Effects of Orthodontic Intermaxillary Class III Mechanics on Craniofacial Structures Part II - Computerized Cephalometrics

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Part I of the effects of orthodontic intermaxillary Class III mechanics on craniofacial structures dealt with the photoelastic visualization of force application. It was shown that utilization of Class III mechanics on the photoelastic skull affected various sutures of the craniofacial complex. It was also observed that the stress trajectories produced in the mandible lead to the conclusion that Class III traction affects mandibular growth and opening as well as condylar repositioning. With the aid of computerized cephalometrics and growth forecasting techniques this article will correlate ten treated Class III cases with the photoelastic laboratory studies.

Review of the Literature

In 1931 Broadbent developed a major breakthrough by introducing a method of assessing treatment and changes in growth by the utilization of his cephalometric roentgenography technique.[1] Cephalometrics aided in the understanding of the effects of orthopedic force at the time. The literature reveals very little regarding the different areas that are affected by Class III appliances other than the mandible.

In 1952 Ricketts, by utilizing his cephalometric laminagraphy, revealed different temporomandibular joint morphologic conditions.[2] He regarded the mandible as an unstable bone and recognized the possibility of experimental morphologic transformation in the condyle.

Mandibular growth individualization has been demonstrated in terms of direction. A significant linear correlation was found by Odegaard between the change in the gonial angle and the shape of the mandible.[3] Using metallic implants, Björk reported anatomic characteristics of individual mandibles, which were observed to grow abnormally in vertical and horizontal directions.[4] Moss[5] has proposed a method based on the theory that the mandible grows in a logarithmic spiral, which is basically in agreement with Ricketts'[6] theory that the mandible grows along an arc. Mitchell and associates evaluated Ricketts' method for predicting the size and form of the mandible.[7] They concluded that the arcial method is valid for prediction of mandibular growth, and that it is also possible to predict the form of the mandible with the use of an individualized method. Schulhof et al. recently reported the first published demonstration of computerized methods showing the ability to distinguish between normal and abnormal growth in particular patient types.[8] They found four significant factors, identified in the lateral cephalometric radiograph, which would indicate the likelihood of the patient growing in an abnormal Class III manner.

Material and Methods

Computerized Cephalometrics

Utilizing ten treated cases, an *in vivo* comparison on the action of Class III intermaxillary elastics with that of the

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birefringent model was achieved. Processing of these cases was possible with the aid of a computer program on orthodontic roentgenographic cephalometry developed by the Rocky Mountain Data Systems.

Due to the relatively scarce number of Class III cases in our Western society, ten cases constitute a sufficient population to establish an acceptable norm.

Methodology

The RMDS cephalometric computer provides the clinician with an accurate idea of the location and magnitude of the skeletal, facial, and dental problems. The program includes 51 measurements in the lateral headplate and 49 in the anteroposterior headplate. These measurements are separated into various fields representing areas of clinical interest or diagnosis.

Lateral Headplate Fields and Coverage

Field I: Denture problem—concerned with the relationship of teeth exclusively.

Field II: Maxillomandibular relationship to skeletal (orthopedic) problem. Deals with skeletal problems on upper and lower face relation to the orthodontic solution.

Field III: Denture to skeleton relation—associates position of teeth to bone relationship and location of each other in space.

Field IV: Esthetic problem (lip relation)—analyzes soft tissue problems in relation to skeleton and teeth.

Field V: Craniofacial relation—studies the harmony of the cranium with bones of the upper and lower face.

Field VI: Internal structure—shows basal and skeletal dysplasias as well as identifying the skeletal member contribution to a dentoskeletal relationship or malocclusion.

Growth Forecast Without Treatment and Treatment Superimposition

The possibility of growth forecasting rests on the discovery of relationships which may be assumed to remain constant. This means that the relationship should stay the same on average in the population and, in addition, should show relatively little individual variation from the average.

By evaluating many samples of growth series without treatment, several angles were found not to change on the average and which show only a small deviation of change over a relatively long period of time (5 years).

With this in mind, processing of the ten treated cases to growth forecast without treatment was performed.

Since treatment of cases was achieved with the same technique as the one used on the photoelastic human skull, a comparison was made utilizing:

1) growth forecast without treatment, 2) lateral headplates, and 3) computerized printout of each one of the fields where measurements were taken.

The material obtained from the computer included the following items:

1) complete printout of the fields described above, 2) suggestions for treatment alternatives, and 3) growth forecast without treatment tracing composite.

To evaluate the difference between the predictive growth forecast without treatment and the actual treatment result five superimpositions were considered:

1. Overall changes, taking the point of intersection of cephalometric planes PTV (pterygoid vertical) and Frankfort, a valid evaluation of the overall changes that took place can be visualized (Fig. 1).

