

Stability of anterior openbite treated with crib therapy

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Malocclusions characterized by anterior openbite are often difficult to treat successfully. Numerous theories have been proposed for the etiology of openbite, including heredity,^{1,2} unfavorable growth patterns,³⁻⁶ digit habits,^{3,7,8} enlarged lymphatic tissue^{3,9} and tongue function and posture.^{7,10,11-16} Orthodontic treatment of openbite before the 1970s consisted mainly of dentoalveolar changes and/or modification of oral habits. While this treatment was appropriate if the problem was due to a dental malrelationship, it was often inadequate for addressing openbites which were due to skeletal imbalance. Fortunately, these unfavorable skeletal patterns can now be corrected with orthognathic surgery. However, correcting the openbite is only part of the challenge. Lopez-Gavito¹⁷ reported that more than 35 percent of openbite patients treated with conventional orthodontic appliances relapsed more than three millimeters ten years after treatment. Sim-

ilarly, Denison¹⁸ has reported that openbites treated surgically also exhibit significant relapse posttreatment. One possible explanation for these findings is that anterior openbite may be caused and/or maintained by tongue function or posture, and that this etiologic factor may be ignored in both conventional and surgical treatment. If this is true, then modification of tongue behavior might increase the stability of corrected openbite. Cribbs have been used to modify tongue behavior, but there have been no studies of posttreatment stability. Therefore, the purpose of this study is to determine if crib therapy has an effect on the stability of anterior openbite correction.

Materials and methods

Sample selection and characteristics

Sample selection was based upon the following criteria: 1) a crib was used for modification of tongue and/or thumb habit; 2) cephalometric

Abstract

The records of 33 openbite patients treated with cribs were collected. The sample was divided into two groups with group one comprised of 26 growing patients and group two comprised of seven nongrowing patients. There was a significant increase in overbite for both groups during treatment. The nongrowing group also showed a significant increase in overbite during the posttreatment period. During the posttreatment time interval 17.4 percent of the growing sample and zero percent of the nongrowing sample exhibited relapse. However, all patients who achieved a positive overbite during treatment maintained a positive overbite posttreatment. These findings suggest that patients who achieve a positive overbite with crib therapy have a good chance of maintaining this correction after orthodontic treatment is completed. This statement appears to be true for both growing and nongrowing patients. The reason for this increased stability may be due to a modification of tongue position or posture.

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Key Words

Crib • Openbite • Stability • Relapse • Cephalometric

Table 1
Sample characteristics.

	age crib placed (yr-mo)		length crib used (yr-mo)		length T2 to T3 (yr-mo)		Overbite at T1 (mm)	
	mean	range	mean	range	mean	range	mean	range
Group 1 (n=26)	9-7	7-2 to 14-10	1-2	0-6 to 3-4	5-8	1-0 to 14-0	-2.88	-7.1 to -0.4
Group 2 (n=7)	20-10	16-5 to 33-11	1-1	0-5 to 1-11	3-5	1-1 to 8-11	-2.71	-6.1 to -1.0

Figure 1

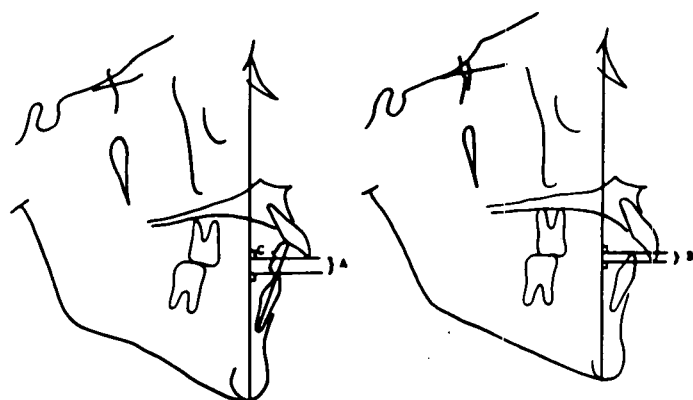


Figure 1
Definition of negative and positive overbite.

radiographs were available pretreatment (T1), immediately posttreatment (T2), and a minimum of one year after appliance removal (T3); 3) at least seven years old at T1; 4) negative overbite at T1 (Fig. 1); 5) Class I or Class II malocclusion at T1; 6) no speech or myofunctional therapy; and 7) no orthognathic surgery. (Treatment success or failure was not a factor in patient selection.)

