AN IMPLANT STUDY OF THE EFFECT OF
CERVICAL TRACTION

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INTRODUCTION

One of the most commonly used of extraoral appliances consists of a face bow which applies pressure to the maxillary first molars from a cervical strap passing around the back of the neck. The most frequently used appliance is referred to as the Kloehn type cervical traction.

Besides a primary distal action on the maxillary first molars there are other force vectors. Among these it has been theorized that the action which would tend to extrude the maxillary molar causes an opening of the bite. This should in turn cause an increase in the angle which the mandible makes with the Frankfort-Horizontal plane.

It is the object of this investigation to study, by the use of metallic implants, the effects of Kloehn cervical traction with regards to distal positioning and elongation of the maxillary first molar and changes in the Frankfort Mandibular Plane Angle. The implants were used to overcome instability of bon y surfaces due to resorption and deposition. This approach also permits testing of the hypothesis that extraoral force exerts an influence in the direction of growth of the maxillary complex.

REVIEW OF THE LITERATURE

Kloehn[1] improved and reintroduced the employment of the double face bow with cervical traction as extraoral anchorage for the correction of Class II malocclusions by attempting to "stop this forward growth of the maxillary teeth and alveolar process until the normal forward growth of the mandible has advanced sufficiently for normal relationship of the teeth..."

A force diagram of this type of device (Figure 1) illustrates the vectors of force acting upon the maxillary first molar to which it is attached by means of bands equipped with round tubes and cemented to the teeth.

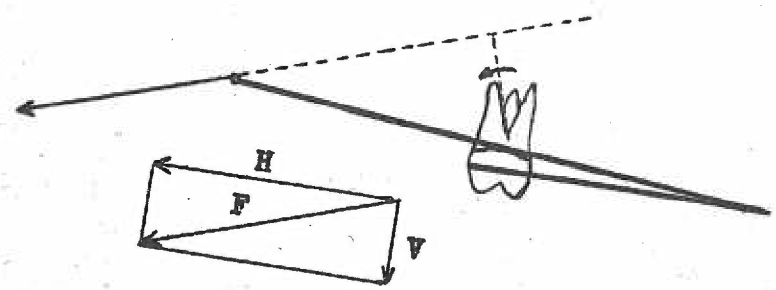

Figure 1. Force diagram. The retangular vector diagram shows linear forces acting on the molar. Lengths of the three arrows are proportional to the respective forces, indicating the relative horizontal and vertical components acting on the tooth. (From Thurow, R.C.: Edgewise Orthodontics, ed.2, St. Louis, 1966, The C.V. Mosby Co.)

It is because of the vertical component of force that Wieslander[2], Poulton[3], Sandusky[4], Shudy[5] and others believe there is a tendency for the maxillary first molars to be extruded by the pull of the Kloehn type cervical traction.

Since Moore[6] states "There is continual growth of the alveolar process as well as eruption of the maxillary denture in a downward direction" and Björk[7] "As a rule the direction of eruption of the teeth is predominantly vertical" we have the problem of differentiating an extrusion of the maxillary first molar from the normal maxillary growth pattern, the growth of the alveolus and the normal eruption of the maxillary dentition. Compounding the problem is the whole problem of facial growth patterns of individuals where variation rather than constancy is the rule.[6]

As previously stated the arguement that maxillary extrusion occurs means an increase in the Frankfort Mandibular Plane Angle. The objection cited is that this vertical component causes a vertical or posterior movement of menton. This is considered an undesirable treatment effect which does not maximize the normal forward growth of the mandible in treatment of Class II Division 1 malocclusion. This is said to occur particulary in those patients with a steep original Frankfort Mandibular Plane Angle.[5,8]

Bergersen[9] observed in his facial growth studies that it was not possible to predict growth directions from the mandibular plane angle at a young age (approximately six years of age and under) but "At the older ages a steep inclination of the mandibular plane is associated with a steep growth direction of menton and conversely." He also further observed "of the individual patterns of growth-progression of menton, it becomes obvious that growth of the mandible in most cases (80%) does not strictly progress on a straight line. In 72% of the individuals of this study, the growth at menton occured in a "wave-like" manner with alternating vertically and horizontally-inclined direction... Each individual wave of each cycle lasted on an average of three and one half years, and occurred with equal frequency at all age levels."