2. Central and facial axis behavior is obtained by superimposing on the

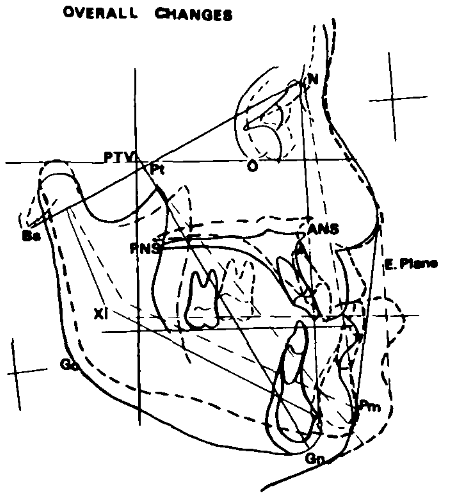

Fig. 1 Overall picture of the changes expected and changes that actually occurred with Class III elastic treatment for patient M.L. Broken lines show growth forecast without treatment. Solid lines are result of treatment.

basion-nasion plane at the cephalometric landmark Pt, intersection of central axis and basion-nasion (Fig. 2, upper left).

3. Palatal alterations and midface changes are found by superimposing on the line basion-nasion at nasion (Fig. 2, upper right).

4. Mandibular growth, incisor relocation, and condylar behavior can be readily evaluated by superimposing on the corpus axis at Pm, slightly superior to pogonion (Fig. 2, lower right).

5. Evaluation of maxillary teeth behavior is possible by superimposing at anterior nasal spine along the palatal plane (Fig. 2, lower left).

Results

Representative superimpositions are presented in Figures 2-5 for four of the cases studied. A summary of the comparisons of the major treatment changes against growth forecast predictions for all ten cases is shown in Table I. The changes are presented for six pertinent areas.

It was noted that the majority of the cases (80%) experienced an inferior vertical displacement with a slight counterclockwise rotation in the maxilla. In only 20% of the cases the maxilla showed a superior displacement with a slight counterclockwise rotation in the maxilla.

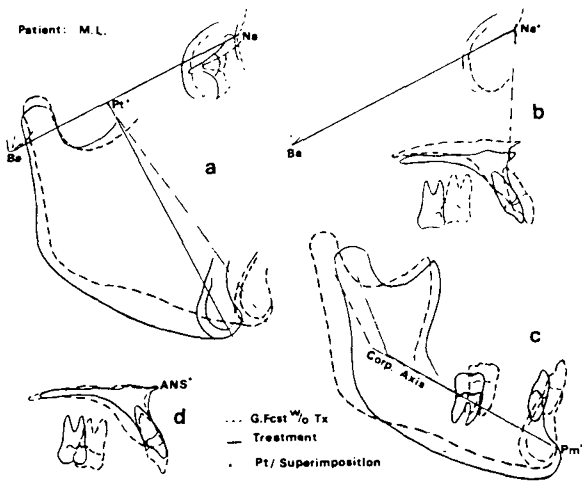

Fig. 2 Superimpositions of the specific areas analyzed for patient M.L.: a) mandibular and central axis behavior, b) mid and upper face behavior, c) condylar and mandibular teeth evaluation and d) changes in maxillary teeth.