Based on these criteria, records for 33 patients were collected. There were five males and 28 females, and their ages ranged from seven to 33 years at crib placement. The sample was divided into two groups based on facial growth status. If there was an increase of three millimeters or more in anterior and posterior facial height after T1, the patient was classified as a growing subject. Group 1 consisted of 26 growing patients. Fourteen of these patients had complete orthodontic appliances in addition to cribs. The remaining twelve patients did not receive any other orthodontic therapy except for palatal expanders and/or headgear. Group 2 consisted of seven

nongrowing patients who each received complete orthodontic therapy. Additional characteristics of these groups are given in Table 1.

Cephalometric analysis

All cephalometric radiographs at T1, T2 and T3 were digitized by the primary author. Fourteen digitized points were used to compute the following measurements (Fig. 2).

1. Overbite: distance between U1T and L1T, measured parallel to the Na-Me line
 2. Upper facial height: distance measured along the Na-Me line from Na to the intersection of the palatal plane (ANS-PNS)
 3. Total anterior facial height: distance from Na to Me
 4. Lower posterior facial height: distance from Ar to Go
 5. Total posterior facial height: distance from S to Go
 6. SN-PP: angle formed by S-Na and ANS-PNS
 7. SN-OP: angle formed by S-Na and PFOP-AFOP
 8. SN-MP: angle formed by S-Na and Go-Me
 9. Gonial angle: angle formed by Ar-Go-Me
- These measurements were compared with measurements from other openbite samples reported in the literature (Table 2).

Errors in landmark identification and digitizing were determined by digitizing 10 randomly selected headfilms twice, with one week intervening. All radiographs were digitized by one investigator. The mean error, standard deviation, and range of error were calculated. The mean measurement error was 0.12 millimeter for overbite (SD = 0.13, range = 0 to 0.3 millimeter). For angular measurements, the mean error was less than two degrees (SD = 1.0, range = 0 to 3.4 degrees). The mean error was less than one percent for facial height ratios (SD = 0.9, range = 0.03 to 2.1 percent).

Statistical analysis

To test if there were any significant differences between the patients in Group 1 who received complete orthodontic appliances and those who did not, *t*-tests for means and non-

Table 2
Comparison of mean pretreatment cephalometric characteristics
for reported openbite samples.

	SN-MP	SN-PP	SN-OP	Gonial Angle	UFH/TAFH	TPFH/TAFH	LPFH/TAFH
Group 1 (n=26)	37.4	7.1	19.8	132	45%	60%	36%
Group 2 (n=7)	41.5	10.0	18.9	134	43%	59%	36%
Nahoum (n=52)	41.8	6.4	17.6	131	41%	59%	—
Subtelny & Sakuda (n=25)	39.2	7.8	17.6	129	42%	—	37%
Lopez-Gavito (n=41)	39.8	5.9	16.6	—	42%	61%	39%
Lopez-Gavito normals (n=83)	34.1	8.3	16.3	—	46%	62%	38%
Subtelny & Sakuda normals (n=30)	29.1	8.3	13.9	123	45%	—	41%

parametric tests (Wilcoxon rank sum) were done. To test the significance of changes in overbite between T1 and T2 and between T2 and T3, student's *t*-test for paired data was used. Criteria were established to identify patients that exhibited relapse. Stepwise logistic regression and the Wilcoxon rank sum test were used to determine if there were characteristics at T1 that were useful in predicting patients that were likely to relapse. For all tests, significance was established at the $p < 0.05$ level.

Results

The *t*-test means and Wilcoxon rank sum test were used to compare the growing patients who received complete orthodontic appliances ($n=14$) with those who did not ($n=12$). No significant differences were found in pretreatment (T1), immediately posttreatment (T2), or long-term posttreatment (T3) amount overbite. Additionally, there were no significant differences in the mean pretreatment cephalometric characteristics, length of crib use, or posttreatment time interval (T2 to T3). There was a significant difference of 21 months in the mean age at which the crib was placed (crib only = 8 years 8 months, complete orthodontics = 10 years 5 months). Based on these findings, it was decided to treat these 26 growing patients as one group.

