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VARIABILITY IN TRACINGS OF LATERAL HEAD PLATES  
FOR DIAGNOSTIC ORTHODONTIC PURPOSES.  
A METHODOLOGIC STUDY

by

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INTRODUCTION

Cephalometric studies have rendered valuable information of both investigative and diagnostic nature. The measurements obtained are relative, and depending on various biological and methodological factors. The reproducibility of cephalometric landmarks has been investigated following strict, scientific procedures (*Björk*, 1947; *Bergland*, 1963; *Richardson*, 1966). The variability of tracings performed for diagnostic purposes has received less attention, however. In the present investigation measurements from lateral head plates determined for diagnostic analysis were evaluated. The cephalometric angles to which the study is restricted, are all commonly used in the diagnosis of malocclusions. Besides a comparison between operators with different levels of competence in clinical cephalometrics, the magnitude of the methodological error of the angles employed was also evaluated.

MATERIAL AND METHODS

Lateral head plates from three young individuals were used. The plates were x-rayed in a Björk cephalostat in a lateral projection with a focus-M.S.P. distance of 160 cm and a film-M.S.P. distance of 10 cm. The head plates were

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Received for publication, February 10, 1969.

selected from the patient files, and were of an average good quality (Fig. 1). In the following, the head plates will be termed case A, B and C.

Eighteen participants traced the same plates. The tracing was performed on sheets of acetate films. Each participant measured 8 angles from each of the three cases. Thirteen of them were regular dental students who had participated in a short course of cephalometric tracing, in addition to the ordinary orthodontic education in the dental clinic. The remaining 5 were post-graduate students of a two-years course of orthodontic training. The latter will be named post-graduates, while the former will be named students. None of the participants had any particular routine in tracing work except what they had learned during the case analysis of a restricted number of their own patients.

Both groups received printed definitions of the landmarks and reference lines which were to be used in the present investigation. A model of the tracing pattern was also available (Fig. 2). Convenient and identical supplies of adequate light boxes, T-squares etc. were available for both groups. Each participant performed a complete, cephalometric analysis of the different films without access to the result of the others.

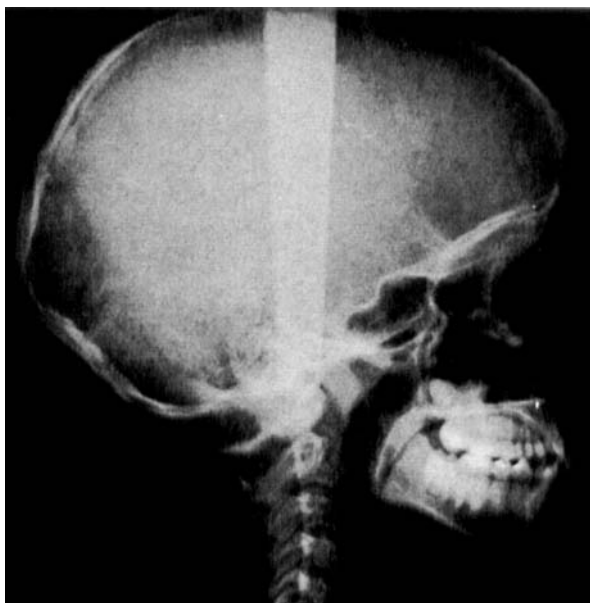


Fig. 1. Profile radiograph representing Case A.

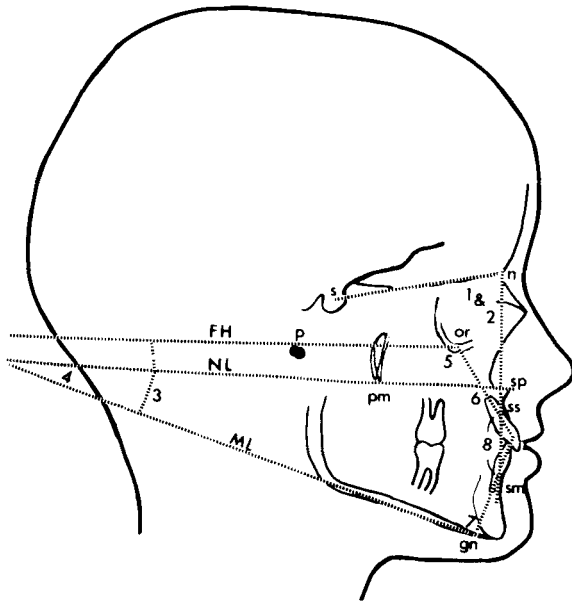


Fig. 2. The tracing pattern of cephalometric roentgenogram; for explanation see text.

