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A Comparison of the Nance Holding Arch and Kloehn Headgear in Maxilliary Molar Anchorage

Michael J. Fillman

Abstract

A COMPARISON OF THE NANCE HOLDING ARCH
AND KLOEHN HEADGEAR IN MAXILLARY MOLAR ANCHORAGE

by

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A sample of thirty first bicuspid extraction patients, ages 9 through adult, were evaluated for maxillary molar anchorage loss during cuspid retraction. The Nance Holding Arch and Kloehn cervical headgear were compared as anchorage devices. A control group received no anchorage mechanics during cuspid retraction. All cuspids were retracted with Hilger's loop retractors.

Anchorage loss was measured cephalometrically by comparing the difference in the $\underline{6}$ to PTV measurement on the initial and post cuspid retraction lateral head films.

Anchorage loss, as the dependent variable, was compared to the study groups, Angle class, facial type, treatment length, palatal angle and distance of cuspid retraction as independent variables.

Eighteen patients were treated with the Nance Holding Arch, six with Kloehn cervical headgear and six with no

anchorage mechanics during cuspid retraction. Results show no significant difference in mean anchorage loss in the three groups (Nance = 1.288 mm loss; Headgear = 0.833 mm loss; Control = 1.583 mm loss).

Initial molar Angle classification had no significant effect on maxillary molar anchorage. This study showed the least anchorage loss in the Class II end-on sample and the greatest loss in the Class I sample.

Dolichofacial patients demonstrated greater anchorage loss than Brachyfacial patients but the difference was not significant. (1.76 mm and 1.26 mm respectively.)

Although not significant statistically, steeper, high vaulted palates tend to provide greater molar anchorage when the Nance Holding Arch is used.

No correlation was demonstrated between anchorage loss and length of treatment (T_1 radiograph to cuspids retracted radiograph).

The study showed that the upper molar position can be reliably traced and evaluated for anchorage loss.

LOMA LINDA UNIVERSITY

Graduate School

A COMPARISON OF THE NANCE HOLDING ARCH AND KLOEHN HEADGEAR IN MAXILLARY MOLAR ANCHORAGE

by

Michael J. Fillman

A Thesis in Partial Fulfillment
of the Requirements for the Degree Master of Science
in Orthodontics

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Each person whose signature appears below certifies that this thesis in his opinion is adequate, in scope and quality, as a thesis for the degree Master of Science.

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INTRODUCTION

In the treatment of Class II malocclusion or bimaxillary protrusion where bicuspids are extracted, it is often desirable to utilize all of the extraction space to retract the anterior segments. Thus, any mesial movement of the maxillary molars would not be desirable. Kloehn cervical headgear has long served as the principal means of anchorage preservation, and when maximum patient cooperation can be relied on, the molar stability is assured.

Cuspid retraction forces, whether via coil springs, loops or elastomeric chain in a continuous arch, or loops in a segmented arch, are generally continuous. If extra-oral anchorage is not sufficient to compensate for these continuous mesial forces applied to the maxillary molar, it will move forward.

Hays Nance, in the 1940's, began using the Nance Holding Arch as another method of preserving maxillary first molar anchorage; however, he did not publish details of its construction, use or effectiveness. Ricketts(1979) lists the Nance appliance as one method of obtaining maximum anchorage. Since the Nance is a fixed appliance, patient cooperation becomes less of a concern to the orthodontist.

To date, there are no published reports that quantify anchorage loss when using the Nance appliance. Controversy exists among orthodontic practitioners regarding the Nance's effectiveness; thus, the purpose of this paper was to measure the effectiveness of the Nance Holding Arch appliance on maxillary first molar anchorage in first bicuspid extraction cases.

The present study attempts to show if there is a superior method of controlling anchorage in first bicuspid extraction cases. Also studied was the correlation of the following variables to anchorage loss: treatment time, palatal angulation, Angle classification, age, facial type and distance of cuspid retraction.

LITERATURE REVIEW

Very little information is available regarding either the construction or application and uses of the Nance Holding Arch. Hays Nance designed the Nance Holding Arch appliance in the 1940's to hold maxillary molars during cuspid retraction. Elbel (1982) describes a modification of the Nance appliance when second bicuspids are extracted. Steiner (1960) describes the use of a "palatal plate" to aid in maxillary anchorage of an extraction case. It seems that the use of the Nance Holding Arch has been based almost solely on clinical judgment with no scientific data to assess its anchorage capabilities.

Cuspid Retraction Forces and Anchorage Loss

Reitan (1957) and Gjerset(1965) noted that the magnitude of force is important in the anteroposterior movement of the anchorage unit. Story and Smith (1952) stated a similar concept - that heavier forces (400-600 g) result in mesial movement of the anchor unit with the cuspid remaining stationary. With forces in the range of 175-300 g, the cuspids rapidly move distally with the posterior teeth only very slowly moving mesially. Begg (1956) speculated that the application of these differential forces would negate the need for extra-oral mechanics during anterior retraction.

Boester and Johnston (1974) showed no significant relation between anchorage loss and force of retraction. They showed that 8 out of 10 patients subjected to 11 oz (310 g) of cuspid retraction force had more canine retraction than molar slippage. Twenty-two out of 30 patients treated in the 2 oz (55 g), 5 oz (140 g), and 8 oz (225 g) range still showed more canine retraction than molar slippage. Andreasen and Zwanziger (1980) reported similar results that tend to disprove the differential forces theory. Their research showed that 12 out of 14 patients exhibited increasing rates of tooth movement as retraction forces increase.

Pritchard (1972) retracted cuspids on six patients. His data shows a mean cuspid retraction distance of .521 mm per month and a mean molar forward movement of .440 mm per month. He retracted with Pletcher t-springs activated to 4 oz. No anchorage mechanics to the upper molar were used. This shows cuspid retraction and molar anchorage loss to be almost equal with 4 oz of retraction force.

Hixon (1969), in disagreement with Story and Smith (1952), states that any initial retraction force does not remain constant. An initial force of 300 g will decay rather quickly. Hixon also reports that tooth movement is a linear function of force up to about 300 g.

Burstone (1965) advocates 150 g as the most desirable canine retraction force. Weinstein's (1967) study on minimal forces required to move a tooth, is of interest. He used gold inlays on the buccal surface of premolars to cause an increase of buccal musculature force of 1.68 g. Significant tooth movement occurred with this light force.

Caputo, Chaconas and Hayashi (1974) showed that bodily movement of the canine occurs most favorably when activation does not exceed 300 g and when a 45 to 60 degree gable angle is placed on the sectional retractor.

There is a wide variability in forces reported to be capable of cuspid retraction; however, most investigators state that a light continuous force is the most effective.

Extra-Oral Traction

The use of extra-oral traction in orthodontics has long been used to reinforce the anchorage of posterior teeth during anterior retraction. Numerous references in the literature report on how extra-oral traction can retard and redirect maxillary development as well as move posterior teeth distally (Graber 1955, Klein 1957, Kloehn 1962, Moore 1959, Poulton 1967, Ricketts 1960, Wieslander 1963).