The growing group exhibited a significant increase in mean T1 versus T2 overbite ($\bar{x} = +4.7$ mm, $p < 0.001$). There was not a significant difference between mean T2 and T3 overbite for this group. The nongrowing group had sig-

Figure 2

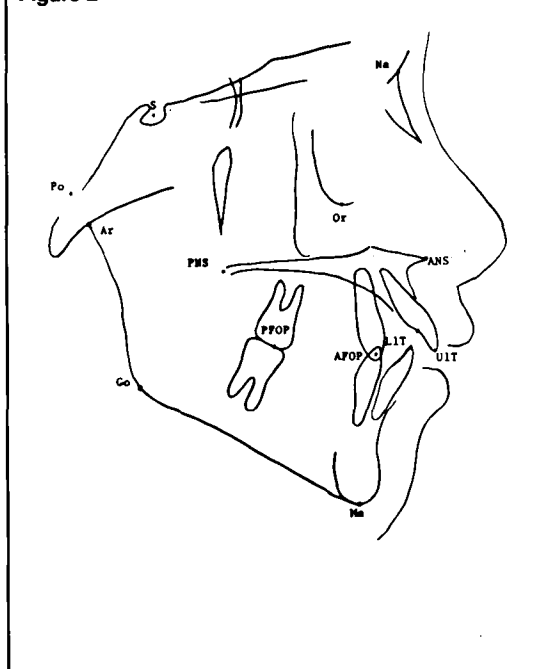


Figure 2
Digitized points.

nificant differences in mean T1 versus T2 overbite ($\bar{x} = +4.2$ mm, $p < 0.001$) and in mean T2 versus T3 overbite ($\bar{x} = +0.8$ mm, $p < 0.005$).

The group of 26 growing patients was used to determine the stability of openbite after treatment. In order to judge relapse, it was decided that only cases that were successfully treated would be used. Success was defined as occurring when there was a positive overbite at T2. Using this criterion, two patients from the crib

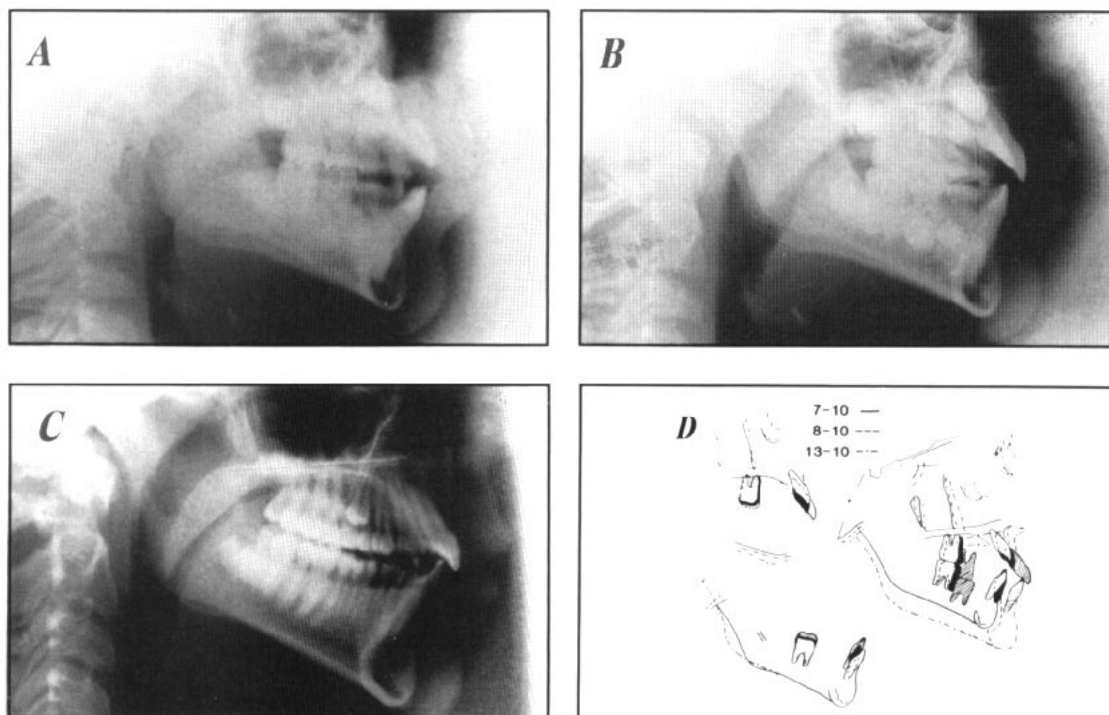
Figure 3
Patient treated with crib only.