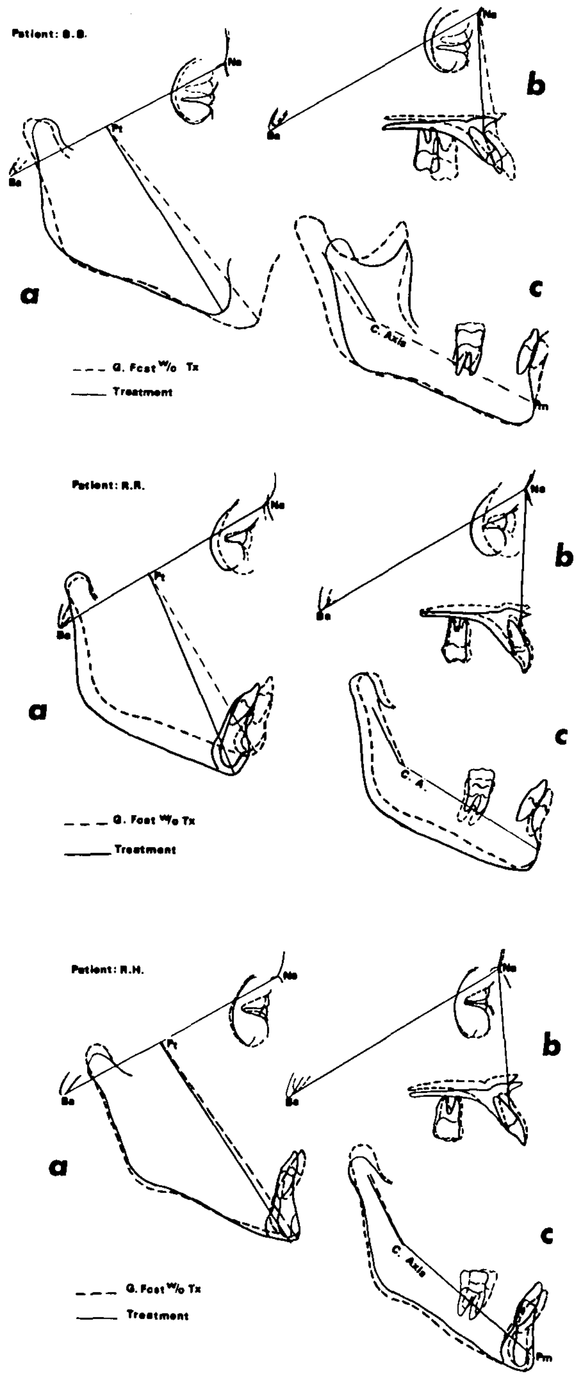

Fig. 3, 4 and 5 Superimpositions of the specific areas analyzed: a) mandibular behavior, b) upper and midfacial changes and c) condylar repositon and mandibular teeth evaluation.

Patient	B.B	C.M.	D.M.	M.L.	S.F.	C.C.	R.H.	N.F.	R.R.	J.C.	Average
Age at beginning of Tx. (yr/mo)	3/5	8/9	16/5	7/2	8/1	15/9	8/7	8/4	5/5	11/7	%
Age at retention (g.f. range) (yr/mo)	14/5	15/7	23/7	17/1	9/5	18/9	13/7	14/2	14/7	15/4	
Inferior palatal vertical displacement	X	X	X	X	X		X		X	X	80
Superior palatal vertical displacement						X		X			20
Mandibular opening	X	X		X	X		X		X	X	70
Mandibular closing			X			X		X			30
Condylar reposition	X	X	X	X	X	X	X		X	X	90
Mandibular incisor retrusion	X	X		X	X	X	X	X	X	X	90
Mandibular molar change	X	X	X	X	X	X	X	X	X	X	100
Soft tissue change (profile)	X	X	X	X	X	X	X	X	X	X	100

TABLE I

In 70% of the cases an increase in the posterior facial height due to mandibular opening was displayed. A decrease in the posterior facial height due to mandibular closing was observed in the remaining patients.

The mandibular condyle changed from the expected growth position in 90% of the treated cases. The condylar reposition did not follow any predominant pattern.

It was noted that 90% of the cases showed incisor retrusion in the mandible as a result of Class III forces.

The mandibular molars were affected in all of the treated cases. They were either extruded or distalized from the predicted position without treatment.

Following mandibular incisor position, soft tissue change was observed in all of the cases.

It is important to remember that the results mentioned above were obtained after careful and detailed evaluation of the superimpositions on growth forecasts without treatment compared with actual treated cases (Table I).

Discussion

With the aid of computerized cephalometrics and growth forecasting techniques ten treated Class III cases were evaluated to correlate the clinical results with the photoelastic laboratory studies.

Palatal displacement

The consequence of the increased photoelastic activity observed in the posterior region (zygomaticotemporal suture), as compared with the anterior segment (frontomaxillary suture), was the counterclockwise rotation of the palatal plane observed in 80% of the treated cases (Table I). It is interesting to note that the two cases which exhibited superior palatal vertical displacement also revealed a mandibular closure during treatment. Therefore, it can be assumed that the dominating closing force of the mandible prevented the normal downward growth of the maxillary complex and counteracted any effects produced by the intraoral traction during treatment.

Mandibular opening

As observed in the photoelastic studies, intermaxillary Class III traction produced an effect along the ramus and condylar neck of the mandible. The pronounced effect at the mandibular angle could very well produce a bending at that site with a consequential mandibular opening. This phenomenon was observed to occur in 70% of the cases treated with Class III traction.

The overall changes in Figure 1 reveal the extruded position of the maxillary molar with treatment as compared with the forecast position of this tooth. This representative case illustrates the extrusion of the maxillary molar as a result of the vertical vector of force produced by Class III intraoral tension. As observed previously in the discussion of the reasons for palatal displacement, the counterclockwise rotation of the maxillary complex and the increased vertical positioning after treatment could also have the net effect of mandibular opening.

