An evaluation of the relationship between rest position of the mandible and malocclusion

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Identification and clinical application of rest position of the mandible has a long and controversial history in dental literature. Many investigators have attempted to identify physiologic factors contributing to the determination of mandibular rest position. Mentioned as influential characteristics have been tongue-space encroachment,[1] muscle and connective tissue physiology,[2-5] as well as more peripheral factors such as general body posture, gravity, and emotional state.[6] Clinical application of the principles of mandibular rest position include evaluating rest position determination and vertical dimension[7,8] and relative stability and reproducibility of rest position.[9,10,11] Atwood[12] offers a comprehensive review of the research literature of rest position of the mandible and its ramifications.

Cephalometric radiography has been used as a study method for evaluating rest position of the mandible. Emphasis has been on evaluation of the vertical dimension of the face[13,14] and path of closure of the mandible.[15] Limitations in the use of cephalometric radiographs include image reproducibility, difficulties of measurements of the soft tissue, artificial effects of the head holder on the position of the mandible and multiple radiation exposure.

Vertical dimension of the face as a measure of mandibular rest position represents the major theme developed in both theoretical and clinical literature. However, there has been recognition of anteroposterior changes in the mandible associated with mandibular rest position. Ricketts[16] noted condylar displacement in rest position for some Class II subjects and inferred a forward position of the mandible. Extreme examples from his sample included an edge-to-edge bite as well as one subject with underjet. He attributed the forward positioning of the mandible to multiple factors including respiration requirements, improved lip seal for swallowing, and improved speech. Posselt[17] also documented atypical rest position of the mandible as measured by condylar displacement. Ingervall[18,19] has

Abstract
Rest position of the mandible and integumental change in a control group of Class I occlusions is compared and contrasted with a study group of Class II malocclusion and a study group of Class III malocclusion. Change from centric occlusion to rest position of the mandible was suggestive of simulated correction of the malocclusion and improved facial esthetics.

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Key Words
Rest position • Malocclusion • Mandibular displacement • Facial esthetics

Figure 1

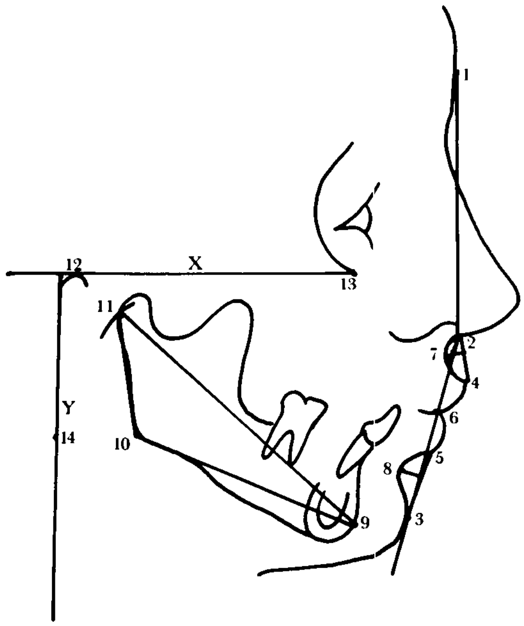

Figure 1
Measurements of mandibular movement and integumental contour. Coordinate system is Frankfort Horizontal (X) and a perpendicular to Frankfort Horizontal through Bolton Point (Y). Glabella (1), Subnasale (2), Soft Tissue Pogonion (3), Upper Vermilion Border (4), Lower Vermilion Border (5), Stomion (6), Upper Lip Concavity (7), Lower Lip Concavity (8), Pogonion (9), Gonion (10), Articulare (11), Mechanical Porion (12), Orbitale (13), Bolton Point (14). Mandibular Triangle 9-10-11, Facial Contour Angle 1-2-3, Upper Lip Length 2-6, Lower Lip Length 3-6, Upper Lip Depth 7 to 2-6, Lower Lip Depth 8 to 3-6.

documented rest position in children with Class II occlusion demonstrating increased anteroposterior displacement in Class II, division 1 subjects as opposed to Class II, division 2 subjects. Benediktsson[20] suggested muscular compensation inducing forward positioning of the mandible for a large overjet in Class II, division 1 subjects to secure a lip seal when speaking or swallowing.