Most all headgear studies quantify how much distalization of the upper molar occurs in treatment of Class II patients. Very few studies discuss anchorage loss of the upper first molar during anterior retraction.

Ricketts (1960) observed up to 1.3 mm distal movement of the maxillary first molar, as measured from PTM, in patients receiving headgear therapy. He compared this to over 2 mm mesial movement in the non treatment controls. In his first bicuspid extraction sample, the upper molar drifted 1.2 mm mesially during anterior retraction, even though night time cervical headgear was used.

Paulson, Speidel and Isaacson (1970) measured molar and cuspid movement radiographically in Class I extraction cases. Cuspids were retracted with grey power chain on a continuous round arch wire. Molar anchorage was effected by night cervical headgear and a fixed transpalatal bar. There was no mesial movement of the upper molars in their sample of six. The authors hypothesize that the initial Class I molar may have been a dominant factor in holding the molar from slipping anchorage.

Ludwig (1966) describes the Kloehn cervical headgear as the means to provide support or anchorage for the retraction of anterior teeth into bicuspid extraction spaces.

Cephalometric Analysis

The variability of locating cephalometric landmarks is an old problem of cephalometric analysis. The location of cephalometric landmarks is complicated by superimposition, difficulty in locating certain anatomic landmarks, the growth factor, tracing errors, and variations in observers.

Baumrind and Frants (1971) classified cephalometric errors into three types: 1) Errors of projection, 2) Errors in landmark location, and 3) Errors in tracing.

McGonagle (1960) showed the degree of human error in tracing by selecting five orthodontists to trace the same head film. He found a high degree of similarity in most measurements of the Downs analysis. Measurement discrepancies were 3.5 degrees or less for angular measurements of the Downs analysis. He recommends caution however, in accepting any and all findings based on cephalometric tracings.

Salzman (1964) believed that cephalometric norms should not be used as a basis for treatment, primarily because the radiograph does not present information on the quality of growth and development.

Cephalometric analysis of maxillary molar anteroposterior movement is commonly measured from PTV to distal of upper first molar. Ricketts (1960) recorded upper molar position by this method. PTV is a vertical plane from the posterior margin of pterygomaxillary fissure and is perpendicular to the Frankfort horizontal plane. Broadbent (1937) and Brodie (1941) recognized the relative stability of the pterygomaxillary fissure (PTM) in the developing cranial base. In 1953, Brodie (1953) said that PTM is the most stable point in the facial area, at least in the anteroposterior direction. The fissure drops straight downward from the location in which it is found at about three years of age and the distance between it and a perpendicular dropped to the Frankfort plane from the center of sella turcica does not change.

Moore (1959) used pterygomaxillary fissure as a stable landmark to describe changes in the maxilla. He superimposed the maxilla on the palatal plane registering on pterygomaxillary fissure. This shows the maxillary denture and anterior nasal spine to move forward with growth. The teeth erupt downward and forward in relation to the pterygomaxillary fissure.

Cornforth (1975) demonstrated the importance of the mandibular arc measurement in determining facial type and facial axis changes with treatment. Frank (1981) used mandibular arc as one determining factor in establishing the facial type of a patient.

METHODS AND MATERIALS

Target Population

The population in this study consisted of 30 orthodontic patients, ages 9 through adult, all receiving maxiliary first bicuspid extractions and all receiving sectional Hilgers cuspid retractors. Both Class I and Class II initial molar relations were accepted. The anterior teeth had no mechanics affecting anchorage until the cuspids were retracted.

The population was divided into three groups: 1) Nance - 18 patients (7 males, 11 females); 2) Headgear - 6 patients (3 males, 3 females); and 3) No Anchorage: Control - 6 patients (1 male, 5 females). The Nance and Headgear groups were diagnosed as maximum anchorage cases in the maxilla. Eleven patients in the target population were treated by graduate orthodontic students at Loma Linda University. The remaining 19 patients were treated by 5 Loma Linda University faculty members in their private practices. Patients with high cuspids requiring minimal retraction, and patients with congenitally missing teeth were excluded from this study. No consideration was given to treatment mechanics in the mandible.

Materials

1. Initial lateral Cephalometric radiographs on each patient.
2. Progress lateral cephalometric radiographs (taken when cuspid retraction was complete) on each patient.
3. .016 x .016 Hilger's cuspid retractors (see Figure 1).
4. Nance Holding Arch - .036 stainless steel wire with palatal button (see Figure 2).
5. Kloehn cervical headgear - 8-10 hours/day - Orthodontic force - less than 500 g.
6. Millimeter ruler.
7. Bow divider.
8. Tracing paper.

Standardization

1. Of Cuspid Retraction:
    a. Hilger's cuspid retractor - .016 x .016
    b. Activation - every 3-4 weeks by opening the vertical step 1 mm - 1.5 mm
    c. Force - approximately 4 oz (113 g) with 1.5 mm activation