It has been reported, however, that excessive mandibular growth in extreme Class III malocclusions causes mandibular closing as explained by the arcial growth theory.[9] Therefore, it can be assumed that the three cases exhibiting mandibular closure grew more than the predicted value and counteracted the effects produced by Class III intraoral mechanics (Table I).

Condylar reposition

As noted in the photoelastic observations, stresses occurred along the posterior border of the condylar neck and at the site of the external pterygoid muscle insertion. The stresses at the prechondroblastic zone could alter the morphology of the condylar head and the glenoid fossa as described by Petrovic.[10,11] Also, according to Petrovic, hypopropulsion of the mandible would increase the sarcomeres of the external pterygoid muscle and would decrease the proliferation of the condylar cartilage prechondroblasts, causing a decrease in length between the posterior edge of the condyle and mental foramen. Therefore, the net effect of Class III intraoral traction during treatment would have the dominant effect of condylar reposition as was observed in 90% of the cases (Table I).

The variation exhibited in condylar positioning after treatment could be related to the results of several factors: namely, degree of muscle tension, the magnitude of Class III mechanics, and differences in patient cooperation. Another reason for the varying degrees of condylar positioning may be the aforementioned maxillary molar extrusion causing opening, and a possible translatory movement of the mandible. This mandibular movement causes a repositioning of the muscles of mastication and may further change the position of the condyle.

Mandibular incisor retrusion

During normal growth the mandibular incisor is expected to erupt upward and forward but to remain in the same position relative to the APo line. The photoelastic observation in the study revealed an effect at the apices of the mandibular premolar teeth, but no stress activity was observed in the incisor area. It is safe to assume that, if Class III mechanics were attached to the anterior segment of the mandibular archwire, this would affect the teeth connected to it. Due to the distal vector of force of the Class III intraoral traction, the mandibular incisors would be expected to retrude from their predicted position. Table I reveals that 90% of the cases exhibited such a change, and Figures 2, 3, 4 and 5 corroborate this evidence.

It is interesting to note that the one

case that did not exhibit this retrusion was one that also showed mandibular closure. As the mandible closed in an arcial fashion, the lower incisor not only followed upward but was also placed in an anterior position.

Mandibular molar change

During normal growth the mandibular molar is expected to erupt upward and slightly forward toward the new occlusal plane. Physiologic mesial drift occurs when the deciduous molars are lost and the permanent first molars move forward to occupy the leeway space.

In the ten cases studied, all revealed a lower molar change. Horizontally, the tooth was either at the predicted position or distal to it. The more posterior position of the molar was most likely due to the posterior vector of force of the Class III traction during treatment. Variation in the vertical position of the mandibular molar may have been due to extrusion of the maxillary molar, rotation of the palatal plane, or a combination of these two factors. Another important consideration is the effect of musculature, especially the masseters, internal pterygoids, and temporalis. Those patients with weak muscles had less of a tendency to reveal molar intrusion.

Soft tissue changes

Normal soft tissue convexity increases with age when the nose is taken into consideration because the soft tissue nose grows more in an anterior direction than does the mandible.

In a Class III skeletal pattern the convexity of the soft tissue profile decreases due to the overdeveloped mandible. The hypodeveloped maxilla, the hypofunctioning upper lip, and the hypertonic lower lip of a Class III exaggerate the concave soft tissue profile.

In the ten treated cases all revealed an improvement of the expected Class III profile (Fig. 1). The decrease in soft tissue concavity was due in part to the redirection of mandibular growth, anterior positioning of the maxilla, and retrusion of lower incisors. The net result was a more pleasing and esthetic profile. No photoelastic comparison was possible, because only bony structures were modeled.

Summary and Conclusions

The relation between active growth and induced anatomic changes was examined using a computerized cephalometric analysis of ten Class III cases treated with intermaxillary traction. The following can be concluded from this investigation:

1. Mandibular growth was redirected and mandibular opening was observed due to maxillary molar extrusion and counterclockwise rotation of the maxilla.

2. Condylar repositioning was noted to occur in all cases due to the effect of the external pterygoid muscle and a possible translatory movement during mandibular rotation.

3. Counterclockwise palatal development occurred in most of the treated cases through vertical action of the Class III mechanism.

4. The effect of the Class III traction was also observed in the mandibular incisor and molar teeth. The incisors retruded and the molars either were located in the predicted position or farther distally.

5. The soft tissue profile was less concave than the predicted value due to less mandibular growth and more retruded incisors in the treated cases.

6. Evidence was shown that a positive relationship exists between computerized cephalometrics and photoelastic techniques in the analysis of ten treated cases. This relationship is based on the fact that specific changes which

took place during treatment were found to be consistent with the results of the photoelastic analysis.

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