More recent investigations have focused on the interrelationship between facial morphology and rest position of the mandible. Peterson, et al.,[21] compared mandibular rest position in subjects with high and low mandibular plane angles. Using clinical and electromyographic rest positions in ten high angle subjects and ten low angle subjects, they were able to conclude that vertical dimension of the clinical rest position was significantly greater in the low angle group. Electromyographic rest positions, however, demonstrated no significant differences. Wessberg, et al.,[22] performed similar measurements on a group of subjects with increased, normal, and decreased vertical dimension using transcutaneous electrical stimulated position. An inverse relationship was demonstrated between interocclusal distance and vertical dentofacial morphology. Their findings support the conclusions of Peterson et al.[21] concerning clinical rest position of the mandible. Both studies evaluated vertical parameters only.

While literature concerning rest position of the mandible has been well developed in regard to physiology, function, and stability, the interrelationship among dentofacial deformity, facial esthetics and mandibular rest position suggests further study. Patients with dentofacial deformity may recognize that self-induced, postural change of the mandible could dramatically improve not only function, but also facial esthetics. Learned behavior may cause the patient with mandibular retrognathia to self-correct by transient mandibular advancement. The patient with mandibular prognathism may opt to increase rest position vertically to take advantage of favorable horizontal change associated with opening rotation and achieve transient improvement in facial esthetics.

The hypothesis to be tested in this investigation is that patients with severe horizontal dysplasia may override the neuromuscular-determined rest position and assume a rest position different from a control group with Class I occlusion and a balanced skeleton. With intent to establish a basis for evaluating these possibilities, this paper has the following objectives:

1. Evaluate rest position of the mandible by skeletal and integumental analysis in a Class I control group and Class II and III study groups.
2. Compare changes associated with assuming mandibular rest position between Class I and Class II subjects, and Class I and Class III subjects.

Materials and methods

Three subject samples were collected for the study. Subjects in the control group (N = 42) had Class I occlusion as determined by neutrocclusion buccal segment relationship. The Class II study group members (N = 35) measured six millimeters or more of overjet with a distocclusion in the buccal segments and normal or decreased vertical dimension as measured by mandibular plane angle. All but four subjects were candidates for mandibular advancement. The Class III study group (N = 8) demonstrated underjet in excess of two of the anterior teeth with mesiocclusion in the buccal segments and normal or decreased vertical dimension as measured by mandibular plane angle. All subjects but one were candidates for mandibular setback or maxillary advancement. The buccal segments were evaluated in centric occlusion. No distinction was made between males and females. None of the subjects had a history of respiration difficulties. No growth status requirements were mandated, but the minimum age of the subjects was nine years to enhance the ability to follow instructions and thus improve quality of records.

Two standard, diagnostic cephalometric films were exposed, one in centric occlusion and the other in rest position. Natural head position was used.[23] The first cephalometric radiograph was exposed in centric occlusion in the usual manner. Achievement of rest position for the second cephalometric radiograph is recognized as being subjective. Conceptually, the second radiograph represented an instantaneous posture as defined by the criteria indicated below. Several techniques have been suggested in the literature including use of phonetics, time lapse, and "no command." Various combinations of these three general approaches have also been applied. In this study, a combination approach was used as noted below:

1. The subject was asked to relax and to swallow once.
2. The subject was asked to wet the lips.
3. The subject was requested to say the word "Mississippi." Several seconds were allowed to lapse (time lapse) for assumption of final rest position, and the exposure was made.

The subject was positioned in the cepahalostat according to the natural head position. Ear rods were positioned in the normal manner for the centric occlusion radiograph and then backed off to a comfortable position to minimize the effects of the ear rod on condylar positioning for the radiographic recording of rest position. Care was taken so that head position remained in the same orientation. The operator (author) was attentive to subjective evaluation of overall facial expression and mood to assure a quality recording of rest position. No instructions other than the above were given in order to avoid bias in anteroposterior or vertical positioning.