A) Initial records, age 7 years 10 months

B) Immediate posttreatment records, 8 years 10 months

C) Long-term follow up records, 13 years 10 months

D) Superimpositions. This patient demonstrates continued closure of the openbite after the crib was removed.



only subsample and one patient from the complete treatment subsample were eliminated. The remaining sample consisted of 23 growing patients who had negative overbite at T1 and positive overbite at T2. Relapse was then judged at two levels. The first was very simple — was there a negative overbite at T3? None of these 23 patients had negative overbite at T3.

In order to further discriminate between patients that had vertical changes and those who did not, a second level of relapse was established. It was defined as occurring when there was no incisor contact at T3 and there was a decrease of more than 0.5 millimeter in overbite from T2 to T3. Using this definition, a total of four patients (two crib only, two complete treatment) relapsed ($4/23 = 17.4$ percent). Multiple logistic regression and the Wilcoxon rank sum test were performed on the relapse versus no-relapse groups. No trends were evident linking relapse with cephalometric characteristics, age at which the crib was started, or length of time that the crib was used.

The group of seven nongrowing patients, although small in number, also offers some interesting findings. All of these patients started with negative overbite at T1. At T2, six of the seven patients had positive overbite. The seventh patient had a negative overbite at T2 of 0.1 millimeter. From T2 to T3, these seven patients reacted in a very consistent manner. They all had increases in overbite, with the mean change in overbite being statistically significant. At T3, all seven had positive overbite.

Discussion

The first issue that should be addressed is the effectiveness of crib therapy. Twelve growing patients from Group 1 were treated with cribs but not complete orthodontic appliances. All of these patients had openbites pretreatment, and 10 of the 12 (83 percent) had achieved positive overbite after treatment. Haryett^{19,20} studied the effectiveness of cribs in patients with thumb-sucking habits and reported that cribs were very effective in stopping the habit when they were worn for 10 months. However, more than half of his sample was less than six years old, and he did not measure overbite. Justus²¹ reported that tongue cribs were effective in closing openbites when worn for one year. Subtelny and Sakuda³ evaluated a sample of eight openbite patients who wore tongue cribs for six months. They found no closure of the openbites during that time. Cooper²² also reported that cribs were ineffective in promoting closure of openbite. Epker and Fisch²³ stated that cribs were usually not effective for treating openbites except in growing patients with Class I occlusion, good facial esthetics, and lip competence. Neither Cooper nor Epker and Fisch give any statistical data to substantiate their statements. Subtelny and Sakuda's results may have differed from the present study due to differences in sample age (all patients were greater than 12 years old), crib design, or length of crib use. Although our study suggests that cribs are effective in treating anterior openbites, there is a need for more information on the percentage of untreated open-