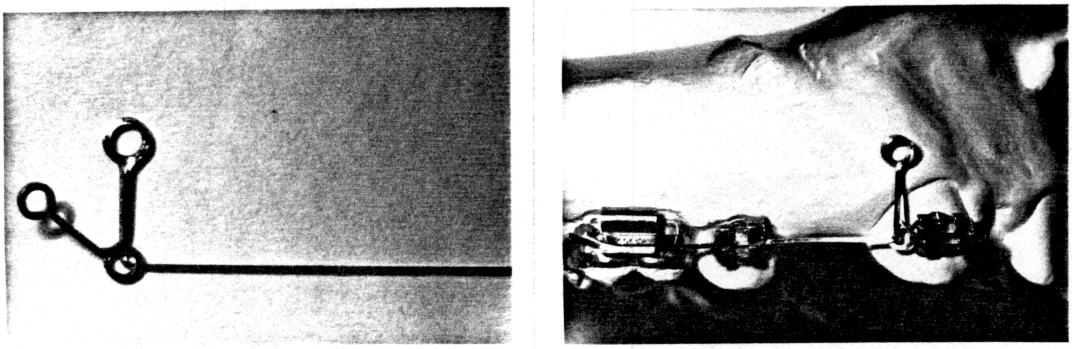

Fig. 1 Hilgers Cuspid Retractor

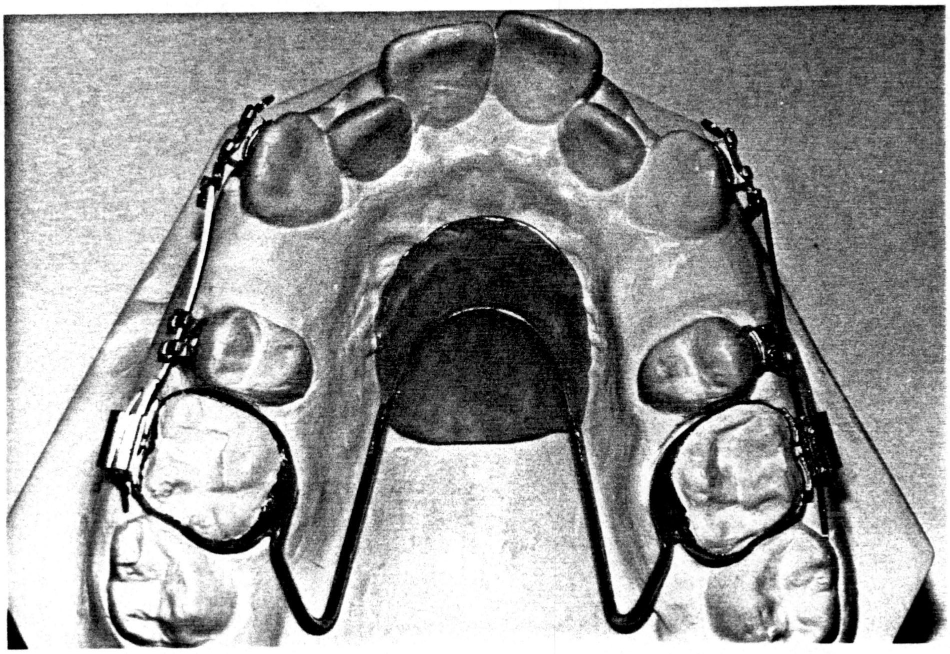

Fig. 2 Nance Holding Arch

2. Of Nance Appliance:

   a. .036 in. stainless steel wire soldered to prefitted molar bands

   b. Acrylic palatal button to approximate size of a quarter

3. Of Cervical Headgear:

   a. Night time wear - 8-10 hours per day

   b. Orthodontic Force - less than 500 g

Method of Evaluation

A lateral cephalometric radiograph obtained prior to orthodontic treatment (T_1) and after cuspid retraction (T_{prog}) was traced by the principal investigator using the Ricketts cephalometric analysis.

The following tracing sequence (Orthodontic Faculty 1982) was used in tracing the progress film:

1. Trace the following landmarks on new acetate from the T_1 film: (see Figure 3):

   a. Nasion - Basion plane

   b. Frankfort Plane (Porion and Orbitale)

   c. PTV

   d. CC Point

   e. Pterygomaxillary Fissure

   Note: Cranial Deflection has been shown to be a growth constant. (Ricketts 1982)

2. Place T_{prog} tracing over T_{prog} film. Move the tracing around until the cranial base, porion, orbitale and especially pterygomaxillary fissure best represent the T_{prog} film.
3. Draw in occlusal plane and maxillary first molar. The distal of the maxillary first molar is of critical diagnostic importance so it was hand traced <u>without</u> using a template. The most distal image of the two first molars was always traced.

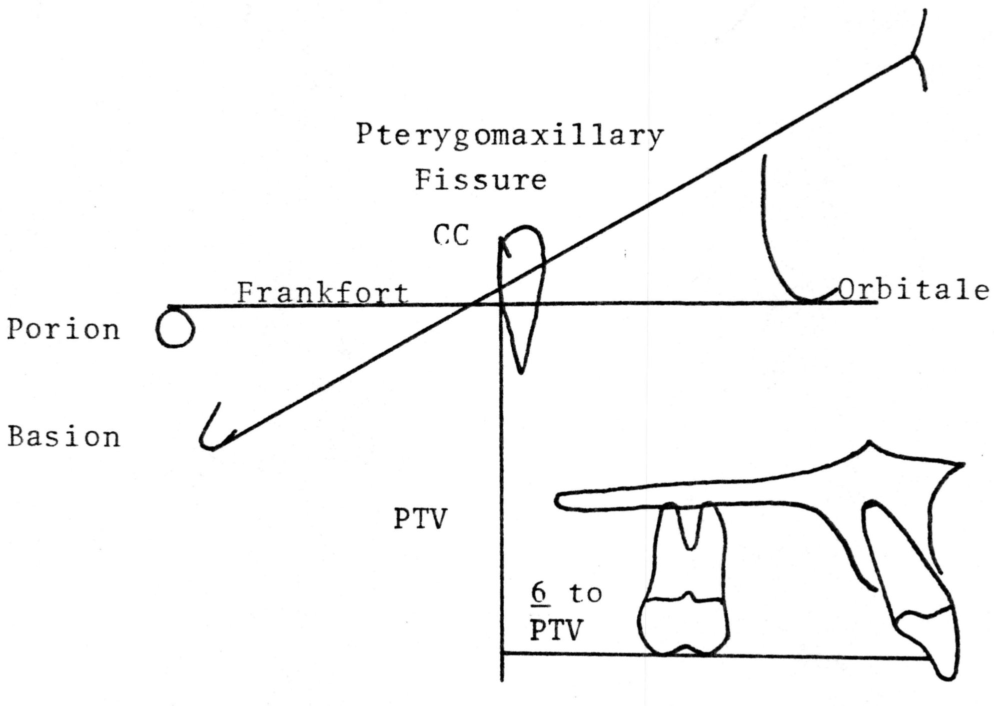

Fig. 3 Tracing Landmarks

Anchorage Loss Determination

6 to PTV was measured with a bow divider on the T_1 film and recorded in millimeters. If the patient is still growing during treatment (determined by comparing T_1 and T_{prog}), the initial 6 to PTV measurement is adjusted for growth by using the Rocky Mountain Data System norm of 6 to PTV increases 1 mm per year (Ricketts 1982). 6 to PTV is then measured on the T_{prog} film and anchorage loss is determined by the following formula:

Anchorage Loss =

$$(T_{prog}\ \underline{6} \text{ to PTV}) - [(T_1\ \underline{6} \text{ to PTV}) + \text{growth adjustment}]$$

Melson (1978) recognized that measurements of tooth position are more accurate with implant studies. This is because the implants move with growth and are thus a more accurate measure of growth changes. The use of 6 to PTV and adjusting for growth in growing patients is recognized as a limitation to the present study.

Facial Type

Facial Type for each patient was determined by establishing a VERT number which quantifies a vertical description of the patient (Frank 1981). The VERT number is established by taking the sum of the clinical deviations of the four following measurements:

1. Mandibular plane angle: measured to Frankfort horizontal.
2. Mandibular arc angle: the angle between the corpus and condylar axis.
3. Lower face height: the angle between a line from anterior nasal spine to the center of the ramus ("Xi" point) and a line from pogonion to "Xi" point.
4. Facial axis angle: the angle between facial axis plane and nasion-basion plane.

If the VERT number is greater than, or equal to, one, the patient is considered a brachyfacial pattern. If the VERT number is less than, or equal to, negative one, the patient is considered dolichofacial. If the VERT number is 0, the patient is considered mesofacial.

Angle Classification

Angle classification for each patient was determined from the T_1 plaster dental casts. Three classifications were used: 1) Class I molar, 2) End-on Class II molar, and 3) Full Class II Molar relation. Class III molar relation was not used.

Distance of Cuspid Retraction

The width of the first bicuspid was measured on the initial plaster casts and recorded as the distance the cuspid was to be retracted. High cuspid cases, where retraction distance was minimal, were not included in this study.