Six variables were measured, one set of skeletal variables documenting mandibular positioning and five soft tissue variables representing esthetic changes. Following is a brief description of the six variables (See Figure 1):

1. The mandible was represented by a triangle. Points in the triangle were pogonion, articulare, and gonion. Pogonion represented movement of the mandible between centric occlusion and rest position both vertically and horizontally. Data was collected for the other two components of the triangle to document displacement of the mandible in space.
2. A facial contour angle measurement was made using glabella, subnasale, and soft tissue pogonion.[24] This measurement represented voluntary facial contour adjustment by the patient from centric occlusion to rest position.
3. Upper lip contour was measured by constructing a line between subnasale and upper vermilion border. A perpendicular to the point of greatest concavity represented upper lip depth.
4. In a similar manner, lower lip contour was measured. A line was drawn connecting soft tissue pogonion and lower vermilion border. A perpendicular line was constructed to the point of greatest concavity and represented lower lip depth.
5. Upper lip length was measured between subnasale and stomion superiorus.
6. In a similar manner lower lip length was measured between stomion inferiorus and soft tissue pogonion.

Data collection on the control (Class I) and study groups (Class II and Class III) were as follows:

A. Centric occlusion and mandibular rest position landmarks were assessed identically.
B. The designated points of the mandibular triangle were transferred between radiographs using "best fit" superimposition of the mandible and spiking of the landmarks.
C. A coordinate system was established with the X axis as Frankfort Horizontal using mechanical porion and orbitale. The Y axis was a perpendicular to X axis through Bolton Point.
D. All study points were digitized incorporating a magnification correction factor of 0.92.
E. Pogonion, articulare, and gonion were connected to form a triangle representing the mandible. Using the coordinate system, displacement of the mandible between centric occlusion and rest position was computed.
F. Difference measurements were computed for the linear dimensions, lip depth and lip length, for both upper and lower lips.
G. Difference measurements were computed for the angular measurement and the facial contour angle.

Data were digitized and processed using the University of Illinois computer facilities. Analysis of variance was used for each of the variables in the study to evaluate statistical differences among the three samples. If the results of the tests were significant ($P<.05$), the Scheppe procedure was used to identify which pairs of group means were different. In addition, descriptive statistics, including means and standard deviations, were computed for all the groups. An error test was performed to evaluate accuracy using a subsample of 10 subjects. The radiographs for these subjects were redigitized, and a new set of measurements was computed. No statistical evidence of differences between the original and redigitized means was noted.

TABLE 1
MANDIBULAR TRIANGLE DATA

Vertical Variables		Centric Occlusion (mm)	Rest Position (mm)	Difference
Pogonion	Control	77.21	80.57	3.35
	Group II	72.50	78.17	5.67
	Group III	82.59	85.74	3.15
Gonion	Control	49.09	50.39	1.30
	Group II	52.76	55.26	2.50
	Group III	56.05	57.52	1.47
Articulare	Control	10.42	10.92	0.50
	Group II	11.72	14.07	2.35
	Group III	9.43	9.90	0.47

TABLE 2
MANDIBULAR TRIANGLE DATA

Horizontal Variables		Centric Occlusion (mm)	Rest Position (mm)	Difference
Pogonion	Control	101.02	100.42	-0.60
	Group II	99.08	100.76	1.68*+
	Group III	109.55	106.39	-3.16*+
Gonion	Control	34.73	34.20	-0.53
	Group II	36.36	37.87	1.51*
	Group III	41.50	39.04	-2.41*
Articulare	Control	26.81	26.29	-0.52
	Group II	26.90	28.82	1.78
	Group III	30.30	29.33	-0.97

**Statistically different from Control.*
+Statistically different from other Study Groups.

TABLE 3
INTEGUMENTAL CHANGES

Horizontal Variables		Centric Occlusion (mm)	Rest Position (mm)	Difference
ULL mm.	Control	20.09	20.37	0.28
	Group II	21.05	20.71	-0.26*+
	Group III	20.00	21.64	1.64*+
UL depth mm.	Control	2.03	2.24	0.21
	Group II	2.00	1.66	-0.34*
	Group III	2.27	2.27	0.00
LLL mm.	Control	29.50	31.39	1.89
	Group II	32.30	33.11	1.21
	Group III	31.92	32.83	0.91
LL depth mm.	Control	5.16	4.98	-0.18
	Group II	8.24	6.06	-2.18+
	Group III	5.00	5.33	0.33+
FCA°	Control	-14.16	-13.91	+0.25
	Group II	-18.12	-15.76	+2.36
	Group III	-2.73	-5.48	-2.75*+