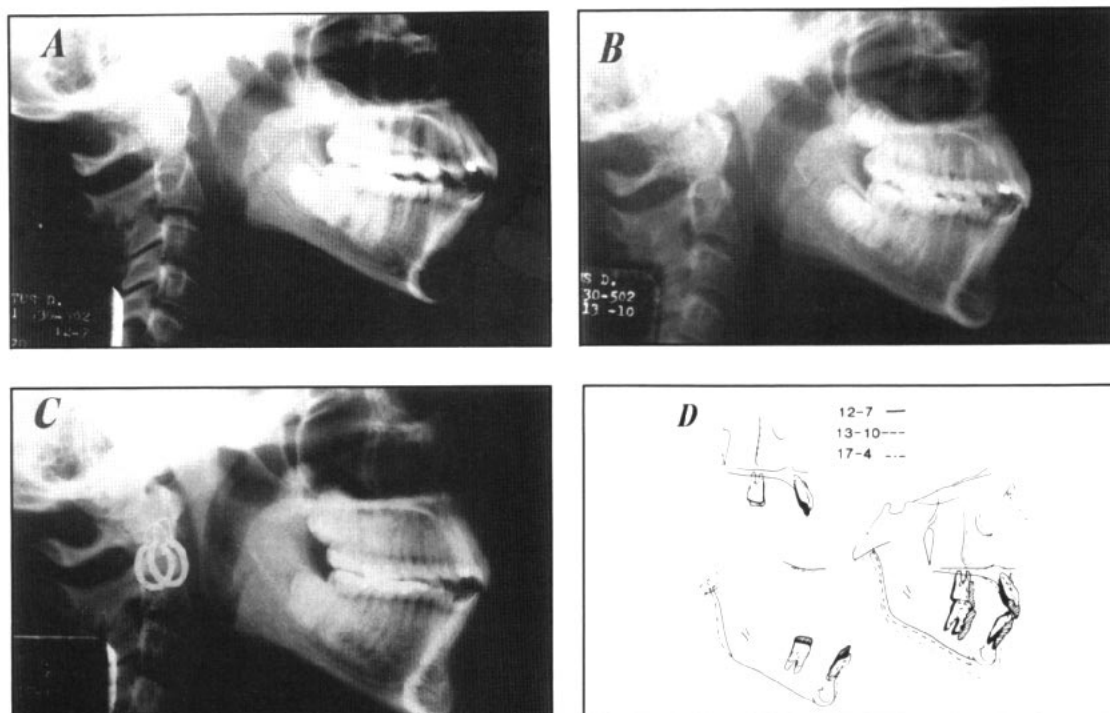


Figure 4
Patient treated with crib only.
A) Initial records, age 12 years 7 months
B) Immediate posttreatment records, 13 years 10 months
C) Long-term follow up records, 17 years 4 months
D) Superimpositions.
 This patient demonstrates incisor contact at T2 followed by slight vertical relapse after treatment.

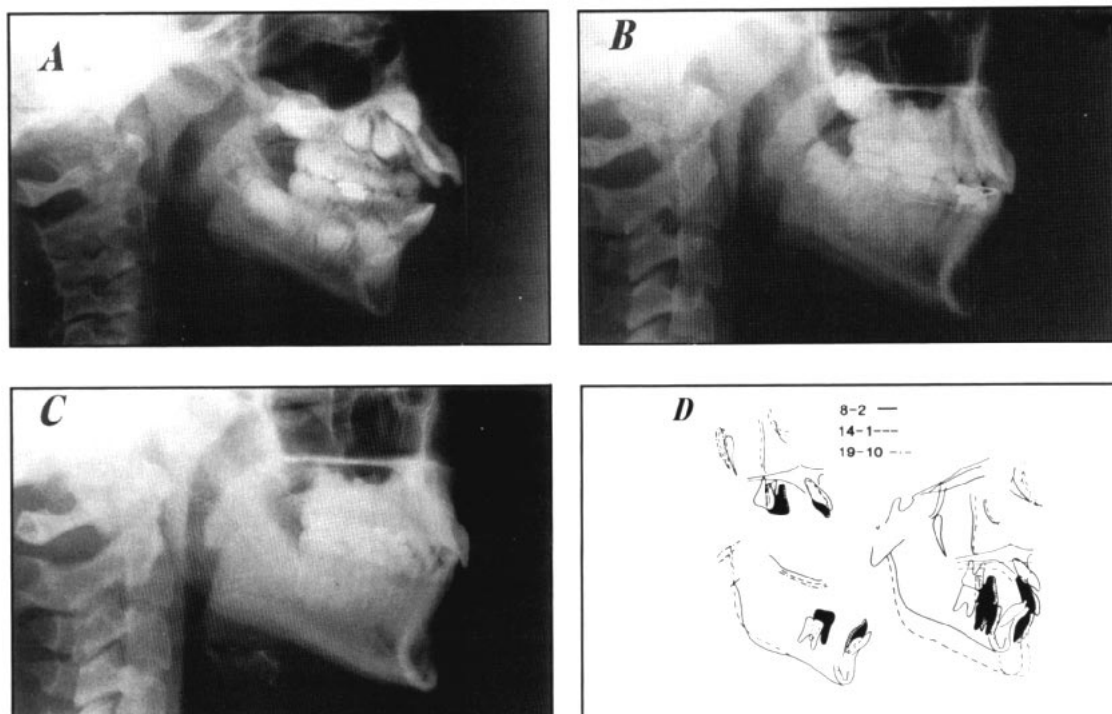
bites that close spontaneously. Studies by Kantorowicz and Korhaus,²⁴ Anderson,²⁵ and Worms²⁶ have reported that 40 percent to 80 percent of openbites in the mixed dentition will close by the time the teenage years are reached. However, all these studies are based on cross-sectional data.

