Methods employed in the analysis of malocclusion in the department of orthodontia at the University of Illinois*

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INTRODUCTION

My objective is to present to you in a brief manner the various steps followed in the department in the course of a routine case analysis. The diagnostic routines to be presented have all been tested in clinical practice for specific purposes. All of them may not be essential and indispensable for the everyday practice of orthodontia. Collectively they serve a very valuable purpose in teaching and research. A clarification of these methods seems justified in the hope that they will aid in the understanding of the case presentations which will follow. This paper will be concerned mainly with the rationale of each diagnostic procedure rather than with the detailed techniques of analysis.

The following diagnostic steps will be considered:

1. *HISTORY*: This includes the information obtained concerning the patient, his family, environment and experiences.
2. *PHYSIOLOGICAL EXAMINATION*: This encompasses a critical evaluation of muscular functions.
3. *INTRA - ORAL EXAMINATION*
4. *PHOTOGRAPHS*
5. *CEPHALOMETRIC ANALYSIS*
6. *STUDY OF PLASTER CASTS*

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HISTORY

Information concerning the medical and developmental history of the child is of importance in evaluating his physical, emotional, and genetic background. We are concerned with obtaining any possible information which might be of value in diagnosis and treatment planning, including contraindicative information and observance of precautionary measures. Hereditary, congenital, or environmental factors may be reflected in the present malocclusion as well as predetermining patterns of growth and behavior. Attention is given to the child's posture, to his general attitude toward treatment as well as the attitudes of his parents. To be considered is not only the patient's early dental history but also that of immediate relatives. In addition, the nature of the patient's diet is always evaluated in terms of its nutritional and physical qualities.

PHYSIOLOGICAL EXAMINATION

Once an insight is obtained from the child's early history we proceed to examine the muscular functions. The reason for doing this lies in the knowledge that perverted muscular activity upsets the normal equilibrium of the denture producing disturbances in relationships of the teeth until a new but abnormal balance is established which maintains the incorrect position of the dental units. It follows that an analysis of the mode of functioning of muscles

which operate upon the denture will aid in explaining the deviations of the teeth from their desired normal arrangement.

The physiological examination thus consists of establishing by observation and interrogation, the past or present existence of muscular habits. Since any alteration of the normal balance of muscular forces from within or without the denture will have a reflection on the denture itself, the information obtained at this point is correlated and substantiated with future findings in the model analysis and vice versa. Typical of this is thumb sucking. That this condition is present may be further evidenced by examining the patient's hands and fingers. Questioning will inform us about posture, leaning, or the existence of some special kind of habit. Further observation may reveal lip sucking and biting which may have been suggested by differences in coloration and surface texture of the lips. Abnormal actions of the triangularis muscles may be determined as well as a mentalis habit with its characteristic dimpling of the chin. Although we have no accurate method of measuring muscular tonicity, we formulate an impression of it by palpation and inspection. The tongue is examined as to size, form activity, and position. Size of the tongue is established from its relation to its bony confinement. Careful examination of this organ in relation to the dental arches' functional activity may indicate some kind of thrust. Perversions of tongue movements may be reflected during speech. Our present plan calls for the referral of such cases to the speech department for examination and establishment of a permanent record available for comparison with a future record following treatment. The position of the tongue is of importance. It has to be established whether it lends support to the maxillary or mandibular arch or whether it is causing abnormal incisal relationships. The behavior of the labial musculature is observed during swallowing and attention is placed again on tongue function. Respiration is differentiated as being nasal or oral by holding cotton strands in front of the mouth, and from the parents is gained information regarding the removal of tonsils, adenoids, as well as the manner of breathing at night. The patient is observed during mastication in an effort to determine the limitations of masticatory excursions and the existence of masticatory habits. In limited cases in which peculiarities of mastication are observed, the analysis is supplemented with electro-myographic recordings of the muscles of mastication. The path followed by the mandible during opening and closing is noted, because deviations from the normal in this regard are of importance in differentiating between skeletal and functional asymmetries.