Palatal Angulation

The palate was traced from the cephalometric radiograph. A line was drawn on the tracing from the incisive papilla area to Frankfort horizontal tangent to the palatal angle. A high angle measure indicates a shallow palate, whereas a low angle indicates a high, steep palate (see Figure 4).

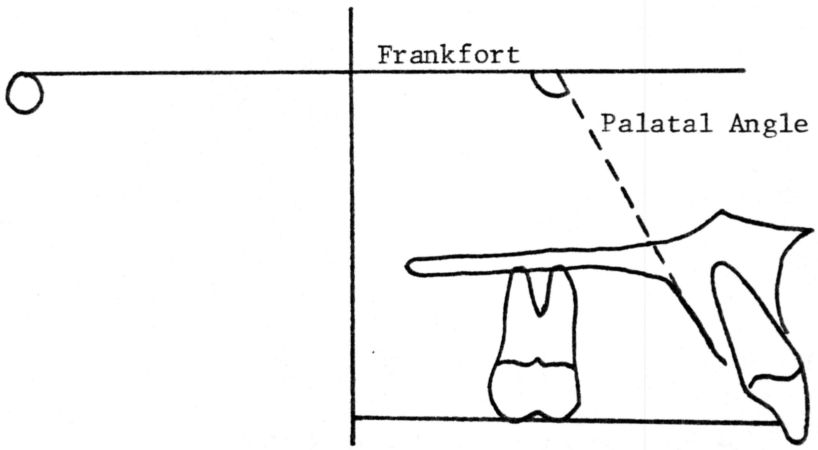

Fig. 4 Palatal Angle Measurement

Reliability Of Cephalometric Measurements

The reliability of measuring anchorage loss cephalometrically was tested by having a graduate orthodontic student, other than the principal researcher, trace the records of 10 patients selected via a random number table. A correlation coefficient of .90 or greater was expected to establish the reliability of this measuring technique.

Statistical Analysis

Analysis of variance (ANOVA) test was performed on the research data with molar anchorage loss as the dependent variable and group, Angle class, facial type, treatment length and distance of cuspid retraction as the independent variables.

Correlation coefficients were used in testing cephalometric tracing reliability. Correlation was also used to test the relationship between anchorage loss and palatal angle, anchorage loss and treatment length, and anchorage loss and retraction distance.

Paired t-tests were used to test the significance in anchorage loss on the three study groups: Nance, Headgear and Control.

RESULTS

Anchorage Loss By Group

TABLE 1

Summary of Anchorage Loss

Group	Population	Anchorage Loss Mean (mm)	Anchorage Loss Range (mm)	Combined Mean Anchorage Loss (mm)
Nance	Children n= 7	1.06	0-2.4	1.288
	Adults n=10	1.45	0-3.0	
Headgear	Children n= 4	1.00	-1.2-3.6	0.833
	Adults n= 2	0.50	0-1.0	
Control	Children n= 4	1.47	0.4-3.5	1.583
	Adults n= 2	1.80	1.5-2.1	

Table 1 is a summary of anchorage loss in the three study groups. Seventeen patients were treated with the Nance appliance (7 were growers and 10 were nongrowers). Mean anchorage loss (mesial movement of maxillary first molar) for the growers was 1.06 mm. The nongrowers showed

1.45 mm mean anchorage loss. Overall mean anchorage loss for the total Nance population was 1.288 mm. Anchorage loss ranged from 0 to 3.0 mm in the Nance group.

In the headgear population of 6, 4 were growers with a mean anchorage loss of 1.0 mm and 2 were nongrowers with a mean anchorage loss of 0.5 mm. Anchorage loss ranged from -1.2 mm to 3.6 mm. The upper molar moved distally 1.2 mm on one patient in this group.

Six patients were treated with no anchorage mechanics during cuspid retraction. Four were growers with a mean anchorage loss of 1.47 mm and two were nongrowers with 1.8 mm mean anchorage loss. Anchorage loss ranged from 0.4 mm to 3.5 mm in this group.

TABLE 2

Comparison of Anchorage Loss Between Nance Group and Control Group

Group	N	Mean Anchorage Loss (mm)	Standard Deviation	T	Significance
Nance	17	1.288	0.787	.732	NS
Control	6	1.583	1.004		

Table 2 is a comparison of anchorage loss between the Nance and Control groups. The t-test score of .732 shows that there is no significant difference in anchorage loss between the two populations.

TABLE 3

Comparison of Anchorage Loss Between Nance Group and Headgear Group

Group	N	Mean Anchorage Loss (mm)	Standard Deviation	T	Significance
Nance	17	1.288	0.787	.989	NS
Headgear	6	0.833	1.454		

Table 3 is a comparison of anchorage loss between the Nance and Headgear groups. The t-test score of .989 shows no significant difference in anchorage loss between these two groups.

Table 4, comparing Headgear and Control, shows no significant difference in mean anchorage loss between the two groups.

Thus the Headgear group showed the least overall mean anchorage loss and the Control group showed the greatest loss, but not statistically significant.

TABLE 4

Comparison of Anchorage Loss Between Headgear Group and Control Group

Group	N	Mean Anchorage Loss (mm)	Standard Deviation	T	Significance
Headgear	6	0.833	1.454	1.203	NS
Control	6	1.583	1.004		

Anchorage Loss By Angle Classification

TABLE 5

Comparison of Anchorage Loss by Angle Classification

Molar Class	N	Mean Anchorage Loss (mm)	Standard Deviation	F Ratio	Significance
Class I	11	1.65	1.92		
Class II End-On	12	0.96	1.49	1.856	0.184 NS
Class II Full	6	1.10	1.31		

Table 5 looks at one of the possible variables to anchorage loss: molar classification. Paulson and associates (1970) hypothesized that an initial Class I molar relation may aid in maxillary molar anchorage. The results of this study (Table 5) show the least anchorage loss in the Class II End-On sample (0.96 mm mean anchorage loss) and the greatest loss in the Class I sample (1.65 mm mean anchorage loss). Analysis of variance shows this difference not to be significant.

Anchorage Loss By Facial Type

TABLE 6

Comparison of Anchorage Loss by Facial Type

Facial Type	N	Mean Anchorage Loss (mm)	Standard Deviation	F Ratio	Significance
Brachyfacial	13	1.26	1.64		
Mesofacial	11	1.24	1.42	.20	0.821 NS
Dolichofacial	5	1.76	2.00		

Table 6 compares brachyfacial, mesofacial and dolichofacial patients by anchorage loss. Dolichofacial patterns resulted in the greatest anchorage loss (mean = 1.76 mm), while brachyfacial and mesofacial were almost identical (1.26 mm and 1.24 mm respectively). Statistical analysis of variance showed no significant difference in anchorage loss among the three facial types.