Klein[10] in a study of twenty four patients with Class II malocclusions, average age eight years six months, treated with Kloehn cervical anchorage found that the maxillary first molar was moved distally an average of 1 mm and was elongated 2.3 mm from the palatal plane. He found a strong correlation of elongation of the maxillary first molar and growth on the Y axsis and believed that growth permitted the molar to erupt. He concluded that "The findings strongly suggest that elongation would occur in most cases only if growth of the mandible occured during treatment."

Ricketts[11] studied the influence of orthodontic treatment in 1960. In thirty three patients with untreated Class I malocclusions he found the maxillary first molar moved forward 3.5 mm while the mandibular plane angle decreased $.5^{o}$. In fifty patients with untreated Class II malocclusions he found the maxillary first molar moved forward 2.0 mm while the mandibular plane angle decreased $.6^{o}$.

In fifty patients with Class II malocclusions treated with cervical traction he found the maxillary molar first moved posteriorly 1.3 mm while the mandibular plane angle increased .5°. In fifty patients with Class II malocclusions treated with intermaxillary elastics he found the maxillary first molar moved forward 1.3 mm while the mandibular plane angle increased .5°. In fifty patients with Class II malocclusions treated with both cervical traction and intermaxillary elastics he found the maxillary first molar moved forward 1.2 mm while the mandibular plane angle decreased more than that of the untreated groups.

He also observed that in all patients, low mandibular plane angles tended to become lower while high mandibular angles tended to remain so or increase and the palatal plane remained the same or tipped downward anteriorly.

Wieslander[(2)] used sixty paired subjects having Class II malocclusions with one half treated by cervical traction and the other half an untreated control group. He found the maxillary first molar elongated 1.30 mm more in the cervical traction group than the untreated when measured from Frankfort-Horizontal but found no difference in the mandibular plane angle. He observed that "The mandibular condyle showed a significantly greater change inferiorly in the headgear group than in the control group. Subsequently, there was no increase in the mandibular plane angle. The same was true for pogonion, which actually seemed to move slightly more forward in the treated group." He also found a tipping of the palatal plane downward anteriorly.

Poulton[3] compared individual headgear cases with means of untreated cases. He showed a slight slow increase in the mandibular plane angle of 1^{o} in the treatment group over a period of three years.

Sandusky[4] studied two groups of treated patients, twenty in each group. All were Class II, Division 1 malocclusion and both groups were treated according to the principles of Tweed; however, one group was treated with Kloehn type cervical traction for a period of 13.20 months before Tweed-edgewise treatment was begun. He reported mean extrusion of the maxillary first molar in the Kloehn type cervical traction group of 1.185 mm measured from the palatal plane while in the Tweed-edgewise only group the molar was extruded a mean of 1.955 mm. According to his interpretation, "This showed a tendency for the maxillary first molars to be extruded by the pull of the Kloehn arch with cervical anchorage." (sic)

The mandibular plane angle increased 0.075 degree during Kloehn type of therapy in that group and then decreased 0.075 degree during the Tweed-edgewise mechanics yielding no mean net change. In the Tweed-edgewise only group, the mandibular plane angle increased 0.02 degree. (!) When the patients in each group were divided further into a lower age group (those below twelve years of age) and an older age group (those above twelve years of age) he found in those treated with Kloehn type of therapy in the lower age group had a mean net decrease in the mandibular plane angle of 0.233 degree, while the older group had an increase of 1.00 degree which decreased to a mean net increase of 0.40 degree after Tweed-edgewise treatment. The older group treated

Tweed-edgewise only had a mean mandibular plane angle increase of 0.71 degree.

He also found that the palatal plane (ANS-PNS) descended more anteriorly than posteriorly in each of the two groups.

Björk[7] observed that "The nasal floor is lowered through resorption together with periosteal apposition on the hard palate, and the anterior nasal spine is likewise lowered through resorptive remodelling... It is obvious that the nasal line through the floor of the nose cannot serve as a reference for analysis of the maxillary growth pattern or of the eruption of the teeth."

Hixon[12] expands these observations, "Thus, without implants the orthodontist must temper longitudinal findings with the knowledge that absolutely stable reference planes are probably nonexistent."

MATERIALS AND METHOD

The material for this study was obtained from the Graduate Orthodontic Clinic of the University of Oregon Dental School. In 1965 this clinic began placing metallic implants after the manner of Björk(13) in all patients accepted for treatment. Cases used in this study were selected from the sixty six patients implanted the first year.