In order to relate muscle imbalances to prognosis, some distinction between the various observed muscular dysfunctions may be made. In one instance we may find disturbances in muscle action which are resolved by correction of the malocclusion and thus require no specific treatment of the perverted muscle behavior. This is the case in those patients in whom there is inability to maintain approximation of anatomically adequate lips because of markedly protruding incisors. On the other hand, there may be what can be considered essential muscular dysfunctions which are not corrected upon correction of the dental anomaly but which require special attention. An example would be pernicious habits such as tongue thrust.

It is necessary to consider the fact that facial musculature operates from origins on the bony skeleton and thus, the relation between the different skeletal parts greatly influences the re-

Fig. 1. Postural photographs. A. frontal view; B. lateral at rest; C. alert position; D. patient looking at the image of his pupils in a mirror on the wall.

sult of muscular activity. In certain cases, the malrelation of skeletal parts is the main factor responsible for muscular dysfunctions. Hence the importance of analyzing the morphology and relationship of the skeletal framework.

INTRA-ORAL EXAMINATIONS

This includes a clinical and radiographic study. Clinically, the attempt is made to determine any deviation of the teeth from the normal in terms of structure, form and number. The status of gingivae and mucous membrane is noted and the degree of susceptibility to gingival inflammation and caries. No appliance is placed without a com-

plete operative restoration of the denture. The palatal tonsils are inspected and careful attention is given to the mouth hygiene as well as to the amount and consistency of the saliva. Digital exploration, by means of thumb and forefinger, will aid in gaining an appreciation of the width of the alveolar process and the relative buccolingual or labio-lingual position of the roots in it. This is supplemented with full mouth intra-oral x-rays including bite wings, and, if necessary, occlusal films. The condition of the alveolar bone in terms of density, trabeculation, continuity of lamina dura, height of alveolar crest, and width of periodontal membrane is recorded as well as the presence of all accessional and successional teeth. Special emphasis is placed on the form of the alveolar crest, any indication of root resorption, congenital absence or malposition of teeth, and the relation between chronological age and dental age.

Photographs

These provide a permanent record of the face in full view, and in profile. (Fig. 1) An attempt is made to capture facial expression and muscular balance at rest in order to evaluate harmony and proportionality between facial parts, as well as to make observations concerning asymmetries and posture of the head. Most of these conditions will have been noted before and are herewith submitted for re-evaluation. The description of any case should include remarks concerning the relationship of the lips to each other, whether they are in contact or separated; the relationship between lips and teeth, and relationship of the lips to the rest of the face insofar as they appear retruded, everted, tense, or flaccid. The proportionality between component parts can be appreciated by noting conditions such as anatomically short lips, the contribution of different parts to the total profile, deficiences in vertical height, etc. Gross asymmetries can readily be seen and will be further analyzed from the frontal headplate.

It is of interest to note that the photographs employed are postural photographs, taken in such a way as to represent the position assumed by the head under certain set conditions.

Briefly, the technique employed is as follows: The soft tissue corresponding to orbitale and the skin at the level of porion are painted with barium sulfate; with these marks in place, headplates and photographs are taken. The photos include one frontal and three laterals, made with the patient standing at a fixed distance. All exposures are taken with the camera at the level of the pupils. For the first lateral film, representing rest position, the patient is instructed to close the eyes. The second lateral represents an alert position and the third is taken while the patient looks at the image of his pupils in a mirror on the wall. The Frankfort plane, obtained from the barium marks is corrected with the cephalometric Frankfort of the headplate, and then compared with a true horizontal. By these means, we attempt to determine any deviations of the patient's Frankfort plane from a true horizontal, and thus, more accurately analyze the facial type.

Cephalometric Roentgenograms

For every patient a minimum of four cephalometric x-rays are taken for purposes of study and subsequent comparison. These consist of one lateral taken with the teeth in occlusion, one lateral at rest, and one lateral with the mouth wide open. In any case of doubt about correct positioning, or in cases where asymmetries exist, two or more exposures are made of the film under question. A master tracing is made from the frontal and lateral

set in occlusion and oriented in the Frankfort plane. This enables one to transfer any point from one film to the other. The wide open picture is used to obtain a clear outline of the mandibular condyle which is used as a template to complete the condyle of the tracings. One tracing is made from the lateral at rest, and three tracings of the lateral picture in occlusion which are used in the following manner: one for Downs'[1] analysis, one for Wylie's[7] analysis, and the third is superimposed on the tracing at rest to make a composite which indicates the rest-to-closure path according to the technique advanced by Thompson[6].