Anchorage Loss By Treatment Length

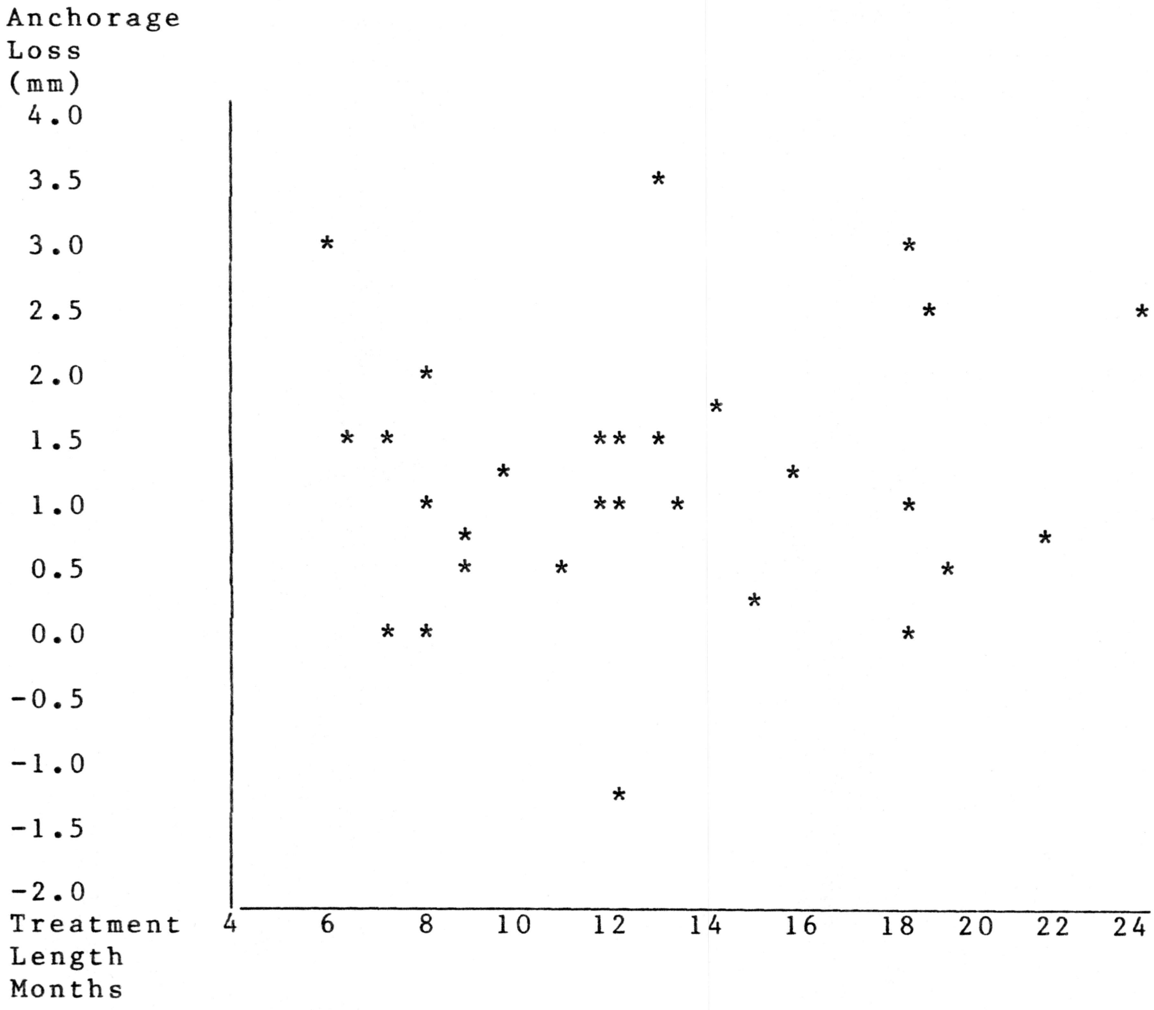

Fig. 5 - Scattergram of Anchorage Loss vs. Treatment Length

Cuspid retraction treatment time was recorded to determine if correlation exists with this variable. Figure 5 is a scattergram which plots anchorage loss on the y-axis to treatment length on the x-axis. The correlation coefficient of R=0.155 shows no correlation of treatment length and anchorage loss.

Anchorage Loss By Palatal Angle

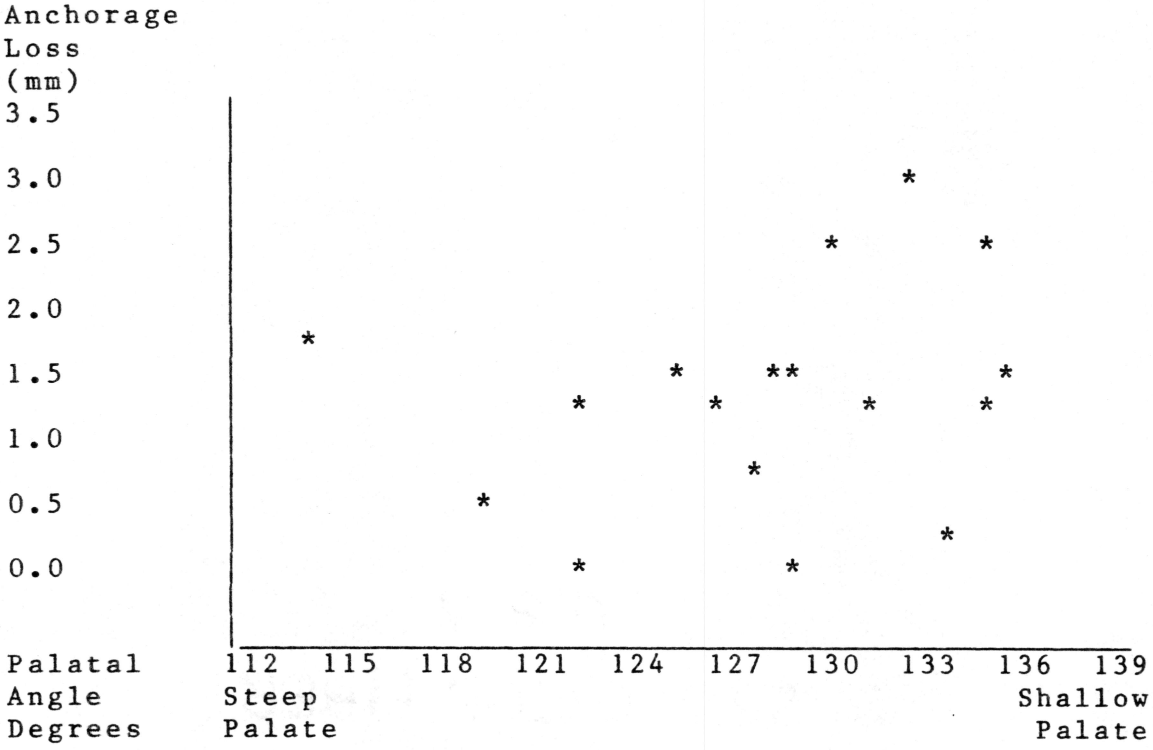

Fig. 6 - Scattergram of Anchorage Loss vs. Palatal Angle

It was hypothesized by the principal researcher, that the steepness of the palate would affect anchorage in the

Nance patients; that is, steep palates would provide greater anchorage than shallow palates. Figure 6 is a scattergram of the total Nance population (n=17): anchorage loss on the y-axis, palatal angle on the x-axis. As palatal angle increases, the palate is more shallow. The correlation coefficient of R=0.236 shows no correlation of palatal angle to anchorage loss.