A total of eight patients (six females and two males) were selected in which treatment in the maxillary arch consisted only of Kloehn type cervical traction. Their average age was 10.9 years at beginning of treatment and seven patients presented Class II, Division 1 malocclusion while one presented a Class I malocclusion. Cervical traction had been used for an average of 10.1 months and during this time had been worn a reported average of 12 hours each day. In six of the cases there was no treatment in the mandibular arch while in the remaining two, treatment in the mandibular arch had been of short duration and consisted of banding and leveling only.

A second group was selected in which no extra oral traction of any type had been used as a treatment control group (four females and two males.) These consisted of two patients with Class I malocclusion, three patients with Class II, Division 1 malocclusion, and one patient with Class III malocclusion. Their average age was 12.5 years at beginning of treatment and they had been under various stages of treatment for an average of 13.0 months.

Pretreatment and progress lateral head films were taken of both groups and were traced on cephalometric tracing acetate. The center of the position of each implant was marked on the acetate. Implant positions of the acetate tracings were numbered consecutively from one to six (Figure 2.)

The maxillary first molar and the mandibular first molar on the side nearest the film were traced, taking advantage of any restorations, bands, etc., that might provide landmarks for superimposition. Then the two tracings were superimposed on the maxillary first molar using the traced outline and any of the above landmarks and a pin was pushed through both tracing acetate sheets through the geometric center of the coronal portion of the maxillary first molar. By rubbing lightly over the immediate area with pencil lead a small dot would be left which was used in marking molar position. The same procedure was then used by superimposing the mandibular first molar and marking its position on both sheets at the same time. Measurements of molar position were made from these markings without regard to the angulation of these teeth.

On each of the tracings the cranial base (S-N), the mandibular plane and the palatal plane (ANS-PNS) were constructed.

On the tracing of the pretreatment lateral head films the Frankfort-Horizontal plane was constructed. To facilitate description of positional change the Frankfort line was used as a reference. This was accomplished by drawing a line parallel to Frankfort-Horizontal through sella, labeled on Figure 2 as FH-TS, and another line perpendicular to the above line was constructed through sella, labeled on Figure 2 as the P line.

The tracing of the progress lateral head film was then superimposed on the tracing of the pretreatment lateral head film on the cranial base (S-N) with registration on sella. At this time linear measurements were made using a Boley gauge and recording the difference is position to a landmark measured in a vertical direction from the line parallel to F H constructed through sella, FH-TS, and also in an anterior direction from the line perpendicular to the above line and drawn through sella, the P line (Table I).

Angular measurements were made recording the original angle and the difference between planes on the two tracings. At this time a line was constructed through the marks representing the middle implant of both the maxilla and the mandible and its angle to the constructed line parallel to Frankfort-Horizontal plane was measured and recorded as representing the path of the implant which "has been taken as a general expression of the direction of sutural growth of the upper face in the sagittal plane. The error of the method is comparatively large; on the basis of repeated measurements it has been put at $\pm 5^{\circ}$."[7]

After the above measurements had been made, the tracings were superimposed first on the marks representing the maxillary implants and then those representing the mandibular implants. Using the same base lines on the pretreatment tracing (FH-TS and P), the difference in position of the respective molars was measured again in a vertical and anterior direction. The change in the palatal plane (ANS-PNS) and the mandibular plane were also recorded as the registration was made on their respective nearby implants.

After all data had been recorded for each group the means, mean net changes, and standard deviations were determined for each set of measurements. The mean net changes of the Kloehn cervical traction group and the control group were tested for significance of difference using "t" tests within the 95 percentile range (alpha equals .05), and those which were significant marked on the Tables.

Reduction of error inherent in all cephalometric measurements was attempted by careful attention to each step in tracing and measuring. All lateral head films were taken on the same machine with constant machine-mid-sagittal plane and mid-sagittal plane-film distances. No correction was made for enlargement as it would be constant in all instances. For the same reason correction for distortion was not made for structures not lying in the same sagittal plane, as implants and first molars in the side of the cranium nearest the film were used in all instances. Differences in the distance of the measuring points from the constructed planes were used rather than total distances. It was felt that in most instances the individual growth and/or treatment changes are much larger than the measurement errors. Further such unavoidable errors would be randomly distributed around group means.