From the headplates we are not only able to distinguish the bony structures, but also the outline of the soft tissue. In addition to serving the different skeletal analyses, they yield information about impactions, the presence of adenoid tissue, the amplitude of the respiratory passages and the position of the tongue. From the lateral film the total facial height can be measured, and the percentage contributions of upper and lower facial heights obtained. The frontal headplate is very useful for the identification of landmarks in the lateral film, for the analysis of asymmetries, for differentiation of right from left in paired structures, and for studying the position of unerupted permanent anterior teeth. Employment of the Wylie-Elsasser[8] compensator permits the taking of accurate linear measurements. It should be pointed out that cephalometric roentgenography is indispensable for the accurate and quantitative evaluation of changes during and following treatment as well as for appraising the effects of growth.

An experienced clinician is able to determine by the study of plaster casts and photographs, the relation in which the dental units and skeletal parts stand to each other and do this with a high degree of accuracy. His knowledge is based on years of experience and the astute judgment often described as clinical sense or "feeling." By means of the present denture and skeletal analysis obtained from a cephalometric x-ray, we may remove analysis from the realm of subjective thinking and translate it into quantitative terms more readily understood by the less experienced and less endowed clinician. We further eliminate the factor of personal opinion which, even among highly skilled clinicians, is likely to vary. This is said with the understanding that this analysis in itself does not give all the answers, nor can it ever be a substitute for models and photographs. Combined with them, it gives a clearer and better understanding of the conditions to be dealt with.

Downs' Analysis

Contrary to certain prevalent misconceptions, this analysis does not tend to classify a given pattern by comparing it to one ideal norm. It does, however, indicate whether the individual pattern is harmonious in its type or not. It determines whether the malocclusion has its origin in a skeletal dysplasia or if it is limited to the area of the denture or whether both are involved. Indications of the regions requiring correction are delineated as well as the possibilities of success.

The most frequent cause of misunderstanding and alienation of the clinician's interest from a cephalometric appraisal lies in the presentation of a set of mean values. The mean values taken individually and separately are not the most important findings and their appearance in a certain pattern does not indicate that this is the most balanced and harmonious skeletal pattern that can exist, but that it is the average harmonious mesiognathic type of face (Fig. 2). Thus there also exist an ideal prognathic type, and an ideal retrognathic type, which are as bal-

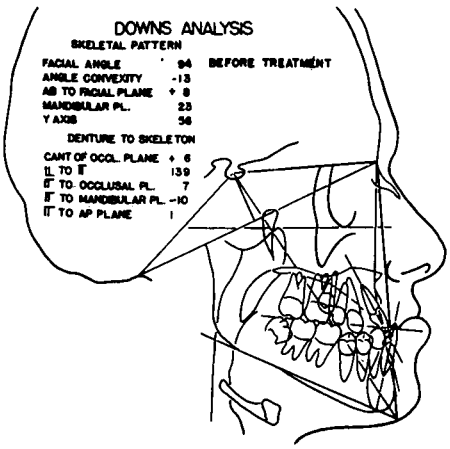

Fig. 2. Tracing of lateral cephalometric roentgenogram demonstrating Downs analysis.

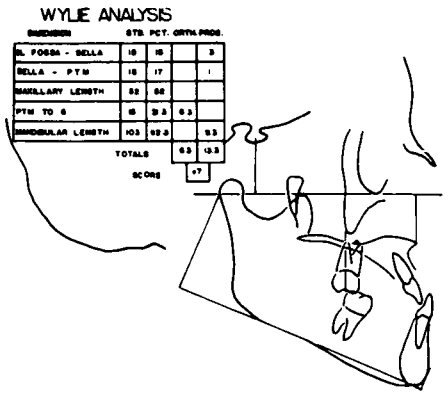

Fig. 3. Tracing of lateral cephalometric roentgenogram showing the Wylie analysis.

anced and harmonious as the first, although their readings would not fall on the mean. Nevertheless, and this is the important factor, when the angular readings taken together, correlate well, the result is balance and harmony for that type. The mean figures mark the point of departure from which the face tends toward the prognathic or retrognathic type. Thus, if the readings depart from the mean in a consistent manner, we are apt to be dealing with a balanced type. On the other hand, if some figures fall toward one side while others tend toward the other, we know that we are dealing with a dysplastic skeletal pattern. This information is of great value for the purpose of establishing a prognosis.