Anchorage Loss By Extraction Distance

Extraction space ranged from 6.0 mm to 8.1 mm in the total sample population. Because of this very narrow range, the correlation coefficient was -0.17805 and thus was not significant.

Reliability of Cephalometric Measurements

Table 7 lists 10 patients selected by random number table. Anchorage Loss Column 1 represents this researcher's measure of anchorage loss, and Column 2 represents the results of a graduate orthodontic student's tracings. The third column records the difference. The correlation coefficient R=0.882 shows a highly linear relationship ($p<.01$).

Table 7

Reliability of Cephalometric Measurements

Patient I.D.	Anchorage Loss (mm)		Difference (mm)
	1	2	
3	0.80	1.00	-0.20
5	1.20	1.40	-0.20
8	0.25	0.50	-0.25
12	1.40	2.00	-0.60
18	1.60	1.10	0.50
19	2.40	2.60	-0.20
23	3.60	3.90	-0.30
25	1.10	0.00	1.10
30	2.10	1.80	0.30
32	1.00	0.00	1.00

DISCUSSION

The use of the Nance appliance has become popular among many clinicians for maxillary molar anchorage. Just as many, however, find its use unpredictable and thus unworkable. One main criticism voiced against the Nance is the frequency of burying the palatal acrylic button into the mucosa. In this study's sample of seventeen, there were no cases in which the acrylic button caused mucosal hyperplasia. Retraction forces, no doubt, are largely responsible for this hyperplasia, although, certainly the patients oral hygiene and overall systemic health could be contributing factors. With the use of sectional loop retractors, and with light continuous forces applied, palatal hyperplasia has been very minimal in this sample.

The inconvenience of fabricating the appliance to each individual is also a common criticism of the Nance. Extra chair time and lab time is involved. When the cuspids are retracted, the Nance is generally removed and Kloehn headgear is initiated for anchorage control during anterior retraction; thus, many find more practicality in using headgear for all anchorage needs.

Patient motivation becomes the key factor in anchorage control if the clinician chooses Kloehn headgear. The Nance appliance, conversely, being a fixed appliance, does not require patient cooperation. (One patient fitted with the Nance did show remarkable finesse at making it a removable appliance.) Key factors in using the Nance appliance would be care in retraction forces and oral hygiene motivation.

Anchorage Loss By Group

The primary null hypothesis of this study is that there is no difference in molar anchorage loss between patients treated with Nance appliance (maximum anchorage) and those treated with no anchorage mechanics (Control) during cuspid retraction. Table 2 shows that we accept this hypothesis because of a t-score of .732 which is not significant. Mean anchorage loss in the Control group (1.583 mm) was not significantly different than mean anchorage loss in the Nance group (1.288 mm). This is somewhat surprising, since greater mesial movement of the upper first molar and second bicuspid might be expected in the Control group. This is in contrast to Pritchard's (1972) study where cuspids were retracted with Pletcher t-springs on a continuous arch. His sample size was also six and he showed a mean molar forward drift of .44 mm/month. Normal cuspid retraction time being 6-8 months, this is approximately 3.0 to 3.5 mm anchorage loss; thus, approximately 46% of the extraction space in Pritchard's study was filled by the upper molar drifting forward. In the present study's control sample, approximately 17% of the extracted space was filled by mesial drift of the first molar. A larger sample size would be required before any definite conclusions are drawn. Certainly, greater mesial drift of the maxillary molar would be expected in a larger control group sample.

The Nance appliance and Kloehn headgear are compared in Table 3. The results of the t-score (.989) again show there is no statistically significant difference in anchorage loss with one or the other form of anchorage. Comparing the ranges of these two groups perhaps is helpful. (See Table 1) Range of anchorage loss for the Nance group is 0 mm to 3.0 mm. Headgear anchorage loss ranges from -1.2 mm to 3.6 mm. The patient showing -1.2 mm molar movement was reported to be an extremely cooperative patient; whereas the patient showing 3.6 mm anchorage loss was reported as a poor cooperator. A greater variability in anchorage loss is noted in the headgear group, although a sample size of 6 is not sufficient to make conclusive statements about.

Table 8 in the Appendix, Raw Nance Data, shows the amount of anchorage loss on every Nance patient. Five patients show anchorage loss of less than 1 mm. Nine patients show loss between 1 mm and 2 mm. Four patients show anchorage loss greater than 2 mm. Note that patient 01 was excluded from the study (3.6 mm anchorage loss). Data for this patient was significantly different on all statistical tests when included, so it was decided to exclude patient 01.

It is of interest to note the number of patients resulting in greater than 1 mm of anchorage loss. The Nance group showed 12 of the 18 patients, or 66%, with more than 1 mm anchorage loss. The Headgear group showed only 2 of the 6 patients, or 33%, with more than 1 mm anchorage loss. The Control group showed 5 of the 6 patients, or 83%, with more than 1 mm anchorage loss. These percentages, however, are not significant because of the small sample size.

With good headgear cooperation there is more potential for zero anchorage loss and even gaining anchorage as demonstrated by patient 21. (Table 9, Appendix).

Table 4 compares headgear patients to control and again the data is not significant to reject the null hypothesis. The Headgear sample shows the least mean anchorage loss (0.83 mm) while the Control group shows the most loss (1.58 mm). It should be noted that with small sample sizes in these two groups, one patient's results can significantly change mean values; thus definite conclusions are avoided. For example, if patient 21 had only held anchorage instead of gaining anchorage, the mean anchorge loss would have been 1.03 mm - much closer to the Nance mean.

Table 1 shows the three study groups subdivided into growers (children) and nongrowers (adults). It was felt that nongrowers would provide more accurate data measurments than growers since the growth adjustment factor could be eliminated for nongrowers. Mean anchorage loss for all growers was 1.17 mm and for nongrowers, mean anchorage loss was 1.25 mm. Thus we conclude that in our sample, there is no significant difference in anchorage loss between growers and nongrowers.

Angle Classification and Anchorage

Table 5 shows the results of initial molar Angle classification and its effect on anchorage. Class I patients showed the greatest loss (1.65 mm). Full Class II patients showed 1.10 mm anchorage loss, and End-on Class II patients showed the least anchorage loss (0.96 mm). If there is any anchorage control in locked in Class I molar relation as suggested by Paulson and associates (1970), this data does not support that hypothesis.

It is helpful to consider whether upper and lower first bicuspids, or just two upper bicuspids were extracted. In the Class I sample, all eleven patients had upper and lower first bicuspid extractions. Ten of the 12 Class II end-on sample had upper and lower first bicuspid extractions. The lower molar has a greater potential for anchorage loss when lower first bicuspids are extracted than if the mandibular arch is treated non extraction. This slipping of the lower molar may tax the anchorage of a locked in Class I molar relation by the forces of mastication. In Class II end-on molar relation, the inclined planes of opposing cusps do not lock in, thus leaving the lower molar free to slip without appreciably affecting the anchorage of the upper molar. This may explain why anchorage loss was least in the Class II end-on sample, and greatest in the Class I sample.