FINDINGS

The Kloehn type cervical traction obviously moves the maxillary first molar distally as seen in Table I and Figures 2 and 3 and there is some evidence that it may influence the position of the maxilla.

When superimposed on the cranial base (Figure 2) there were significant differences in an anterior direction in the mean linear movements of maxillary implants numbers two and three and the maxillary first molar demonstrating the effects of the distal force vector of the cervical traction. Although the mean difference anteriorly of implant number one was of approximately the same magnitude as the others in the cervical traction group it was not significantly different from the control group. This is possibly because of the change in the palatal plane in a downward direction anteriorly and because of the increased variation in locating the implant probably due to measurement error.

There was no significant difference in a vertical direction between the maxillary first molars between the two groups although a significant difference was found in a vertical direction in the mean linear movements of all the maxillary implants. The greater linear distance downward of the implants in the cervical traction group may be partly because of the change in the palatal plane since it changed in a downward direction anteriorly a mean of 1.3 degrees in the cervical traction group and 0.3 degree in the control group.

Although the difference was not significant stastically it could be significantly different when translated into linear measurements.

There was an apparent difference in the growth pattern of the maxilla as designated by the angle of the maxillary implant path but it was not found significant when "t" tested due particularly to the large standard deviation of the control group. Perhaps the important point in this statistic is the apparent reduction in the proportion of the standard deviation to the mean which gives an impression that cervical traction tends to reduce the large variation in direction of maxillary growth.

When superimposed on the cranial base there were no differences in implant movement in the mandible. Changes in the Frankfort-Mandibular Plane Angle of -0.2 degree in the cervical traction group and 0.4 degree in the control group were not significant nor was there any meaningful difference in the angle of the implant path in either group (Figure 2).

When superimposition was made on the maxillary implants (Figure 3) there was also a significant difference in the maxillary first molar anterior position illustrating that the distal force vector affects both the maxillary bone and the first molar's position in that bone.

Again on the implants there was no significant difference in a vertical direction between the maxillary first molars although it is interesting to note that in the control group the difference between the maxillary molar mean change and the maxillary implants mean change is greater than that in the cervical traction group showing more eruption of the molar in the control group though this difference is not significant. The mean change for the palatal plane is now the same in both groups.

There was no vertical change of the mandibular first molar when superimposition was on the mandibular implants. The movement in an anterior direction of this molar in the control group was considered the result of treatment (extraction) and is of no significance in this study. The changes in the mandibular plane angle, although not significantly different, showed an opposite trend to that when superimposition was on the cranial base which might be explained by remodeling action on the lower border of the mandible.

Table I. LINEAR MEASUREMENTS

Change in millimeters of landmarks with head films superimposed on S-N and registered on sella.*

	ANTERIOR DIRECTION				VERTICAL DIRECTION			
	Headgear		Control		Headgear		Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<u>Maxillary</u>								
Implant #1	-.6	1.1	.2	.8	.9^{x}	.5	.4	.4
Implant #2	-.6^{x}	.8	.5	.7	1.0^{x}	.5	.4	.4
Implant #3	-.9^{x}	1.1	.4	.9	1.0^{x}	.3	.3	.5
First Molar	-1.3^{x}	2.2	1.9	1.6	2.2	1.4	2.0	.4
PTM	.1	.3	.4	.7				
<u>Mandibular</u>								
First Molar	.6^{x}	1.1	3.1	2.1	2.5	1.4	1.8	1.2
Implant #4	-.4	.7	.2	1.4	2.4	.6	2.1	1.2
Implant #5	.5	1.4	.3	1.3	2.4	1.0	2.2	.5
Implant #6	1.1	1.2	.5	2.0	2.2	1.2	2.3	.5

Change in millimeters with head films superimposed on maxillary implants.*

Maxillary First Molar	-.6^{x}	1.6	1.3	.9	1.1	1.2	1.9	.8

Change in millimeters with head films superimposed on mandibular implants.**

Mandibular First Molar	.3^{x}	.8	3.3	1.6	0.0	.8	.2	1.0

* Positive values represent either downward or forward movement.
** Positive values represent either eruption of teeth or forward movement.
^{x} Significant difference.

