The Mandibular Dental Arch: Part II Effects of Lower Incisor Position on the Soft Tissue Profile

ROBERT J. SCHULHOF, A.B., M.A.
ROGER H. ZIERENBERG, D.D.S., M.S.
ROLAND D. WALTERS, D.D.S., M.S.

The purpose of this paper is to examine the questions: 1) what methods are available for positioning the lower incisors for the purpose of achieving optimum esthetic results and 2) how often will methods of determining incisor "ideal" conflict, i.e., will any one reference line serve all three purposes (function, stability, and esthetics)?

Since successful methods of predicting soft tissue relationship as a function of tooth movement have not been tested, a comparison of the methods proposed by Ricketts and Holdaway will be presented.

Riedel[4] has shown a relationship between the lower lip and the esthetic plane. Different groups of people were asked to examine profiles and determine which they approved of and which they did not. Those with lips falling just behind the esthetic plane registered the most pleasure from the majority.

Holdaway[3] has determined the harmony line. He has also found the relationship between the patient's lips and the harmony line to be of esthetic significance.

Although the esthetic plane of Ricketts[5] and the harmony line are currently being utilized for esthetic evaluation, for diagnosis to be useful there has to be a reliable method of predicting the effect of the ultimate position of the dentition in the soft tissue profile.

For the purpose of determining the soft tissue prediction accuracy of the Holdaway and Ricketts methods, Zierenberg[6] conducted a study at Loma Linda University using a sample of 40 patients from the Project Stability files.

Holdaway recognized the need for including soft tissue analysis along with hard tissue analysis in making a diagnosis. He contends that, in the unstrained upper lip, the thickness of the soft tissue at point A should be within one mm of the distance from the labial surface of the upper incisor to the vermilion border of the upper lip (Fig. 1). In cases where lip strain exists, i.e., soft tissue thinner at upper incisor to the vermilion at point A, the upper lip will not follow the maxillary incisor back until all lip strain has been removed. Once removed, the lip will then follow further incisor retraction back at a one-to-one ratio.

The Holdaway method for the lower lip is based upon the posttreatment lip falling within one mm of a line (H-line) drawn from the unstrained soft tissue chin to the vermilion border of the posttreatment upper lip.

Ricketts offers a rule of thumb that, as the upper incisor is retracted, the upper lip will follow it back two thirds of the amount retracted, and will thicken the remaining one third (Fig. 2). For the lower lip the Ricketts method of determining its posttreatment location involves bisecting a line drawn from the tips of the upper and lower incisors (this point of bisection is referred to as the interincisal point on the pretreatment cephalometric tracing). The dis-

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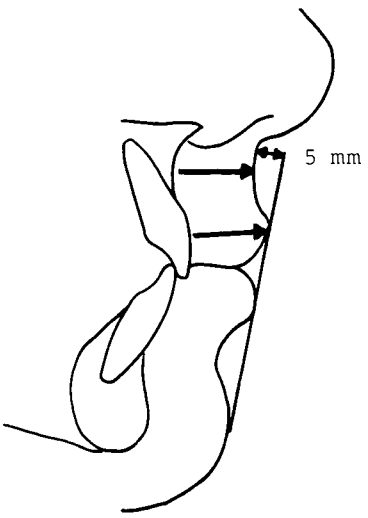

Fig. 1 *Holdaway Harmony Line.* This analysis represents a balance between the perioral musculature and the tooth positions. The lips should be relaxed, with an even distribution of soft tissue comparing the thickness at soft tissue A and the vermilion border. There should be a distance of 5 mm (±2) from soft tissue A to the harmony line.