In the Class II Full sample, 4 of the 6 patients had only upper first bicuspids extracted with a mean anchorage loss of 1.63 mm. If locked in cusps do provide anchorage, this sample does not lead to that conclusion. More anchorage control would have been expected with the mandibular arch treated non extraction. Although the data in Table 5 is not statistically significant, it is the closest to being significant of all the data in this study. (F ratio 1.85, p=0.184.)

Note that the one patient showing anchorage gain (#21, Table 9), is in the End-on Class II group; whereas the patient showing the highest anchorage loss (#22, Table 9), had an initial Class I molar relation; thus, the sample size may have biased the results unexpectedly.

Occlusal forces and related facial type may be of importance in anchorage control and this aspect is discussed subsequently.

Facial Type and Anchorage Loss

The data, as represented in Table 6, shows no significant correlation between facial type and anchorage loss. More anchorage loss is postulated in dolichofacial patterns, and the present research shows a trend in that direction. Out of the total population of 29, only 5 are dolichofacial. Four of the 5 dolichofacial patients were Class I molar relation at T_1, with a mean anchorage loss of 1.8 mm.

Thirteen patients were classified as brachyfacial. Four out of 13 were Class I molar and showed a mean anchorage loss of 1.4 mm. Five of the 13 brachyfacials were Class II end-on and showed a mean anchorage loss of 0.64 mm. The remaining four brachyfacials were full Class II at T_1 and showed 1.16 mm mean anchorage loss.

Thus the trend is for more anchorage loss in the dolichofacial sample, and the least anchorage loss in brachyfacial patients with Class II-end on molar relationship.

Treatment Duration and Anchorage Loss

Treatment duration (T_1 to cuspid retraction) varied widely. Table 11 in the Appendix (Raw Data Summary) shows a range of 6 to 24 months with a mean treatment time of 12.48 months for the total population. Treatment times were generally longer for those patients treated by the graduate students, and proportionately shorter for those treated in private orthodontic offices.

The null hypothesis for this variable states there is no difference between treatment duration and anchorage loss. One might expect to reject this hypothesis and find greater anchorage loss with increasing treatment time. The longer a continuous cuspid retraction force is applied, the greater potential for slippage of the molar anchor unit. Figure 5 plots anchorage loss against treatment length and no correlation was found between the variables (R=0.155). Thus we accept the null hypothesis.

A possible future study might measure at what point, in the course of treatment, the majority of anchorage loss is achieved. Does most of it occur within 1-2 months? Does anchorage loss occur evenly over the entire treatment duration? Perhaps, in this study, the majority of anchorage loss occurred within the first 3 months with the molar being held during the remaining treatment time irregardless of how long it took. This hypothesis would be the subject of further study. In this study, duration of cuspid retraction forces made no significant difference in anchorage loss.

Another factor in the wide variability of cuspid retraction time is the individual differences in bone density. Although it was not in the scope of this research to measure bone density, the assumption is made that greater bone density is directly related to treatment time.

Whether or not the first bicuspid was extracted with the buccal plate of bone being left intact is another assumption of this study. Certainly a traumatic extraction site could unfavorably effect the ability to retract the cuspids.

Palatal Angle and Anchorage Loss

The Nance Holding Arch is constructed to fit snugly against the vault of the palate and provide anchorage to the maxillary posterior teeth. Most clinicians postulate greater anchorage capability in patients with steep, high palates. This argument would seem plausible since the acrylic button would be closer to a right angle to the 0.036 inch wire. One clinician expressed his opinion that greater anchorage control would be realized with shallow palates because of the potential for greater surface area coverage of the acrylic button.

Figure 6 shows that in this sample of 17 Nance patients, there is no correlation (R=0.236) between palatal angle and anchorage loss. There does appear to be a trend, however, that steep palates provided more anchorage.

A major limitation to this study is the variability in construction, placement and adjustment of the Nance. More valuable data would have been realized had one researcher placed and adjusted all appliances.

Extraction Distance and Anchorage Loss

The distance of cuspid retraction, and thus the time involved to do so, is thought to be a factor in anchorage control. The retraction distance, as measured by the width of the extracted first bicuspid, had a very narrow range: 6.0 mm to 8.1 mm (see Table 11, Appendix). Results show no correlation between anchorage loss and distance of cuspid retraction (R=-0.178).

Again one may hypothesize that the majority of anchorage loss occurs during the initial retraction phase after which anchorage is well established and little further anchorage loss occurs independent of cuspid retraction distance.

Reliability of Cephalometric Measurements

With the high degree of linear correlation (R=0.882) as reported in Table 7, the measuring of anchorage loss cephalometrically is accepted as a reliable, reproducable entity.

Limitations of the Study

One major limitation to this study is the use of multiple clinicians, each one given the freedom, within the bounds of the research design, to fabricate and activate the various appliances used in the study to his satisfaction. Nance appliances were not checked for standardization of palatal coverage and tissue engagement. Headgear activation was not measured on each patient, although 5 of the 6 headgear patients in this study were treated by one orthodontist.

Activation of the Hilger's retractors was not monitored. Retraction force was not a studied variable in this research; however, Boester and Johnston (1974) showed no significant relation between anchorage loss and retraction forces ranging from 2 oz to 11 oz.

Both elgiloy and stainless steel wire were used to fabricate cuspid retractors. The physical property differences between the two types of wire used were not considered and thus may be a limitation to the results of this study.

The use of cephalometric analysis and growth norms is a recognized limitation to this study. Based on treatment length, the 6 to PTV measurement was adjusted on growing patients according to Rocky Mountain Data System norms. No consideration was given, therefore, to the individual's rate of growth and maturation. An implant study would have provided greater value in accurately measuring anchorage loss.

Careful examination of all treatment records indicated that four of the Nance patients (I.D.#'s 5, 8, 15, 18) had maxillary utility arches placed during cuspid retraction, even though this treatment design was not indicated. Mean anchorage loss in the Nance sample increased 0.1 mm (from 1.288 mm to 1.388 mm) when these four patients were excluded. The increase in anchorage loss is thus insignificant, and it does not change any of the results and conclusions of the study.

SUMMARY AND CONCLUSIONS

Thirty orthodontic patients, ages 9 through adult, were evaluated for molar anchorage loss during cuspid retraction. Treatment for all patients consisted of first bicuspid extraction and cuspid retraction with Hilgers loop retractors.

Eighteen patients had the Nance Holding Arch placed to evaluate anchorage control. This was compared to 6 patients fitted with Kloehn cervical headgear. A third group of 6 patients provided a control sample, and received no anchorage mechanics during cuspid retraction. Anchorage loss was measured cephalometrically by comparing molar position on initial and post retraction lateral head films.

Results of statistical analysis led to the following conclusions:

1. No significant difference was found in anchorage loss between the Nance and the Control groups.
2. There was no significant difference in anchorage loss between the Nance and the Headgear groups.
3. No significant difference was demonstrated in anchorage loss between the Headgear and the Contol groups.