We know that in a well-balanced face, not only the skeletal figures but also the dental readings correlate with each other. This enables us to differentiate between malocclusions which have a skeletal basis and those which are dental in origin. By knowing the type of skeleton with which we are dealing, we can predict the type of denture relation that would be necessary to harmonize with that pattern. This enables us to determine what changes are necessary to bring the denture into balance, not only within itself, but also with the surrounding structures and the rest of the face.

The age of the individual is an important factor in the interpretation of the findings and its implication in treatment. Since the process of growth may alter to some extent the relationships between denture and skeletal parts, the ability to prognosticate the direction and amount of future growth assumes great importance. The early recognition of favorable growth changes may simplify our method of treatment. If future growth is limited, or not to our advantage, the treatment may have to be modified to serve the prevailing condition. At present, the ability to prognosticate growth tendencies on the basis of cephalometric x-rays obtained over a short period is limited. However, encouraging progress is being made in this direction.

Wylie's Analysis

This consists of a method of comparing linear measurements of five different dimensions in the maxilla and mandible to certain standards established from a sample of normal occlusions. Such comparisons permit the observer to localize the sites responsible for

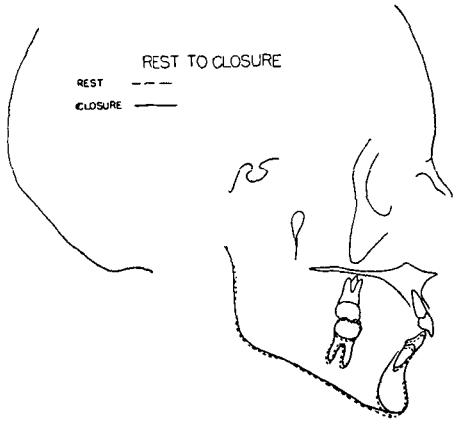

Fig. 4. Rest-to-Closure tracing obtained from lateral cephalometric roentgenograms, depicting the path of closure and the amount of inter-occlusal space.

abnormal molar relationships. (Fig. 3).

The difference between each one of the patient's measurements and the standard value, locates the specific site which is out of proportion. The total set of figures is related in such a manner as to establish a final score which determines the amount of anteroposterior-discrepancy between mandible and maxilla. Depending upon which region is at fault, we may estimate the prognosis for treatment.

A perfect relation of mandible to maxilla is represented by any set of figures which results in a net score of zero. This score can be obtained by any given values which keep the same proportions of the standard, or in which existing deviations of proportion are cancelled out. The final score represents the relation in which the mandible stands to the maxilla; it does not tell, however, in which position these structures are to the cranium and is thus not necessarily indicative of facial type.

In Class II and Class III displacement cases, the net score is frequently inconsistent with the impression obtained from the models in occlusion. Similar discrepancies are also observed in cases in which ramus height is very deficient in relation to total face height. Such lack of correlation is, however, a good indication or warning for carrying out a more detailed analysis of the case.

Rest-to-Closure Tracing

This tracing (Fig. 4) graphically depicts the direction of the path of closure and the amount of inter-occlusal space. Clinical observation of the patient during rest and closure as well as the study of plaster casts, noting axial inclinations, interlocking of cusps, overbite, and the possible existence of facets of wear should serve to supplement the roentgenographic analysis of the path of closure.

Deviations of the normal path may suggest dental impediment to the mandibular movement, or muscle dysfunction, and call for a more critical analysis of the temporomandibular articulation.