Figure 2

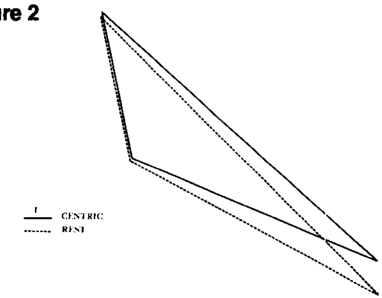

Figure 3

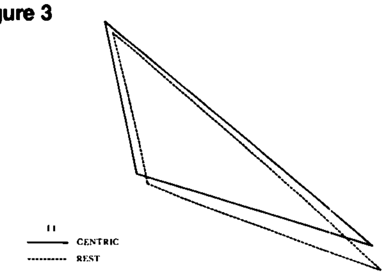

Figure 4

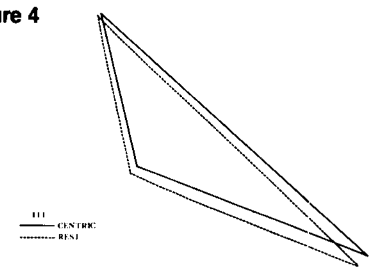

Table 1
Vertical coordinate measurements for pogonion, gonion and articulare in the control group, Class II Study Group and Class III Study Group.

Table 2
Horizontal coordinate measurements for pogonion, gonion and articulare in the control group, Class II Study Group and Class III Study Group.

Table 3
Integumental changes.

Figure 2
Mandibular triangle change from centric occlusion to rest position, Control Group I.

Figure 3
Mandibular triangle change from centric occlusion to rest position, Study Group II.

Figure 4
Mandibular triangle change from centric occlusion to rest position, Study Group III.