Table II. ANGULAR MEASUREMENTS

Degrees from Frankfort Horizontal with head films superimposed on S-N and registered on sella.*

	HEADGEAR		CONTROL	
	Mean	SD	Mean	SD
Maxillary implant path	112.8	34.6	70.3	55.8
Mandibular implant path	83.0	23.6	90.5	30.9
Original difference S-N to FH	7.4	4.5	5.5	4.1
Original Frankfort-Mandibular Plane Angle	26.4	6.6	35.3	6.9
Change in Frankfort-Mandibular Plane Angle	-.2	1.1	.4	1.1
Change in Palatal Plane (ANS-PNS)	1.3	1.8	.3	1.2
*Change in degrees with head films superimposed on maxillary implants.**				
Change in Palatal Plane (ANS-PNS)	1.1	2.5	1.2	1.6
*Change in degrees with head films superimposed on Mandibular implants.**				
Change in Frankfort-Mandibular Plane Angle	1.4	.6	.9	1.6

* Positive values represent either downward or forward movement.
x Significant difference.

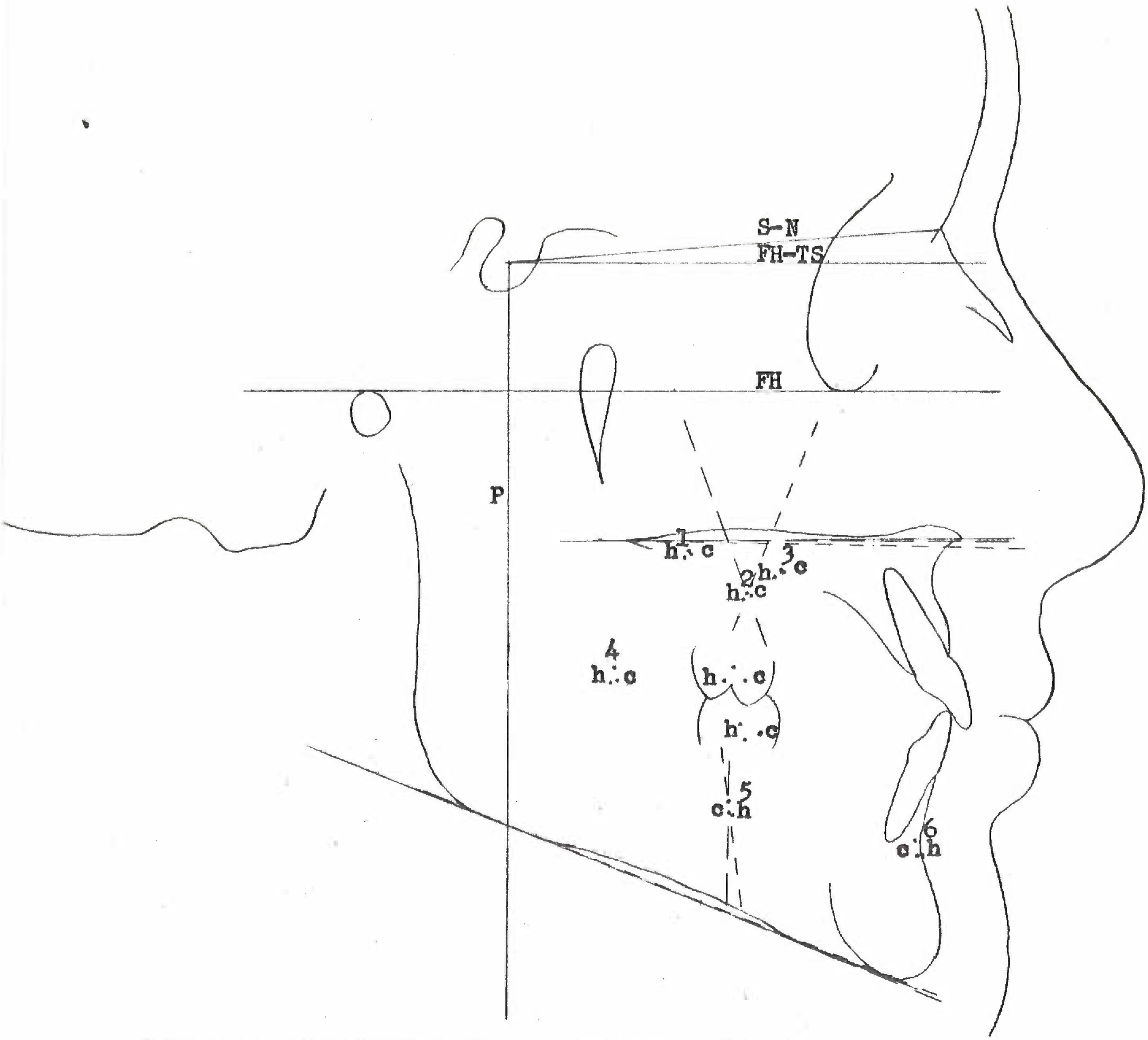

Figure 2. Superimposed on the Cranial Base (S-N).