#### *Definitions of landmarks*

- sp *anterior nasal spine*: The apex of the anterior nasal spine.
- gn *gnathion*: The lowest point of the mandibular symphysis.
- n *nasion*: The most anterior point of the junction between the nasal and the frontal bone.
- p *porion*: The mid-point on the upper edge of porus acusticus externus located by the ear rods.
- pm *pterygomaxillare*: The point of intersection between the dorsal contour of the tuber maxilla and the nasal line.
- or *orbitale*: The lowest point on the infraorbitale margin. The mid-point is used.
- s *the sella point*: The centre of sella turcica.
- ss *subspinale*: The deepest point on the contour between the anterior nasal spine and the alveolar margin.
- sm *supramentale*: The deepest point on the contour between the chin and the alveolar margin.

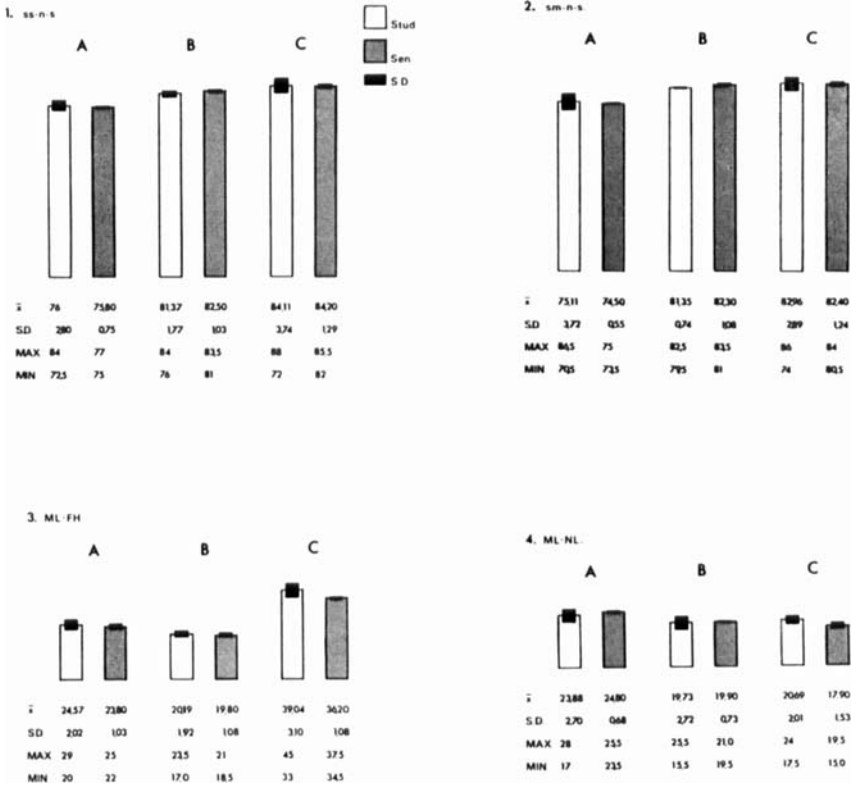


Fig. 3

Figs. 3–4 Graphic illustration of the results of the angular measurements.

A = measurements from case A.

B = » » » B.

C = » » » C.

Stud. = dental student group.

Sen. = post-graduate student.

$\bar{x}$  = average values.

S.D. = standard deviation.

Max = maximum measurements.

Min = minimum »

The abbreviations of the various angles are explained on p. 364.