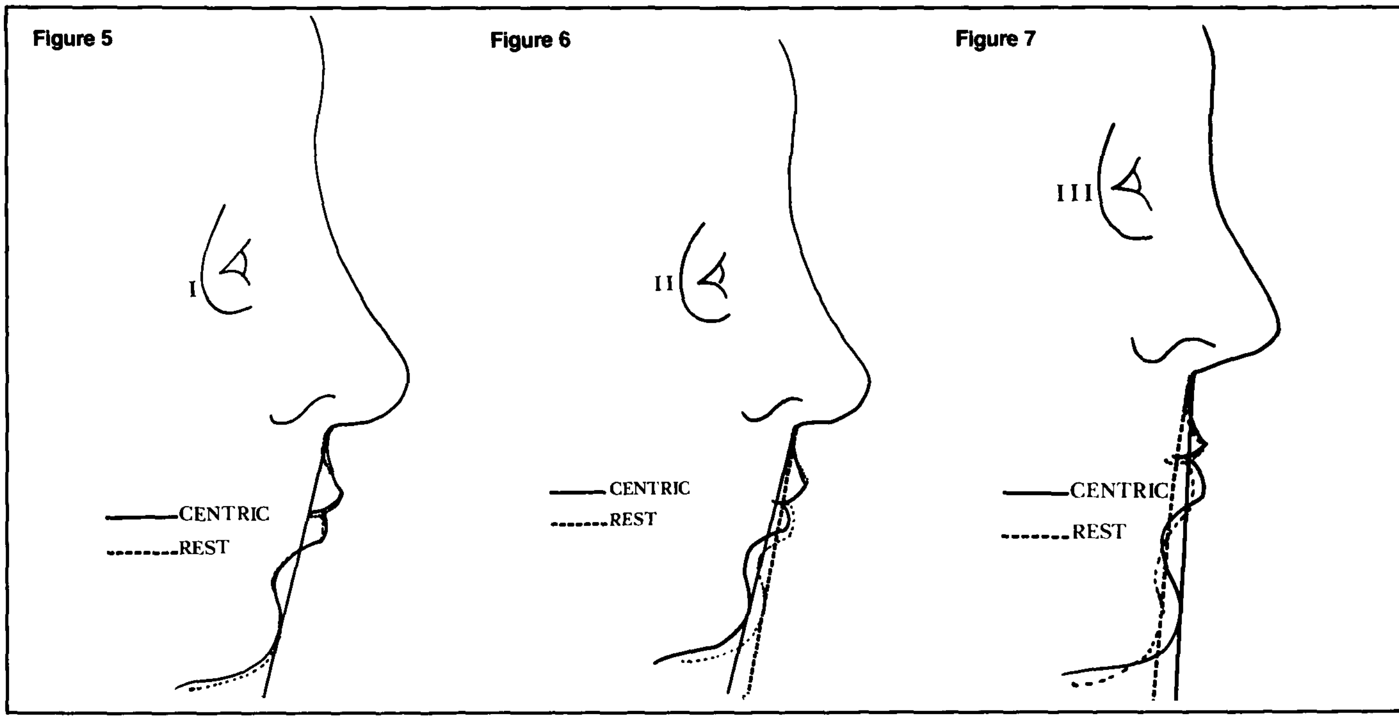

Figure 5
Artistic representation of soft tissue changes, Control Group I.

Figure 6
Artistic representation of soft tissue changes, Study Group II.

Figure 7
Artistic representation of soft tissue changes, Study Group III.

Results

Mandibular triangle

Table 1 presents mean vertical measurement data for the three designated points of the mandible for centric occlusion and rest position. Table 2 presents mean horizontal measurement data. Also presented are the differences and statistical results. No significance was demonstrated for vertical measurements. Horizontal pogonion differences were statistically significant between all group pairs. Horizontal gonion differences were significant between Groups I and II and between Groups I and III. Graphic representations of mandibular displacement are presented in Figures 2 (Group I), 3 (Group II), and 4 (Group III).

Integumental measurements

Table 3 presents mean data for the measurements upper lip length, upper lip depth, lower lip length, lower lip depth, and facial contour angle for centric occlusion and rest position for Control, Group II, and Group III. Also presented are the differences and statistical results.

Upper lip length differences were significant between all group pairs. Upper lip depth was significant between Groups I and II and Groups II and III. Lower lip depth was significant between Groups II and III. Facial contour angle differences were significant between all group pairs. Artistic representations of soft tissue changes in profile are presented in Figures 5 (Group I), 6 (Group II) and 7 (Group III).

Distribution of data

Important information for interpretation was obscured by mean statistical data analysis, but revealed by an analysis of data distribution. The mean differences data for all groups were divided into <0 change and >0 change for pogonion and facial contour angle values. Range values were also calculated.

Sixteen of 42 subjects (38 percent) in Group I had positive differences in pogonion change reflecting anterior displacement. Twenty-five of 35 subjects (71 percent) in Group II had positive differences in pogonion change. In addition, the greatest difference for Group I was 2.29 millimeters, compared with 6.17 millimeters for Group II. The range of values for pogonion change was -5.22 millimeters to 2.29 millimeters in Group I; -3.60 millimeters to 6.17 millimeters in Group II; and -5.79 millimeters to -1.89 millimeters for Group III.

There was a similar distribution for facial contour angle differences. Only one subject measured a four degree positive change (4.13 degrees) in Group I. Ten subjects (29 percent) from Group II had differences greater than four degrees, with the highest being 9.79 degrees. The range of values for facial contour change was -5.93 degrees to 4.13 degrees for Group I; -1.96 degrees to 9.79 degrees in Group II; and -4.70 degrees to 0.00 degrees in Group III.

