statistical significance usually ask the question "Is it probable that the difference between these groups is due only to chance?"[6] The results of this study had highly significant P values and favorable confidence intervals (Table 5 and 6) demonstrating increases in overbite and uprighting of the incisors. Clinical significance, however, usually asks the question "Does that make any difference in treatment outcomes?"[6] In a study by Kevin O'Brien and others[25], a 2mm change or greater in overjet was considered to be clinically significant. Although the results of this study are slightly below this measurement, the ultimate objective of this study was to evaluate the effect of removing/minimizing the pressures from an etiologic factor, not fully treating a case. This makes the results of this study clinically applicable, since it could be hypothesized that comprehensive orthodontic treatment would close the bite further, and the stability of the case may be enhanced from re-training the tongue.

Figure 16. Potential Mandibular Arch Length Changes: Spacing cases

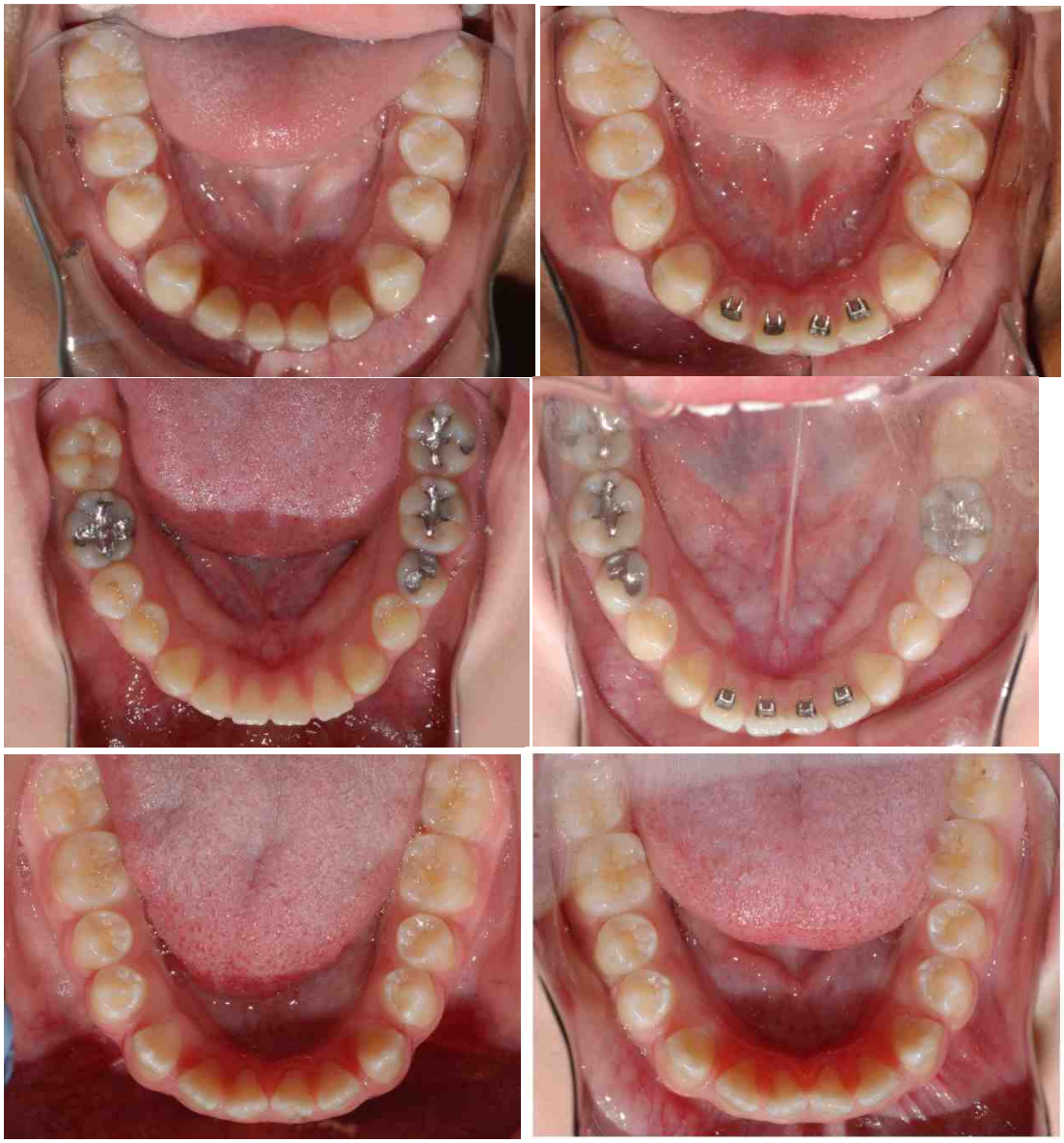

Figure 16: Pre- and post-treatment mandibular arch photographs of 3 spacing cases enrolled in this study that appeared to have had a decrease in arch length with BLTS therapy. Notice the decrease in spacing of the anterior teeth, most notably, the central incisors.

Figure 17. Potential Mandibular Arch Length Changes: A crowded case