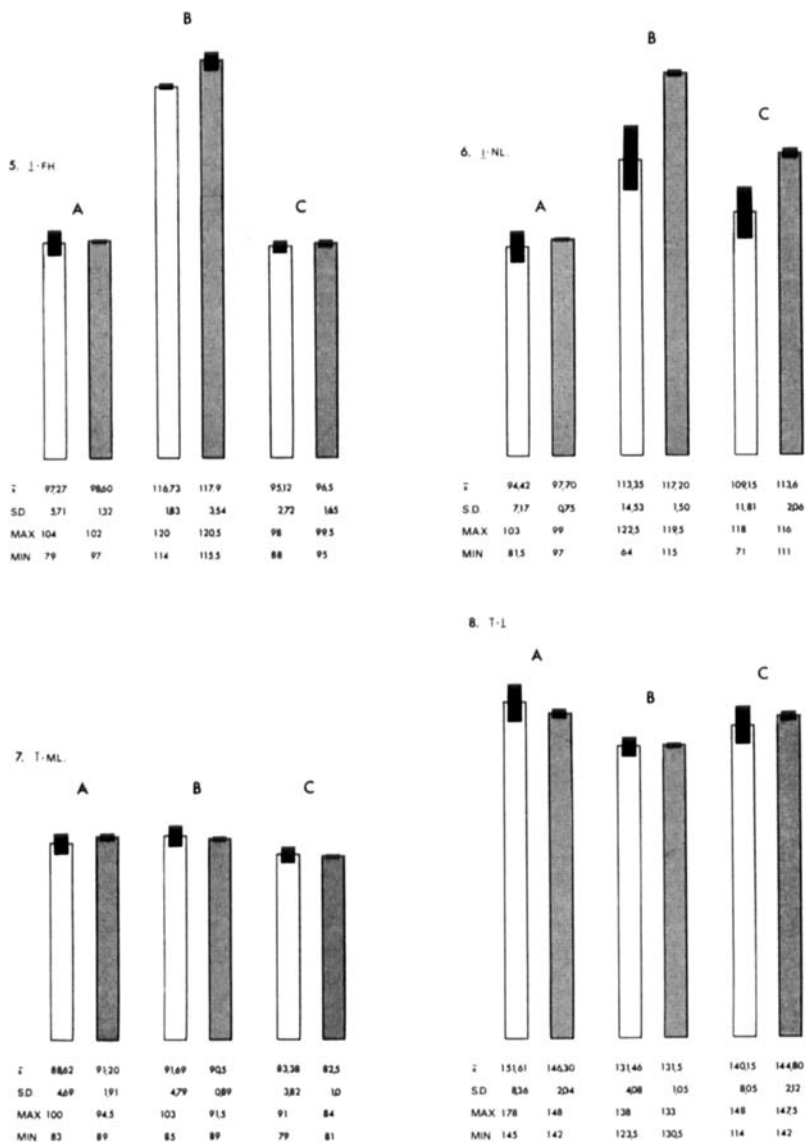


Fig. 4

*Definitions of lines of measurements*

FH: Frankfurt horizontal — a line joining orbitale and porion.

I: upper incisor line — a line through the incisal point and the apex of the upper incisor.

$\bar{I}$ : lower incisor line — a line through the incisal point and the apex of the lower incisor.

OL: occlusal line — a line from the mid-point of the line between the upper and lower incisor edges to pterygomaxillare.

ML: mandibular line — the tangential line of the lower posterior border of the mandible to gnathion.

NL: the nasal line — a line connecting anterior nasal spine and pterygomaxillare.

NSL: the nasion-sella line — a line connecting nasion and sella point.

Where bilateral structures were shown as double images, the mid-point was used.

All angles were measured to the nearest 0.5°.

*Angular measurements*

1. Subspinale-Nasion-Sella (ss-n-s).
2. Supramentale-Nasion-Sella (sm-n-s).
3. ML-FH: The angle between the mandibular line and the Frankfurt horizontal.
4. ML-NL: The angle between the mandibular line and the nasal line.
5. I-FH: The angle between the upper incisor line and the Frankfurt horizontal.
6. I-NL: The angle between the upper incisor line and the nasal line.
7.  $\bar{I}$ -ML: The angle between the lower incisor line and the mandibular line.
8.  $\bar{I}$ -I: The angle between the incisor lines.

## RESULTS

The results of the angular measurements appear in Figs. 3 and 4 in which the average ( $\bar{x}$ ), the standard deviations (S.D.), maximum and minimum values are included.