Discussion

The hypothesis stated that rest position behavior of the mandible in subjects with severe horizontal dysplasia was different from a control group with Class I occlusion and a balanced

Figure 8A

Figure 8B

Figure 8C

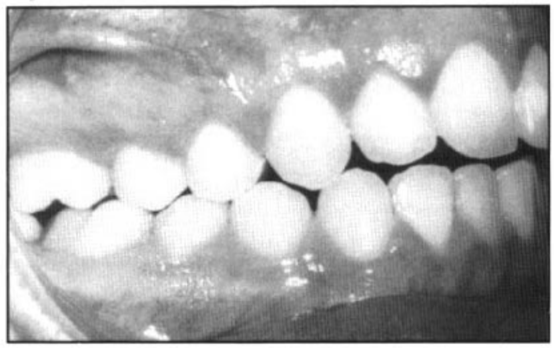

Figure 8D

Figure 8
This subject demonstrates a well-rehearsed, conscious simulated mandibular advancement from centric occlusion (A and C) to rest position (B and D). Esthetics and functional improvement were motivating factors.

skeleton. Such a difference would be consistent with attempts at functional and esthetic improvement. The data established that mandibular displacement in the Class II study group promoted overjet reduction and horizontal improvement of dental, skeletal and integumental characteristics through simulated mandibular advancement. In the smaller Class III study group, mandibular displacement promoted reduction of underjet and horizontal improvement in an analogous manner. In each group, in a conscious or subconscious manner, a simulated malocclusion correction was evident in the form of mandibular displacement.

In the mandibular triangle, only transposition of pogonion was statistically significant between the control group and both study groups. Failure of the two other points, gonion and articulare, to manifest horizontal intergroup statistical significance was a product of the geometry of change between rest position and occlusion. As established by Nevakari,[25] movement in this component of the mandibular envelope is a combination of translation and rotation. Translation of the mandible forward was countered by rotational opening, and this was reflected in those measured points (gonion and articulare) that are closer to the instantaneous center of rotation. The reference point more distant from the operative center of rotation, pogonion, was less vulnerable to the influence of vertical rotational change on horizontal translation.

Gonion displacement was significant between the control group and Class II study group and between the control group and the Class III study group. Gonion is the second furthest point from the instantaneous center of rotation and reflected change consistent with movement of pogonion. Articulare had the least measured change and was not statistically significant, as it is the closest point to the center of rotation.

Integumental changes were consistent with the findings for mandibular displacement and with the hypothesis, suggesting self-induced esthetic improvement, as one possible motivating factor. Facial contour change, as measured by the facial contour angle, was significant between all groups. Study Group II changed from -18.12 degrees to -15.76 degrees. Study Group III changed from -2.73 degrees to -5.48 degrees. In both cases, the changes were in the direction of the established facial contour angle norm of -11 degrees.

Upper lip length differences were also significant between all group pairs. Most notable was an increase in length of 1.64 millimeters in the Class III study group in rest position. As the mandible rotated down and back, the influence of the mandibular incisors and the lower lip on the upper lip was reduced, and redraping allowed lip lengthening. An expected change in upper lip depth did not occur. In the Class II study group, minor changes were statistically significant in upper lip length and depth relative to the control group. The changes were consistent with increased contour at the expense of decreased length promoted by the influence of the anteriorly displaced lower lip.

Figure 9A

Figure 9B

Figure 9C

Figure 9D

Figure 9
This subject demonstrates a major downward and backward rotation of the mandible from centric occlusion (A and C) to rest position (B and D). Improved esthetics, especially notable in lip balance and facial contour angle, and edge-to-edge occlusion are products of this rest position.

Significant changes were anticipated for lower lip length and depth for the Class II study group. Reduction in overjet should promote reduction in lower lip redundancy and improved lip drape. While the mandible displaced favorably, no concurrent significant changes were noted for the integumental counterparts. A 2.18 millimeter decrease in lower lip depth was noted for the Class II study group, compared to 0.18 millimeters for the control group. High data variation prevented a significant relationship. Perhaps the variation represented inconsistent lower lip muscular tonicity. Many subjects with increased overjet would need time to demonstrate improved muscle function in a favorably altered mandibular position.

Data hidden from statistical testing suggest confirmation of what many clinicians have observed in the examination of patients with Class II malocclusion: a distinct and important forward-positioning subgroup. Twenty-five of 35 subjects in the Class II study group moved forward in rest position, with 27 of 35 manifesting an improvement in facial contour angle. In fact, 10 of this latter group exhibited an angular change in facial contour greater than the highest recorded value for a subject in the control group. Clearly, there is a subgroup of subjects with excessive overjet and compensating protrusive mandibular positioning at rest. It is critical to be sensitive to this subgroup when working on a differential diagnosis and treatment plan for patients with Class II malocclusion and mandibular retrusion. (See Figure 8 A-D.)