4. With good headgear cooperation, there is more potential for minimal anchorage loss than with the Nance Holding Arch.
5. Initial Class I molar relationship demonstrated the most anchorage loss whereas and initial Class II end-on molar relationship showed the least anchorage loss. This difference was not significant statistically.
6. Brachyfacial patients had less anchorage loss than dolichofacial patients; however, the difference was not significant.
7. Steeper palates tend to provide greater anchorage control for the Nance appliance than shallow palates. This difference was not significant statistically.
8. No correlation exists between treatment duration (T_1 to cuspid retraction) and anchorage loss.
9. Growing patients were not significantly different in anchorage loss from nongrowers.
10. Acetate tracings of upper molar position can be reliably reproduced.

In the final analysis, whether one chooses to use a Nance or Headgear for anchorage will continue to depend largely on the personal preference of the orthodontist. The data presented in this study does not favor one over the other. The ease of fitting a custom Kloehn headgear may make it preferable over the fabrication of an individualized Nance appliance when good patient cooperation is reasonably certain. If the orthodontist requires the assurance of full time anchorage and is uncertain of patient cooperation, then a Nance will work equally well, provided cuspid retraction forces are not heavy enough to bury the appliance in the palate.

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APPENDIX

TABLE 8

Raw Data Nance Group

Patient I.D.	Sex	Age T_1	Treatment Length (months)	Angle Class	Facial Type	VERT	Extraction Space (mm)	Palatal Angle (Degrees)	T_1 6 to PTV (mm)	Growth Factor (mm)	Adjusted 6 to PTV (mm)	T_{prog} 6 to PTV (mm)	Anchorage Loss (mm)
01	M	14-1	13	I	Meso	0	8.0	119	17.9	1.10	19.0	22.5	3.60
02	M	14-11	9	II Full	Meso	0	8.0	120	21.2	0.75	21.95	22.4	0.45
03	M	19-10	8	I	Dolicho	-2	7.5	128	23.2	0	23.2	24.0	0.80
04	F	20-0	16	I	Dolicho	-4	7.5	123	13.6	0	13.6	14.9	1.30
05	F	15-10	9	I	Meso	0	7.0	132	20.0	0	20.0	21.2	1.20
06	F	13-6	22	II End On	Meso	0	7.0	127	14.0	1.83	15.8	17.0	1.20
07	M	13-9	14	I	Meso	0	7.5	114	14.0	1.20	15.2	16.9	1.70
08	M	13-2	15	II Full	Brachy	+6	7.5	134	18.5	1.25	19.75	20.0	0.25
09	F	14-10	7	II End On	Meso	0	6.0	126	17.8	0	17.8	19.2	1.40
10	F	13-9	6	I	Brachy	+1	7.1	133	19.0	0	19.0	22.0	3.00
11	F	11-5	6	I	Brachy	+1	8.0	136	23.0	0.5	23.5	24.9	1.40
12	F	36-10	8	I	Brachy	+3	7.6	129	23.5	0	23.5	23.5	0.00
13	F	25-2	12	II Full	Meso	0	7.0	129	18.2	0	18.2	19.7	1.50
14	M	17-1	10	I	Brachy	+2	7.6	135	12.8	0	12.8	14.0	1.20
15	F	10-5	18	II End On	Brachy	+2	8.0	122	16.0	1.5	17.5	17.5	0
16	F	27-1	24	I	Meso	0	7.5	130	22.0	0	22.0	24.5	2.50
17	M	17-9	12	II End On	Dolicho	-3	7.0	128	16.5	0	16.5	18.1	1.60
18	F	11-9	19	II Full	Brachy	+2	6.5	134	13.0	1.6	14.6	17.0	2.40

TABLE 9

Raw Data Headgear Group

Patient I.D.	Sex	Age T_1	Treatment Length (months)	Angle Class	Facial Type	VERT	Extraction Space (mm)	Palatal Angle (Degrees)	T_1 $\underline{6}$ to PTV (mm)	Growth Factor (mm)	Adjusted $\underline{6}$ to PTV (mm)	T_{prog} $\underline{6}$ to PTV (mm)	Anchorage Loss (mm)
19	F	31-7	7	II End On	Meso	0	7.5		19.5	0	19.5	19.5	0.00
20	F	10-1	11	II End On	Meso	0	7.0		15.5	1.0	16.5	17.0	0.50
21	M	12-0	12	II End On	Brachy	+2	7.8		12.8	1.0	13.8	12.6	-1.20
22	F	11-7	13	I	Dolicho	-1	8.1		18.4	1.1	19.5	23.1	3.60
23	M	29-1	12	II Full	Brachy	+2	7.8		25.0	0	25.0	26.0	1.00
24	M	11-5	13	II End On	Meso	0	7.9		12.8	1.1	13.9	15.0	1.10

TABLE 10

Raw Data Control Group

Patient I.D.	Sex	Age T_1	Treatment Length (months)	Angle Class	Facial Type	VERT	Extraction Space (mm)	Palatal Angle (Degrees)	T_1 6 to PTV (mm)	Growth Factor (mm)	Adjusted 6 to PTV (mm)	T_{prog} 6 to PTV (mm)	Anchorage Loss (mm)
25	F	12-0	19	II End On	Brachy	+1	8.0		10.5	1.6	12.1	12.5	0.40
26	M	11-7	18	II End On	Brachy	+2	7.8		14.9	1.5	16.4	19.4	3.00
27	F	11-8	12	II Full	Brachy	+2	8.0		18.2	1.0	19.2	20.2	1.00
28	F	12-6	8	II End On	Meso	0	7.3		18.8	0	18.8	20.9	2.10
29	F	28-2	13	I	Dolicho	-1	7.1		26.0	0	26.0	27.5	1.50
30	F	13-0	18	II End On	Brachy	+7	7.5		17.0	1.5	18.5	19.5	1.00

TABLE 11

Raw Data Summary

Group	Growth Category	Age (years)		Treatment Duration (mo)		Retraction Distance (mm)		Palatal Angle (degrees)		Anchorage Loss (mm)		Combined Anchorage Loss (mm)
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
Nance n=17	Children n= 7	12.70	10.40-14.90	14.70	6-22	7.50	6.5-8.0	126.7	114-136	1.06	0.0-2.4	1.288
	Adults n=10	20.66	13.75-36.83	11.20	6-24	7.80	6.0-7.6	129.3	123-135	1.45	0.0-3.0	
Headgear n= 6	Children n= 4	11.27	10.10-12.00	12.25	11-13	7.90	7.0-8.1			1.00	-1.2-3.6	0.833
	Adults n= 2	30.33	29.10-31.70	9.50	7-12	7.65	7.5-7.8			0.50	0.0-1.0	
Control n= 6	Children n= 4	12.02	11.70-13.00	16.75	12-19	7.90	7.5-8.0			1.47	0.4-3.5	1.583
	Adults n= 2	20.33	12.60-28.20	10.50	8-13	7.20	7.1-7.3			1.80	1.5-2.1	