The group of 23 successfully treated patients was used to determine the stability of patients treated with cribs. As mentioned in the results, all of these patients maintained a positive overbite posttreatment. When a stricter definition of relapse was applied (i.e., no incisor contact at T3 and more than 0.5 millimeter decrease in overbite from T2 to T3), four of the 23 patients (17.4 percent) exhibited relapse. Two studies have addressed the stability of openbite after conventional orthodontic treatment. Gile²⁷ reported that 35 percent of his 98-patient sample exhibited relapse three years postretention. His criterion for relapse was based on a measurement from the tip of the mandibular incisor to the nearest hard tissue measured along the long axis of the mandibular incisor. If this distance was greater than three millimeters, then the patient was considered to have relapsed. Lopez-Gavito¹⁷ extended the postretention period from three to nine years, and reported a similar percentage of relapse among 41 patients using the same criterion. Anteroposterior changes and changes in incisor inclination can cause this measurement to increase or decrease without corresponding changes in overbite. Therefore, it is not always a reliable indicator of vertical

change. In the present study, the nasion-menton line was used as a reference to measure vertical changes in overbite. The low incidence of relapse in the present study suggests that tongue cribs do increase posttreatment stability. However, the results of this study cannot be directly compared to the results of Gile or Lopez-Gavito. There is a need to measure samples in a manner consistent with the present study before stronger conclusions can be made.

The sample of nongrowing patients treated with tongue cribs and complete orthodontic appliances exhibited no relapse during the posttreatment interval. No studies have evaluated nongrowing patients who were treated in this manner. However, several articles address the stability of openbite cases treated surgically in a nongrowing sample. Frost²⁸ and Proffit²⁹ both reported good stability of skeletal and dental landmarks after surgery to correct openbite. However, these studies were based on data collected seven to 30 months after surgery, and some patients may have still been in orthodontic appliances. Denison's¹⁸ study of surgically-treated openbites reported that six of 28 patients (21.4 percent) relapsed to a negative overbite posttreatment. All these patients were evaluated at least one year after appliance removal. Denison's study also included a sample of patients that underwent maxillary surgery but did not have pretreatment openbite. This group did not exhibit significant changes in overbite posttreatment. Denison suggested that this discrepancy in posttreatment response may have been

Figure 5
Patient treated with crib and full appliances.
A) Initial records, age 8 years 2 months
B) Immediate posttreatment records, 14 years 1 month
C) Long-term follow up records, 19 years 10 months
D) Superimpositions.
 This patient demonstrates maintenance of incisal contact along with a deepening of the overbite after the completion of treatment.



due to differences in orofacial musculature. He proposed that tongue posture may have been the etiology of the pretreatment openbite, and that it might have been the reason why these patients had a return of the openbite after completion of treatment. The patients with positive overbite pretreatment probably did not have this type of tongue posture, thereby explaining their relative stability. Although the sample of nongrowing patients in this study is small ($n=7$), the posttreatment response is consistently stable. This finding tends to suggest that tongue cribs may be effective in modifying tongue posture, which results in improved stability.

The length of crib use for patients in this study varied from five to 40 months. There was no apparent relationship between the length of crib use and success or stability. Haryett²⁰ reported that six months of crib therapy was as successful as 10 months for correction of thumb habits. He also reported that smooth and sharp spurs were equally effective. However, he added that some patients who used smooth cribs were able to continue to thrust the tongue below the crib in order to create a seal during swallowing. Justus²¹ recommended using cribs with sharp spurs for a minimum of one year in patients whose openbites appear to be related to anterior tongue posture. The majority of patients in the present study had sharp spurs. Only five patients in the "crib only" group had smooth spurs. Although the relapse rate was similar for smooth and sharp cribs, the smooth crib sample was very small, and they were all less than nine

years of age. Our clinical recommendation is that cribs should be worn for at least six months or until the patient achieves positive overbite. If positive overbite is not achieved by one year, the crib may be improperly designed and/or the patient may have a refractory oral habit. It is possible that the smooth crib is effective in correcting openbite in young patients with digit habits whereas the sharp spurs would be more appropriate in older patients or those where the tongue is the main concern. Larger samples of patients treated with smooth and sharp cribs need to be collected in order to fully address this issue.