It has been shown that the mandible may assume a forward position during the production of "s" sound.[26,27] In this study, the word "Mississippi" was used as part of the rest position scheme, and it may be postulated that the "s" sounds induced forward positioning of the mandible in the Class II study group. Since the speech component was not sustained, the "s" effect was probably neutralized by the time lapse of several seconds between "Mississippi" and radiographic exposure.

Similar findings support a companion concept for the Class III study group. Although the sample size was small, 100 percent of the subjects demonstrated downward and backward displacement of the mandible into rest position and improvement in facial contour angle. Of particular importance for diagnosis and treatment planning is the improvement in upper lip length and depth associated with acquired rest position. (See Figure 9 A-D.)

Ricketts,[16] Benediktsson,[20] Posselt,[17] and Ingervall[18,19] all have demonstrated mandibular displacement in rest position in Class II subjects. Subconscious behavior with a goal of improvement in function such as respiration, speech, and swallowing was collectively suggested as an etiologic factor. For the Class II and Class III subjects in this study, a conscious act to improve facial esthetics is suggested as an additional motivating factor.

Neuromuscular proprioception is a key factor in determination of mandibular rest position. Traditional teaching emphasizes "mandibular physiologic rest position." Would it be appropriate to refer to "mandibular acquired rest position" for subjects that demonstrate atypical rest position as described above? Is it possible that, through conscious counteraction of the neuromuscular system as described by Yemm[3] and Moller,[4] the subject may override "physiologic" and establish "acquired" rest position? Some subjects may develop such a strong secondary neuromuscular pathway to support this acquired position, that the clinician could easily be confused at clinical examination. Perhaps tactile-neural feedback from lip function served as a trigger to maintain the acquired position in those subjects that maintained the position long term. (See Figure 8.)

There has been little epidemiological evidence of a relationship between malocclusion and temporomandibular joint dysfunction.[28,29] Contrary opinion persists in the literature, especially for a Class II, division 1 malocclusion.[30] One may speculate that a potential physiologic consequence of mandibular postural behavior by the acquired rest position subgroup may strain the temporomandibular joint apparatus past normal limitations of movement. The result may possibly be an increase in incompetence or laxity of the temporomandibular joint capsule and a predisposition for internal derangement. A forward position of the mandible at rest may contribute to promoting a functional dual bite. An investigation of dual bites and the functional ramifications by Egermark-Eriksson, et al.,[31] failed to demonstrate a high prevalence of subjective symptoms of mandibular dysfunction. They suggest, however, that there is a risk of developing clinical symptoms of temporomandibular joint problems and that creating a final occlusion consistent with a more retruded intercuspal position should be a treatment objective. Harvold and Poyton[32] have suggested that temporomandibular joint and muscle pain may be related to dual bite. Inconsistent results in the literature relating malocclusion and temporomandibular joint dysfunction may be the result of smoothing of sample data curves, merging the acquired rest position subgroup with the sample population. If a relationship were established between overjet and temporomandibular joint dysfunction, perhaps it would not be Class II malocclusion as the causative agent, but more probably the mandibular positioning behavior of some subjects with Class II malocclusion.

Whether by statistical testing of the group or by review of distribution of subgroups, the rest position of the mandible was demonstrated to be different from the control group. Self-induced, instantaneous behavior of the mandible consistent with functional and esthetic improvements was observed. Further studies to determine consciousness and sensitivity of the subject to mandibular rest position, ramifications for the temporomandibular joint, and implications in regards to growth and development of the mandible seem warranted.

Conclusions

1. The rest position of the mandible in subjects with Class II malocclusion was more anterior than the Class I control group.
2. The rest position of the mandible in subjects with Class III malocclusion was more posterior than the Class I control group.
3. Integumental change between the Class I control group and the Class II and III study groups reflected esthetic improvement in facial contour, lip length, and lip depth.

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