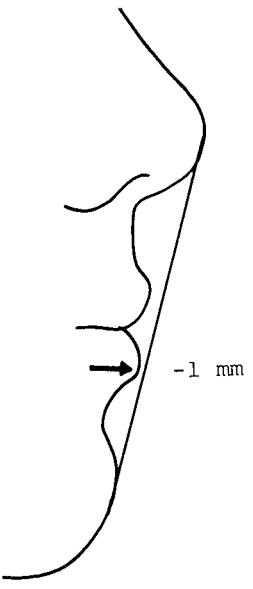

Fig. 2 *Esthetic Plane.* This analysis represents the balance between the lips and the other features of the profile. The lower lip should be approximately 1 mm (±2) behind the esthetic plane at age 8. The lips will tend to recede compared with the nose and chin at the rate of .2 mm per year of growth, so that the norm at adulthood is 2 mm for females and 3 mm for males.

tance from the interincisal point to the labial contour of the lower lip is measured and then projected as the posttreatment interincisal point to lower lip distance.

Zierenberg employed the following methodology. Pretreatment cephalometric tracings were used to predict the posttreatment locations of the upper and lower lips under the guidelines of both the Holdaway and the Ricketts methods of profile prediction. These positions were then compared with the actual lip positions as they existed on the posttreatment cephalometric tracings. Forty cases, each selected from the files of Rocky Mountain Data Systems, were examined in the initial phase of the study.

To be included in the sample, the pretreatment (T1) and posttreatment (T2) cephalograms had to exhibit: 1) a minimum of three mm of lingual movement of the upper incisors between T1 and T2; 2) posterior teeth in occlusion; 3) lips closed and subjectively judged to be relaxed except for strain induced by inability to close without strain; and 4) no orthodontic appliances in place. The mean age at Time 1 was 10.8 years. The mean age at Time 2 was 14.7 years, a mean interval of 3.9 years.

Since both methods are based upon lip thickening versus lip retraction following lingual movement of the upper incisors, it was necessary to determine the amount of upper incisor retraction and the response of the upper and lower lips to this movement.

The amount of retraction was determined by superimposing the T1 and T2 tracings on the facial plane at nasion measuring the horizontal differences from the labial surfaces of the T1 and

T2 upper incisors to the T1 facial plane. This indicated the amount the incisors had been retracted during treatment, whether by actual tooth movement or by orthopedic movement of the maxilla.

The response of the upper lip to the retraction of the upper incisor was determined by superimposing the tracings on the labial surfaces of the upper incisors with the basion-nasion planes in a parallel relationship. The distance between the T1 and T2 vermilion borders was measured to determine the amount of change in lip thickness. Since some of this thickness may have been the result of natural thickening with growth, or possibly due to weight gain of the patient, the difference between the T1 and T2 soft tissue thicknesses at point A was subtracted from the initial lip thickening measurement to compensate for this potential source of error. The difference between the upper incisor retraction and the corrected upper lip thickening measurement was taken to be the amount of upper lip retraction with treatment. The lower lips were measured as they related to the "interincisal point" or H-line of the Ricketts or Holdaway methods, respectively.

The above-mentioned measurements indicated what actually occurred in the soft tissue with treatment. Soft tissue profile predictions were then performed according to the techniques of Holdaway and Ricketts. These predictions were based upon the actually measured tooth movements between T1 and T2, and upon the soft tissue profile as it existed on the T1 cephalogram. The predicted lip positions were compared with the actual lip positions, the lack of congruence being regarded as the amount of prediction error. For cases in which the upper or lower lips fell behind the predicted positions, a negative value of error was assigned. Positive values of error were assigned where the actual lip positions were located ahead of the predicted positions.

The cases were then subdivided into eight different categories based upon the individual lip type or functional abnormality represented in each case. Several of the cases were included in more than one category. The eight subdivisions (bilabial protrusion, short lips, lip strain, mentalis habit, lip sucking, perioral contraction, upper proversion and lower eversion) were analyzed independently for accuracy of the two prediction methods, and an attempt was made to improve upon these methods where necessary and possible. A statistical analysis of the errors was performed to make these determinations.