One original purpose of this study was to determine if there were any predictors of openbite relapse. However, only four patients had relapse of the openbite. Therefore, it was difficult to statistically determine any meaningful correlations.

The small number of relapse patients does suggest that the crib improves stability in patients with pretreatment openbites. Although our patients exhibited a wide range of cephalometric measurements, the mean values for mandibular plane angle, gonial angle, and facial height ratios tended to be similar to mean values reported for other openbite samples.^{3,17,30} The mean mandibular plane and gonial angles were higher than those reported for normal samples, and the mean posterior facial height ratios were usually lower than those for normal samples. Unfortunately, the large degree of individual variation makes it difficult to predict which

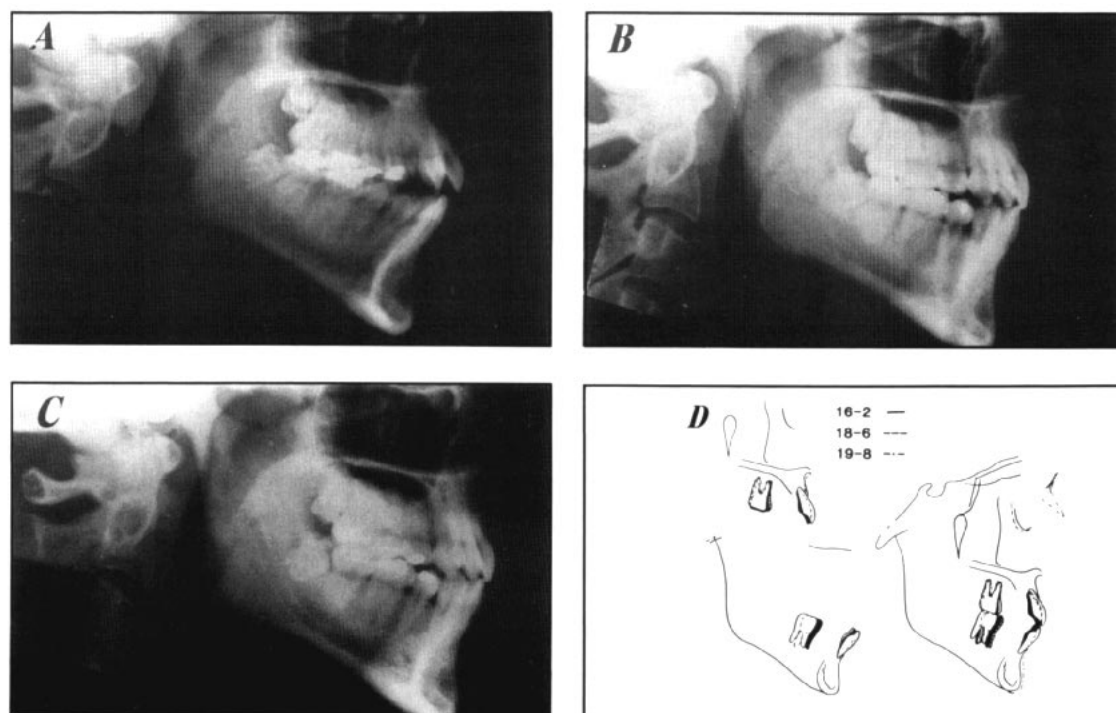


Figure 6
Patient treated with crib and full appliances.
A) Initial records, age 16 years 2 months
B) Immediate posttreatment records, age 18 years 6 months
C) Long-term follow up records, age 19 years 8 months
D) Superimpositions. This patient demonstrates maintenance of incisal contact after treatment.

patients will have openbites or be prone to relapse based on cephalometric values. Dung and Smith³¹ reported similar conclusions regarding the ability to diagnose openbites and predict responses to treatment based on cephalometric values.

This study attempts to answer some questions regarding the stability of patients treated with cribs. While the results of this study are encouraging, the limitations that have been discussed make it difficult to interpret these findings conclusively. Despite these limitations, this study suggests that patients who achieve a positive overbite with crib therapy have a good chance of maintaining a positive overbite after orthodontic treatment is completed. This statement appears to be true for both growing and nongrowing patients. The reason for this increased stability may be due to a modification of

tongue position or posture. Additional studies on untreated, orthodontically treated, and surgically-treated openbite patients will be necessary before a complete understanding of this problem can be reached.

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