

Dental Arch Width Stability after Quadhelix and Edgewise Treatment in Complete Unilateral Cleft Lip and Palate

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ABSTRACT

Objective: To evaluate the transverse stability of the dental arch in unilateral cleft lip and palate (UCLP) patients after orthodontic treatment with quadhelix and edgewise appliances.

Materials and Methods: Twenty repaired complete UCLP patients with posterior crossbites were chosen as the study subjects. All had ceased retention at least 15 months previously. Measurements were carried out directly on the pretreatment, posttreatment, and postretention study models using a three-dimensional dental cast analyzer. The interdental widths were measured for the canines, first premolars, second premolars, first molars, basal bone, and the alveolar arch. Two-way analysis of variance and Fisher's LSD was performed in comparing the difference between intervals.

Results: Lower inter-first-premolar width and upper arch widths of each region increased significantly ($P < .05$) after orthodontic treatment. The expansion was greater in the anterior than the posterior region in the upper arch, and the greatest increase was in the upper first premolar region. The upper arch width decreased after retention, with the decrease of the arch width in the upper canine (1.3 ± 0.8 mm) and first premolar (1.5 ± 0.8 mm) regions being statistically significant. The increased upper arch width in each region and the lower inter-first-premolar width maintained significant expansion after retention.

Conclusions: The widths of the dental arch increased significantly after expansion with a quadhelix followed by preadjusted edgewise treatment. Relapse occurred, especially in the upper canine and first premolar region, but most of the treatment effect on the upper arch remained after retention.

KEY WORDS: Cleft lip/palate; Transverse discrepancy; Orthodontic treatment; Stability

INTRODUCTION

Surgery to the lip and soft palate, together with alveolar bone grafting are considered the most important factors causing disturbance of maxillary growth and development in patients with cleft lip and palate. These disturbances are due to the traumatic effect of surgery and constriction of the scar tissue.¹⁻¹⁰

The transverse dental relationship is one of the main considerations in cleft lip and palate patients. In unoperated complete cleft lip and palate patients the char-

acteristic feature of the upper dental arch is constriction anterior to the molars, but posterior crossbites are less of a problem.¹¹⁻¹⁴ McCance et al¹⁴ studied unoperated cleft patients and reported that the width of upper dental arch was reduced compared to normal controls. Anterior crossbites occurred in 19.5% of the sample, whereas posterior crossbites were not considered significant.

The dental arch constriction in unoperated unilateral cleft lip and palate (UCLP) patients reflects the primary deficiency of palatal tissue as the segment hinges around an axis in the tuberosity region. In a group of studies on repaired cleft lip and palate patients, the interdental width of the upper dental arch also was reported reduced.¹⁵⁻²¹ The reduction of arch width in the repaired cleft patients was more severe than that of the unrepaired patients.¹² Buccal crossbites occurred in 75.6% of the repaired unilateral cleft lip and palate patients,¹⁸ which was more frequent than that of the unoperated UCLP patients. Palatal surgery and the

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constriction of scar tissue caused more severe collapse of the buccal segment in the repaired cleft lip and palate patients.

Such posterior crossbite and transverse discrepancies in UCLP patients¹⁵⁻¹⁷ makes orthodontic treatment more complicated. Upper arch expansion is often conducted in UCLP patients during orthodontic treatment. However, lack of supporting bone in the palate, constriction due to scarring of palatal soft tissue, abnormal muscular force, and the large amount tooth movement during treatment may not be stable in cleft patients. Very few studies have been reported on the transverse changes in the dental arch in repaired UCLP patients after orthodontic treatment and the stability of the increased dental arch width.^{22,23} The aim of this study is to investigate transverse dental arch stability after orthodontic treatment in repaired UCLP patients.

MATERIALS AND METHODS

Subjects

The sample consisted of 20 repaired complete UCLP patients (14 boys and 6 girls) who had posterior crossbites before orthodontic treatment. The pretreatment age range was 11.2–19.1 years (mean 14.7 ± 2.6 years). All patients had upper arch expansion using a quadhelix, followed by treatment with a preadjusted edgewise orthodontic appliance. All patients had stopped retainer wear for at least 15 months. Lip surgery was carried out before the age of 12 months and none had presurgical orthopedic treatment. The palatal surgery (modified von Langenbeck procedure) was performed for each patient before the age of 4 years, and alveolar bone grafting was performed between 9 and 14 years of age. All patients were in the permanent dentition and had no previous orthodontic treatment.