Cephalometric Laminagraphy

Laminagraphs are used according to Ricketts' (5) technique as our method of detailed study of the joint. They are taken on all cases in which there are deviations in mandibular movement or any indication of joint disturbances. (Fig. 5). They are also used routinely for all Class II cases, and are of diagnostic value since they clearly and accurately portray the morphology and function of the condyle in the glenoid fossa.

The significance of the freeway space is considered in its relation to the amount of overbite, giving some indication as to the possibilities of obtaining normal incisal relationship. Clinical observation of the amount of overlapping of the incisors at rest, and in occlusion as well as examination of the facial outlines may yield similar and helpful information.

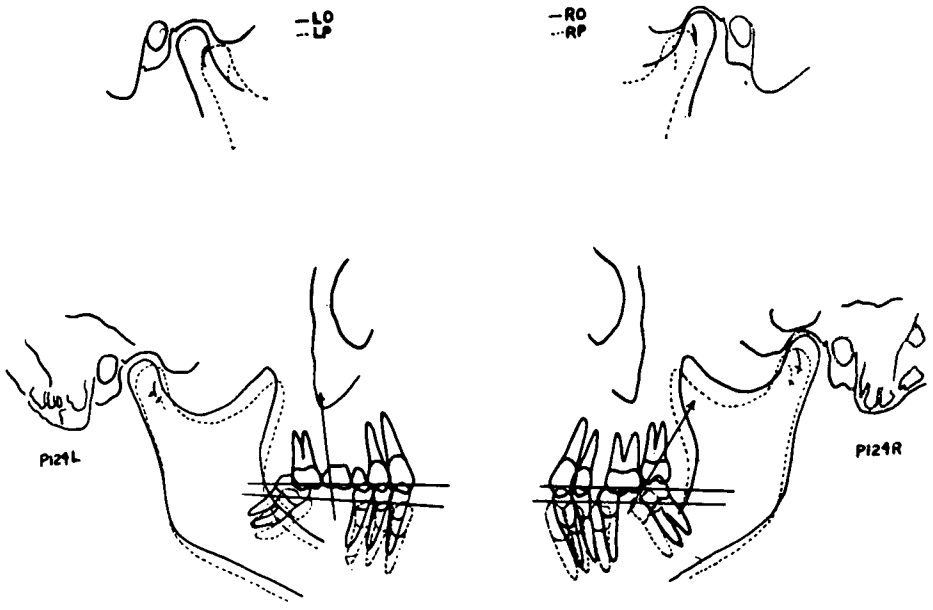

Fig. 5. Tracing obtained from lateral cephalometric laminagraphs, illustrating right and left condylar paths during mandibular movements.

Model Analysis

All preceding methods of evaluation had as their main objective, the determination of the conditions of the structures surrounding the denture, and their possible effects upon the dental units, thus facilitating the interpretation of the conditions presented by the plaster casts.

To evaluate intra-dental relations, accurate casts are indispensable. Models are anatomic reproductions of upper and lower dental arches, plus the alveolar process in the greatest part of its extent, trimmed to their relation in centric occlusion.

For the sake of clarity of discussion, model analysis may be carried out in the following order:

SYMMETRY. This is determined with the aid of Grünberg's (2) Symmetroskope (Fig. 6) The mid-palatal raphé is taken as representative of the mid-sagittal plane, and on the upper model is marked the point where a prolongation of the raphé would cut the incisor teeth. A line perpendicular to this mid-palatal line is made to cross the most posterior positioned first permanent molar at its mesio-buccal cusp. This point, and the corresponding point on the opposite side of the arch is recorded.

After occluding both models, all the points on the upper are transferred to the lower, and finally, all significant marks are indicated by the placing of pieces of solder. This permits the location of the points when the models are x-rayed individually. On the processed films, the mid-palatal and transverse lines are scratched in by uniting the radiopaque points, and thus are established two base lines from which to measure both halves of the dental arch in the anteroposterior and lateral dimensions. Since distal drift of the permanent molars is not likely to occur, the more posteriorly situated molar is considered to be in the least disturbed position, and is taken as the base of reference.