Figure 17: Pre- and post-treatment mandibular arch photographs of a crowded case enrolled in this study that appears to have had a decrease in arch length with BLTS therapy. Notice the increase in crowding of the anterior teeth, most notably, the right lateral incisor and canine.

Table 5. Confidence Intervals from Model Analysis

Paired Samples Test

Pair	Model Variable	Mean	Std. Deviation	Std. Error Mean	Lower*	Upper*	t	df	Sig. (2-tailed)
Pair 1	UR3OB2 - UR3OB1	0.58	0.62	0.18	0.19	0.98	3.27	11	.008
Pair 2	UR2OB2 - UR2OB1	0.93	1.08	0.31	0.24	1.62	2.98	11	.013
Pair 3	UR1OB2 - UR1OB1	1.71	1.57	0.45	0.71	2.70	3.77	11	.003
Pair 4	UL1OB2 - UL1OB1	1.55	1.53	0.44	0.58	2.52	3.52	11	.005
Pair 5	UL2OB2 - UL2OB1	1.06	1.29	0.37	0.23	1.88	2.83	11	.016
Pair 6	UL3OB2 - UL3OB1	0.84	0.71	0.21	0.39	1.30	4.09	11	.002
Pair 7	UR3OJ2 - UR3OJ1	0.01	0.38	0.11	-0.23	0.24	0.05	11	.958
Pair 8	UR2OJ2 - UR2OJ1	0.02	0.73	0.21	-0.44	0.49	0.10	11	.920
Pair 9	UR1OJ2 - UR1OJ1	-0.29	1.12	0.32	-1.00	0.42	-0.89	11	.390
Pair 10	UL1OJ2 - UL1OJ1	-0.17	0.95	0.27	-0.77	0.44	-0.61	11	.557
Pair 11	UL2OJ2 - UL2OJ1	-0.02	0.66	0.19	-0.44	0.40	-0.11	11	.915
Pair 12	UL3OJ2 - UL3OJ1	-0.11	0.37	0.11	-0.35	0.13	-1.00	11	.338

*95% Confidence Interval of the Difference

Table 5. Confidence Intervals from Model Analysis: Pair, model measurement variable, mean, standard deviation, standard error of the mean, 95% confidence interval of the difference between T1 and T2 (upper and lower limits), t-value, degrees of freedom, and significance (2-tailed test) from the paired samples T-test.