Protocol of Orthodontic Treatment

A quadhelix appliance was used to expand the upper arch for each patient followed by preadjusted edgewise appliances fitted after the posterior crossbite was overcorrected by approximately 2 mm. The quadhelix appliance was kept in place until a heavy rectangular stainless steel wire could be inserted into the edgewise brackets. The active quadhelix treatment time was 4–7 months. Total treatment time ranged from 1.9–3.3 years. The average age of the patients at completion of treatment was 17.0 ± 2.6 years. Good buccal occlusion was attained before the end of treatment.

Hawley retainers were prescribed for each patient. The patient was instructed to wear the retainer full-time except for meals and tooth brushing for 12

months, and at night only for another 6 months. The patients were recalled after at least 15 months out of retention. The longest time after retention was 4 years and 2 months (mean 23.8 ± 11.8 months); the mean age at recall was 21.1 ± 2.9 years.

Dental Cast Analysis

Dental casts were made for each patient before orthodontic treatment (T_0), after orthodontic treatment (T_1), and at least 15 months after retention (T_2). Twelve measurements were carried out directly on the study models using a three-dimensional model analyzer. The arch width was measured to 0.1 mm. Inter-canine width, inter-first-premolar width, inter-second-premolar width, inter-first-molar width, basal bone width, and alveolar arch width of both arches were measured.

The intercanine width was measured between the cusp tip of the canines; the inter-premolar-width was measured between the tips of the buccal cusps; the inter-first-molar width was measured between the tips of the mesiobuccal cusp of the first molars; the width of the basal bone was measured between the most concave point of the basal bone at the first premolar area; and the width of the alveolar arch was measured between the most prominent points of the alveolus in the area of the first premolars. The cusp tip was marked on the very top point of the buccal surface of the measured cusp, which was easily identified. The dental casts obtained at each stage were then occluded, the occlusal relationship examined, and any posterior crossbite recorded.

A 0.5-mm 2H pencil was used to mark the point of measurement. Each model was measured twice on separate occasions and the average was used in the statistical analysis. The method error ranged from 0.1 to 0.2 mm for all measurements.

Statistical Analysis

Two-way analysis of variance (ANOVA) for a within-subject design was performed to assess the arch width change at different observation times. LSD analysis was carried out to compare the difference between each interval. All computation was performed by the computer program SPSS (version 10.0, Chicago, Ill).

RESULTS

A posterior crossbite existed in every patient before orthodontic treatment; 65% (13 subjects) had a bilateral posterior crossbite and 35% (7 subjects) had a unilateral crossbite. No subjects had a posterior crossbite after orthodontic treatment. Buccal occlusion was

Table 1. The Mean and Standard Deviation of Three Intervals of Observing: Pretreatment, Posttreatment, and Post Retention

	Pretreatment		Posttreatment		Post Retention	
	Mean, mm	SD	Mean, mm	SD	Mean, mm	SD
Upper arch						
Inter canine width	25.9	2.9	31.4	2.9	30.0	2.9
Inter-first-premolar width	35.0	4.0	40.8	3.5	39.2	3.5
Inter-second-premolar width	41.6	4.5	46.0	3.9	45.0	3.2
Inter-first-molar width	48.7	4.5	51.9	2.2	50.8	2.3
Basal bone width	42.8	2.1	43.8	2.1	43.6	2.1
Alveolar arch width	43.2	2.7	45.2	2.5	44.9	2.5
Lower arch						
Inter canine width	26.8	2.2	27.3	1.8	27.1	1.8
Inter-first-premolar width	35.1	3.2	35.9	2.9	35.7	2.8
Inter-second premolar width	42.4	2.9	42.7	3.0	42.5	2.9
Inter-first-molar width	47.6	3.3	47.4	3.2	47.3	3.2
Lower basal bone width	45.0	2.3	45.1	2.2	44.9	2.2
Alveolar arch width	45.2	2.2	45.7	2.3	45.7	2.4

Table 2. Mean Difference and Standard Deviation Between Pretreatment, Posttreatment and Post-Retention, and LSD Analysis^a