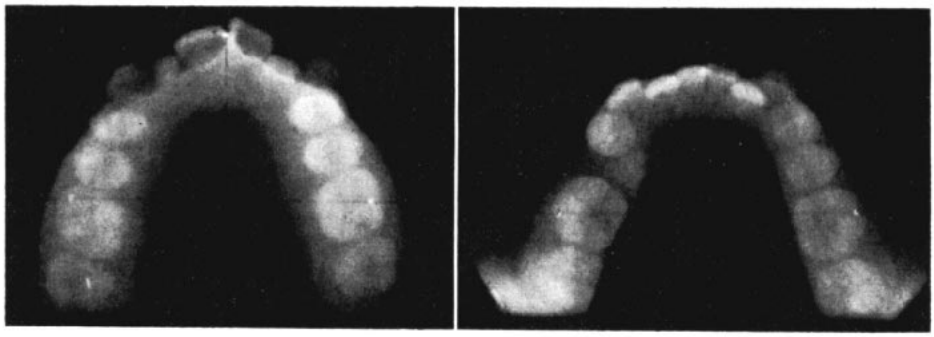

Fig. 6. Photographs of roentgenograms obtained from upper and lower symmetroscoped models.

It is of importance to note the relation of the dental midlines to each other and to the facial midline as represented by the raphé. Deviations of the lower midline are analyzed in order to differentiate between skeletal or dental asymmetries, or to determine the existence of mandibular lateral displacement.

Relation of Tooth Material to Denture Base. This relationship can be observed on the previously mentioned x-rays (a) by means of Howe's (3) analysis, or (b) by means of the Nance[4] analysis.

The films of the cast, taken vertically to the occlusion, permit the visualization of the outlines of the teeth in contrast to a peripheral area demarcating the denture base. Thus, the relationship of the dental arch to its supporting base in a lateral and also anteroposterior direction becomes evident.

(a) *Howes' analysis.* This is a method of evaluating, by means of certain measurements on the maxilla, the relation between the mass of the tooth crowns and that of the supporting bone. The measurements taken are the first bicuspid width, and canine fossa width. The percentage relationship of these widths to the sum of the maxillary tooth material from first molar to first molar, inclusive, will point out any lateral deficiency in the apical base for the given amount of tooth material. The difference between premolar width and canine fossa width may yield an indication as to the possibility of expansion during treatment. In addition, the measurements of the teeth may point to anomalies or discrepancies in tooth sizes.

(b) *Nance's analysis.* This is applied only to those cases which present a mixed dentition. This appraisal is based upon Nance's belief that the existing arch length in the deciduous dentition cannot be permanently increased, excepting those cases in which arch length has been reduced by the loss of deciduous teeth or by lingual tipping of the incisors. The space available in the mixed dentition between the first permanent molar and the lateral incisor is measured and from it is subtracted the sum of the width of the premolars and permanent canines, taken from the intra-oral x-ray, plus a certain allowance for the forward positioning of the first permanent molar. The result of this is the amount of leeway which, when considered in conjunction with the amount of crowding and tipping of the mandibular incisors as well as the axial inclination and relationship of the permanent molars, constitutes a helpful guide in deciding about the proper time of treatment, the necessity of employing preventive measures prior

to treatment. It is employed as an index of the availability of adequate arch length for the accommodation of the permanent denture.

Finally, a detailed description of the dental condition existing in each arch and of the inter-occlusal relations is prepared. The sum of the information gained from all previous analyses, plus the consideration of the forces of occlusion is applied to interpret the picture presented by the plaster casts. A differentiation is made between the effects of muscular disharmony and imbalance, the ill effects of perverted occlusal forces, the malrelation of the arches whether due to disproportion of the skeletal parts or to improper position of the dental units, etc. In other words, "a reason is established for the status of the denture."

In conclusion, it must be emphasized that no one of these methods of appraisal alone may be regarded as more important or decisive than any other in the formulation of the final diagnosis. The diagnosis must represent the summation and correlation of all the findings. It is obvious that, although all of these analyses consider different aspects of the malocclusion, they also overlap and supplement each other in the consideration of the different factors which may contribute to the anomaly.

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