Cervical traction - h ------------
Control - c ------------

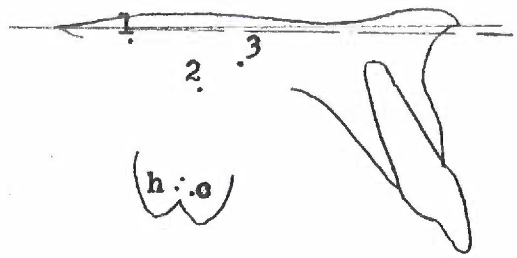

Figure 3. Superimposed on Maxillary Implants.

Cervical traction - h ----------
Control - c — — — — — — —

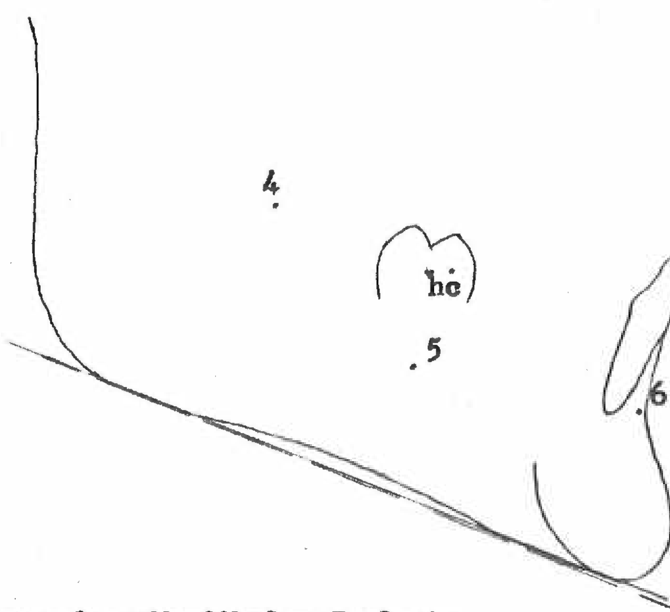

Figure 4. Superimposed on Mandibular Implants

SUMMARY AND CONCLUSIONS

The influence of cervical traction in this small sample of implanted patients not only effected the position of the maxillary first molar but also appeared to exert a measure of control over the maxilla itself. No effect was noted upon the mandible.

1. In an anterior direction there was a significant maxillary difference between groups. With superimpostion on the cranial base, the implants in the control group moved slightly forward while those in the cervical traction group moved slightly backward. The difference was only about 1 mm but this was significant in two out of three implants. Implant superimposition showed that the maxillary molar was not only positioned distally with the maxilla but also distally in the maxilla.

2. In a vertical direction all the implants in the cervical traction group moved downward about 0.5 mm more than those of the control group which was a stastically significant difference although this difference was not reflected in the maxillary first molars which were found to be essentially the same. This lack of extrusion of the first molar during treatment with cervical traction gives credence to the idea of muscular balance of the muscles of mastication. This tends to maintain the mandible and maxilla in the same vertical relationship, resisting those factors which would alter this relationship by elongation or other disturbance of the muscular balance.

3. There was no significant difference between groups in the change of the palatal plane (ANS-PNS). It was thought that the angular

difference when superimposed on the cranial base would account partially for the significant difference of the maxillary implants if translated into linear measurements. This was confirmed by superimposition of the maxilla on the implants, as the mean palatal plane changes were the same showing a tipping rather than an extrusion of the maxilla.

4. There was an apparent though not statistically significant difference in the direction of maxillary growth as exhibited by the difference in maxillary implant paths. The reduction of the proportion of the standard devation to the mean in the cervical traction group also illustrates more control in growth.

5. In the mandible there was no significant difference in any of either linear mean changes or angular mean changes between the two groups in relation to the cranial base. Changes in tooth position relative to the implants in the control group are the result of treatment (extraction) in which the mandibular first molar moved mesially.

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