If the results of the post-graduates ( $\bar{x} \pm \text{S.D.}$ ) are considered acceptable for a case analysis, the frequency of the students tracings which fell within these values were distributed as follows:

Table I  
*Number of acceptable and nonacceptable measurements performed by students*

Angle	1 s-n-ss	2 s-n-sm	3 FH-ML	4 NL-ML	5 I-FH	6 I-NL	7 I-ML	8 I-I
Acceptable	14	14	15	7	17	15	9	11
None acceptable	10	10	9	17	7	9	15	13

The variance of the tracing results of each angular measurement of the two groups was compared statistically. Thus the hypothesis  $\sigma_s^2 = \sigma_v^2$  was tried against  $\sigma_s^2 > \sigma_v^2$

When  $\frac{S_s^2}{S_v^2} > F_{0.95, 12, 4}$  (at the 5% level)\* a significant difference exists between the two groups.

In 16 of the total 24 angular measurements, the post-graduate group showed less variance than the student group. In 7 of the measurements there was no difference. In only one case (case B, sm-n-s) the students had less variability than the post-graduate group. The distribution of significant differences reveals a significant inter-group difference in favor of the post-graduate group.

One might assume, however, that some of the students might be more accurate than the others in the procedure of diagnostic tracing.

Table II  
*Percentage of acceptable measurements performed by each student*

Per cent of acceptable measurements	10-19 %	20-29 %	30-39 %	40-49 %	50-59 %
No of students	2	2	4	4	1

\*)  $\sigma$  = theoretical standard deviation  
 [S<sub>v</sub> = S.D. of post-graduate group  
 S<sub>s</sub> = S.D. of student group  
 F 0.95 = 95 percentile in the Fisher distribution  
 12 and 4 indicate one degree of freedom in each sample

A similar estimation of the post-graduate group is of less interest because 95 % of the values will fall within the accepted variability due to the S.D. employed. The usability of their tracing must therefore be compared with other competent tracers, and the diagnostic value must also be considered in view of the variability of normative, cephalometric findings, i.e. biologic variabilities within a population.

#### DISCUSSION

The use of cephalometric tracings for diagnostic purposes is based on the fact that the greatest source of variation is caused by cranial differences between individuals (*Hatton & Grainger, 1958*). This depends on a tracing procedure which is performed with a certain accuracy.

When comparing the two groups in the present study, it appears that the S.D. of the students exceeded those obtained by the post-graduate group. Comparison by the statistical test also shows a significant difference between the two groups.

The results obtained from the student group are characterized by wide ranges, particularly when dental relations are concerned (Fig. 4). Similar difficulties are also reflected in measurements where NL is involved. The variability is reduced when the landmarks are more easily located. However, for diagnostic purposes the S.D. of a sample of observers is not the only thing of interest. The range of the measurements must also be considered. The wide difference between maximum and minimum values of the tracings performed by students thus generally rejects reliable diagnostic estimation of such tracings. As regards the tracing results of the post-graduate group these show less variability. The values obtained in the post-graduate group can in many cases be compared with those of more experienced operators (*Björk, 1947; Hasund, 1966; Solow, 1966*). The range of their measurements also includes values limiting definite diagnostic conclusions. The observation of the post-graduates must be characterized as usable for diagnostic purposes, with restrictions coherent to the method (*Graber, 1958*).

Differences in the repeatability of various landmarks and angles have earlier been reported (*Richardson, 1966; Hasund, 1967*). Thus Hasund found a significant difference between two investigators when evaluating the angles I-FH and I-NL. For diagnostic purposes the material is usually restricted to one head plate of each individual. Detectable errors are therefore limited to landmark and measurement variability. However, partition of the variability factors has shown that error due to the technical procedure is

small (*Savara et al.* 1966). All errors in this study refer to variability caused by location of landmarks, and to measurement variability. No effort has been made to partition these factors in the present study. Many investigators have pointed out that the variability in landmark location is definitely greater than measurement variability (*Richardson*, 1966; *Savara et al.* 1966). It seems reasonable, therefore, to assume that landmark location variability is responsible for the greatest variability seen in the present study.