	T ₁ -T ₀ Mean Difference		T ₂ -T ₀ Mean Difference		T ₂ -T ₁ Mean Difference	
	Mean	SD	Mean	SD	Mean	SD
Upper arch						
Inter canine width	5.4	2.3**	4.1	2.1**	-1.3	0.8*
Inter-first-premolar width	5.8	2.3**	4.3	2.2**	-1.5	0.8**
Inter-second-premolar width	4.4	2.8**	3.5	2.3**	-0.9	0.7
Inter-first-molar width	3.2	3.3**	2.1	2.7**	-1.0	0.8
Basal bone width	0.8	1.2*	0.7	0.9*	-0.1	0.5
Alveolar arch width	2.0	1.6**	1.8	1.4**	-0.3	0.4
Lower arch						
Inter canine width	0.5	1.1	0.3	0.8	-0.2	0.5
Inter-first-premolar width	0.8	1.0*	0.6	1.0*	-0.2	0.4
Inter-second premolar width	0.3	1.0	0.2	1.0	-0.1	0.4
Inter-first-molar width	-0.2	1.2	-0.3	1.1	-0.1	0.3
Lower basal bone width	0.2	0.6	0.0	0.4	-0.2	0.5
Alveolar arch width	0.5	0.7	0.5	0.8	0.0	0.5

^a T₀ indicates before orthodontic treatment; T₁ after orthodontic treatment; T₂ 15 months after retention.

* $P < .5$; ** $P < .01$.

reevaluated after retention and three teeth of two subjects were in crossbite.

The average arch width and the standard deviation of each segment at each observation time are shown in Table 1, and the mean difference between each observation and standard deviation is shown in Table 2.

Upper Arch

The upper arch width of each region was increased significantly after orthodontic treatment (T₁) and after retention (T₂). The expansion was greater in the anterior area than in the posterior region of the upper arch.

The intercanine width increased by 5.4 ± 2.3 mm ($P < .01$) after orthodontic treatment, and decreased

by 1.3 ± 0.8 mm ($P < .05$) after retention. The net increase was 4.1 ± 2.1 mm ($P < .01$) after retention.

The inter-first-premolar and inter-second-premolar widths increased by 5.8 ± 2.3 mm ($P < .01$) and 4.4 ± 2.8 mm ($P < .01$) after orthodontic treatment and decreased by 1.5 ± 0.8 mm ($P < .05$) and 0.9 ± 0.7 mm ($P > .05$) after retention. The net increase was 4.3 ± 2.2 mm ($P < .01$) in the first premolar and 3.5 ± 2.3 mm ($P < .01$) in the second premolar area.

The inter-first-molar width increased by 3.2 ± 3.3 mm ($P < .01$) after orthodontic treatment and decreased by 1.0 ± 0.8 mm ($P > .05$) after retention. The net increase was 2.1 ± 2.7 mm ($P < .01$).

The basal bone width increased by 0.8 ± 1.2 mm ($P < .05$) after orthodontic treatment and decreased

by 0.12 ± 0.54 mm ($P > .05$) after retention. The net increase was 0.7 ± 0.9 mm ($P < .05$).

The alveolar arch width increased by 2.0 ± 1.6 mm after orthodontic treatment ($P < .01$), and the net increase was 1.8 ± 1.4 mm ($P < .05$) after retention.

Lower Arch

In the lower arch, the inter-first-premolar width increased by 0.8 ± 1.0 mm ($P < .05$) after orthodontic treatment and decreased by 0.2 ± 0.4 mm ($P > .05$) after retention. The net increase was 0.6 ± 1.0 mm ($P < .05$) after retention. There was no significant difference in the rest of the lower arch measurement between the different observing times.

DISCUSSION

Transverse Changes of the Dental Arch in UCLP Patients After Orthodontic Treatment

Although a posterior crossbite is more severe on the cleft side than that of the noncleft side, a bilateral crossbite is more frequent in UCLP patients. In this study 65% of the patients had bilateral posterior crossbites. Collapse and mesial movement of the smaller maxillary segment increased the tendency towards posterior crossbite on the cleft side.^{11,14} However, the constriction of the scar tissues in the palate, pressure from the facial muscles, and the traumatic effect of the surgical correction of the cleft palate have the stronger influence on the transverse growth of the whole maxilla, and this might be the most important reason for the more frequent bilateral crossbites in UCLP patients in this study.

From the current study, we found that the potential for expansion of the upper arch was considerable. The largest increase of upper arch transverse width in this study was about 15 mm. Upper arch crowding together with the posterior crossbite is very common in patients with repaired unilateral cleft lip and palate, but upper tooth extraction is seldom conducted due to the underdevelopment of the maxilla. Upper arch expansion is the most commonly used method for relieving crowding and the posterior crossbite in the orthodontic treatment of patients with repaired cleft lip and palate.