Table 6. Confidence Intervals from Cephalometric Analysis

Paired Samples Test

Pair	Cephalometric Variable	Mean	Std. Deviation	Std. Error Mean	Lower*	Upper*	t	df	Sig. (2-tailed)
Pair 1	OBmm2 - OBmm1	1.38	0.89	0.26	0.81	1.94	5.32	11	.000
Pair 2	Overjet2 - Overjet1	0.43	1.13	0.33	-0.28	1.15	1.33	11	.210
Pair 3	UFHLFH2 - UFHLFH1	0.67	1.22	0.35	-0.11	1.44	1.90	11	.084
Pair 4	U1SN2 - U1SN1	-1.82	2.28	0.66	-3.26	-0.37	-2.77	11	.018
Pair 5	U1NA2 - U1NA1	-2.60	2.43	0.70	-4.14	-1.06	-3.71	11	.003
Pair 6	U1NAmm2 - U1NAmm1	-0.35	1.50	0.43	-1.30	0.60	-0.81	11	.436
Pair 7	L1NB2 - L1NB1	-5.49	3.09	0.89	-7.45	-3.53	-6.16	11	.000
Pair 8	L1NBmm2 - L1NBmm1	-0.43	0.77	0.22	-0.91	0.06	-1.92	11	.081
Pair 9	IMPA2 - IMPA1	-5.69	3.05	0.88	-7.62	-3.76	-6.47	11	.000

*95% Confidence Interval of the Difference

Table 6. Confidence Intervals from Cephalometric Analysis: Pair, cephalometric variable, mean, standard deviation, standard error of the mean, 95% confidence interval of the difference between T1 and T2 (upper and lower limits), t-value, degrees of freedom, and significance (2-tailed test) from the paired samples T-test.

Furthermore, the present study measured differences in overbite, not overjet. A 2mm reduction in anterior open bite is arguably more noticeable clinically than a decrease in 2mm of overjet.

Study Limitations and Recommendations for Future Research

There were several limitations to this study. To begin with, there was no control group for comparison. No studies were found that utilized a habit altering spur appliance and had a control group. In addition, the size of the sample was small, there were multiple habits within the sample, and there was a wide age range to the sample. The subjects were also made aware of their habits and the possible negative side-effects from the habit. The subjects were reminded to try to discontinue their habit on monthly recall visits (subjects were not blinded). Lastly, it could be argued that the results of this study are not clinically relevant since overbite was increased by slightly less than the 2mm mark.

Future studies that utilize a control group of anterior open bite patients matched for the ages of those who use a habit altering appliance would be beneficial. A smaller age range of subjects and separating the data for different habits would be desirable. It would also be interesting to directly compare BLTS and a banded spur appliance, both in terms of overbite increase and incisor position and patient acceptance of the 2 appliances. Arch length changes could also be measured from these studies.

When recruiting patients for future anterior open bite studies, it is recommended to exclude patients with significant CO/CR discrepancies due to the difficulties in reproducing consistent accurate records. It is also recommended to not include patients who have posterior cross-bites because these patients' study models tend to be very unstable, and therefore, difficult to obtain measurements from.

CHAPTER 5

SUMMARY AND CONCLUSIONS

It was hypothesized that changing a patient's habitual tongue posture or eliminating a digit sucking habit would allow the anterior teeth to upright and further erupt, since they would be less prone to lingual interferences. Positive results were obtained in all but one subject. Overall, bondable lingual tongue spurs are an effective, well-tolerated appliance that can be placed simply in a single appointment on a motivated patient to aid in the elimination of a digit sucking habit or an anterior tongue posture problem and begin closing anterior open bite malocclusions.

Conclusions

- Bondable lingual tongue spurs permitted an increase in overbite in 11 of the 12 patients in this study.
- Statistically significant increases in overbite were found with both the study model measurements and cephalometric radiograph analyses.
- BLTS therapy was effective in eliminating a digit sucking habit to increase overbite in subjects with anterior open bite malocclusions. They were also effective in increasing overbite in subjects who solely had anterior tongue posture problems. Patient motivation and perception of the problem was key in both situations.
- Bondable lingual tongue spurs are simple to insert in one appointment and are esthetically acceptable in appearance. They are well tolerated by patients and are an excellent treatment alternative for those clinicians who are concerned about negative patient and parent perceptions of the banded type of spur appliance.

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