As pointed out earlier some differences exist between individuals as regards performing metric observations on casts (*Richardson et al.* 1963). None of the students in the present study had more than 60 % acceptable observations. It can therefore be stated that repeatable measurements requires training and experience. Furthermore, all angles employed in the present study seemed to vary too much when measured by the students. The problem is therefore consistent with basal methodological problems and can therefore not be solved by rejecting some of the angles applied. Some of the variability in the present investigation might be avoided by applying the pinhole technique, i.e. determining the landmark by pinholes whereafter measurement is performed. Methodologically this will introduce a systemic error (*Björk & Solow*, 1962). From an educational point of view, it seems most pertinent to divide tracing procedure performed by unexperienced operators in two stages, whereof the first consists of a controlled localization of the landmarks, whereupon measurement and interpretation of the head plates may be performed.

*Acknowledgements.* The authors are greatly indebted to Miss Grete Bergaust and Miss Thora-Lisa Nilssen for valuable assistance.

#### SUMMARY

A tracing procedure for diagnostic purposes consisting of 8 angular measurements performed by students and more experienced post-graduates has been estimated. The mean and standard deviation of measurements were calculated, and the groups compared statistically.

The post-graduate group showed significantly less variability than the student group, and the results could be used with certain limitations. The student variability was too great in each of these cases to be used diagnostically. None of the students was capable of performing an acceptable tracing procedure in any of the cases. Of the angles employed, none proved easy enough to be regularly used in the student clinic. Dento-facial relationships showed greater variability than the remaining angles, in both groups.

## RÉSUMÉ

DIVERGENCES LORS DE L'ÉTABLISSEMENT DES TRACÉS SUR CLICHÉS DE PROFIL  
DANS LE DIAGNOSTIC ORTHODONTIQUE. ÉTUDE MÉTHODOLOGIQUE.

Cette étude présente l'évaluation d'une technique d'élaboration des tracés destinés à l'établissement du diagnostic et consistant en 8 mensurations angulaires faites par des étudiants et par des diplômés plus expérimentés. La moyenne et l'écart type des mesures ont été calculés, et une comparaison statistique des deux groupes a été faite.

Dans le groupe des diplômés, la variabilité était nettement moins marquée que dans le groupe des étudiants, et, dans certaines limites, les résultats étaient susceptibles d'être utilisés. La variabilité chez les étudiants était dans chacun des cas trop marquée pour permettre une utilisation à des fins diagnostiques. Aucun des étudiants n'était en état d'effectuer des tracés acceptables, quelque fût le cas considéré. Parmi les angles employés, aucun ne s'est révélé suffisamment facile pour pouvoir être utilisé régulièrement dans le travail clinique des étudiants. Dans les deux groupes, les rapports dento-faciaux présentaient une variabilité plus grande que les autres angles.

## ZUSAMMENFASSUNG

METHODISCHEN VARIATIONEN BEI BEFUNDSAUSWERTUNG VON SEITLICHEN  
FERNRÖNTGEN-AUFNAHMEN IN DER KIEFERORTHOPÄDIE

Eine diagnostische Auswertung des kefalometrischen Fernröntgenbildes, bei Verwendung von 8 verschiedenen Winkelmassen, wurde kritisch untersucht, einerseits von Studenten, andererseits von besonders erfahrenen Zahnärzten in fachärztlicher Fortbildung gebraucht. Die Mittelwerte mit Standard Abweichung wurden ermittelt, und die beiden Gruppen statistisch verglichen.

Die Gruppe der erfahrenen Zahnärzte zeigte weniger Variation als die Studentengruppe. Der Unterschied war statistisch signifikant, und die Resultate konnten mit gewissen Einschränkungen benutzt werden. Die Variation unter den einzelnen Studenten war in gegebenem Falle zu gross um die Auswertung diagnostisch zu verwenden. Keiner der Studenten war fähig eine vollständige Auswertung des Fernröntgenbildes vorzunehmen. Unter den benutzten Winkeln war keiner einfach genug, um in der Hand von Studenten diagnostisch zuverlässig gebraucht zu werden. Die ermittelten Winkelwerte zwischen Punkten im Zahnbereich und Punkten im Bereich des Gesichtsschädels schwankten mehr als die übrigen Werte, in beiden Gruppen.

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