In the study of noncleft patients,^{18,19} expansion was found to be greater in the posterior than anterior aspects of the arch during palatal expansion. However, the expansion in the anterior region was greater than that of the posterior in UCLP patients in this study. The expansion of the canine and premolar area was more than 2 mm greater than that of the first molar region in the current study. The increase was the greatest in the first premolar region, then in the canine and the second premolar regions. The increase of the inter-

first-molar width was the least in the upper arch. The increasing anterior constriction of the upper arch in the UCLP patients^{15,16} makes the transverse dimensions in the canine and premolar areas narrower,¹³ with the greater incidence of crossbites in this region.

The upper basal bone and alveolar arch widths increased during the quadhelix treatment followed by a preadjusted edgewise appliance, reflecting some orthopedic effects. The basal bone width increased by just 0.8 mm, and the magnitude of the increase was not of clinical significance, while the alveolar arc increased by 2.0 mm, indicating that the main changes caused by the quadhelix and fixed orthodontic treatment was in the dentoalveolar regions.

The inter-first-premolar width of the lower arch was also increased after orthodontic treatment, but the increase was very small (less than 1 mm) and not clinically significant. With the mild lower arch crowding and posterior crossbite, the lower arch seldom needs to be expanded in UCLP patients. The small amount of lower arch width increase in this study is due to the malformed lower arch and mild lower arch crowding.

Stability of Transverse Dental Arch Changes

Studies on the dental arch transverse stability after palatal expansions in noncleft patients have been reported in recent years,²⁴⁻²⁷ and relapse occurred to some extent after orthodontic treatment in most studies. Nicholson and Plint²³ reported that the interdental width relapsed to an unacceptable degree in 79.5% of cleft patients treated with only rapid maxillary expansion. There was no difference between bone graft and nongraft patients, and no correlation with the amount of expansion and time of retention. However, these patients had no fixed appliance treatment following the rapid maxillary expansion.

In another study of 22 nongrafted UCLP patients expanded by orthodontic treatment,²² the interdental width of the upper arch decreased in each segment after the removal of the upper fixed lingual arch. The intercanine width decreased by 1.3 mm, interpremolar width decreased by 2.4 mm, and intermolar width decreased by 2.8 mm. In the current study, though the upper dental arch width of each region decreased after retention, the magnitudes were smaller than the previous reports and the dental arch widths were still significantly wider than before treatment. The arch width decreased more than 1 mm in the upper canine and first premolar areas after retention, which was statistically significant. It might be because the expansion was greater or the muscular pressure was stronger in the region. In the upper arch, 75.4% of the increase of intercanine width, 73.7% and 78.7% of the increases in interpremolar width and 67.3% of the increase in

inter-first-molar width was maintained after retention. Although relapse occurred after retention in this study, most of the increase of the upper arch dimensions and the main treatment results were maintained. When observed after retention, only three posterior teeth in two patients were in crossbite. Slow expansion with the quadhelix, overexpansion,²⁷ and good buccal occlusion achieved by full fixed appliances after orthodontic treatment decreased the relapse tendency of the upper arch in our present study. Since most of the cases in this study were recalled not more than two years out of retention, longer term stability of the dental arch expansion in UCLP patients should be studied further.

By comparing three types of palatal expanders (Hyrax, quadhelix, and a removable appliance) Herold²⁶ found no significant difference in expansion between the three methods, and the residual expansion was the same after retention in the groups. In the present study, upper arch expansion with the quadhelix, though mainly causing orthodontic changes, can result in orthopedic changes as well in the UCLP patients. The quadhelix is a convenient and efficient appliance for expanding the maxillary arch in patients with UCLP.

The pretreatment interdental width of the lower arch was maintained after orthodontic treatment and after retention except for the inter-first-premolar width in the current study. The lower intercanine width is reported to decrease during the normal growth period²⁸ and stability of the lower intercanine width in noncleft patients after orthodontic treatment was found to be poor.¹⁹ The intercanine width decreased and closely approximated pretreatment dimensions after retention.²⁰ Maintenance of the lower intercanine width during orthodontic treatment has been considered to be important in maintaining treatment stability. Fortunately, dental arch expansion in the lower arch is seldom needed in UCLP patient during orthodontic treatment.

CONCLUSIONS

- In UCLP patients treated with a quadhelix followed by a preadjusted edgewise appliance, the upper arch width of each region increased significantly.
- Relapse occurred to some extent after orthodontic treatment. Arch width decreased after retention, especially in the upper canine and first premolar regions, but most treatment results were maintained.

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