Statistical analysis included the mean error, the mean absolute error (each error considered as an absolute value such that positive and negative value do not cancel each other), the standard deviation, and the root mean squared error. The root mean squared error is the square root of the sum of the squares of the errors divided by the number of samples. It is a measure of the accuracy of an estimate and differs from the mean error in two ways: 1) errors in different directions do not cancel each other, and 2) more weight is given to large errors, thus exposing lack of consistency. To determine where one method was statistically superior to the other, an F test was performed. Calculated F ratios were compared with a standard F distribution table at a 10% significance level.

The results of the study tended to refute the notion held by some[1,2] that soft tissue prediction is impossible. On the contrary, the mean error for the overall study (Table I) was surprisingly low.

It should be noted that neither the Ricketts method nor the Holdaway method was consistently better for all lip types. However, if the better method

COMBINED 40 CASES		MEAN ERROR (mm)	STANDARD DEV. (mm)	RMSE** (mm)	CRITICAL F VALUE	ACTUAL F VALUE
UPPER LIP	HOLDAWAY	-0.38	1.38	1.66		
	RICKETTS	0.54	1.17	1.29	1.51	1.66*
LOWER LIP	HOLDAWAY	0.25	1.42	1.44	1.51	1.07
	RICKETTS	0.70	1.64	1.50		

TABLE I
Combined results of 40 cases. * = statistically significant
** = root mean squared error.

is employed according to lip type, along with the suggestions as outlined in Table II, an error on the average of no more than one mm can be expected.

To answer the question of conflict in methodology, 50 cases were selected at random from the files of RMDS and a calculation made to determine the amount of lower incisor movement required to achieve: 1) ideal position of the lower incisor to APo (1 mm); 2) ideal inclination of the lower incisor to APo (22°); 3) ideal relation of the lower lip to esthetic plane; and 4) ideal relation of the upper lip to the harmony line.

The results showed that, in 14% of the cases, the four criteria gave the same results to within one mm. This indicates that in 86% of the cases it did not. Indeed, in 42% of the cases the criteria differed by more than two mm. Therefore, if the clinician wishes to individualize for his patient rather than being trapped by the "numbers racket," he must combine more than one method of evaluation of the lower incisor to arrive at an optimum compromise.

Summary and Conclusions

It has been demonstrated that there are reliable methods of predicting the ultimate position of the lower incisor and the soft tissue. However, the concept of treating this tooth to any one number for every individual was not supported by the evidence. An optimum system would allow the clinician to select and combine factors from all methods and arrive at a balance of esthetics, function, and stability, obtaining a suitable compromise for his individual patient. This is undoubtedly attempted intuitively by many experienced clinicians.

16661 Ventura Blvd.
Encino, Calif. 91436

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GRAPHIC REPRESENTATION	FUNCTIONAL ABNORMALITY	LIP	SLIGHT SUPERIORITY	DEFINITE SUPERIORITY	STATISTICALLY SIGNIFICANT SUPERIORITY	COMMENTS & SUGGESTIONS TO IMPROVE ACCURACY	EXPECTED ACCURACY
	Lip Sucking	Upper		Ricketts			±1.1
		Lower			Holdaway		±1.1
	Perioral Contraction	Upper	Ricketts				±1.2
		Lower		Holdaway		Place lip 1 mm ahead of H-Line	± .8
	Upper Proversion	Upper				Both methods satisfactory, neither superior to the other	±1.5
		Lower			Ricketts	Or use Holdaway 1.5 mm behind H-Line	± .8
	Lower Eversion	Upper		Holdaway			±1.1
		Lower			Holdaway	Place lip 1 mm ahead of H-Line	± .9
	Bilabial Protrusion	Upper	Holdaway				± .8
		Lower	Ricketts				± .9
	Short Lips	Upper		Ricketts			±1.1
		Lower				Both methods satisfactory, neither superior to the other	± .8
	Lip Strain	Upper	Holdaway				± .8
		Lower		Holdaway			± .8
	Mentalis Habit	Upper				Use either method, but place lip 1mm ahead of prediction pt.	± .9
		Lower		Holdaway			±1.3

TABLE II

A comparison of Ricketts vs. Holdaway methods of soft-tissue profile prediction for eight functional lip abnormalities.