Positive Translucencies

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Cephalometrics is very much a part of orthodontics, both for the clinician and the researcher. The line drawing made on tracing paper has been the main method enabling the orthodontist to reduce the various anatomical configurations as seen on the original cephalometric headplate into a workable form. However, a considerable amount of valuable information may be overlooked if either the clinician or the research worker relies solely on the few isolated points and lines as shown on a tracing.

Thus, two methods have been available to the orthodontist wishing to make a critical analysis of any cephalometric radiograph. It is possible to locate landmarks, draw a construction, and measure directly upon the negative, but thereby damage this record; or make a tracing using some suitable material upon which the analysis can subsequently be made. The latter method is time consuming. It takes between five and ten minutes for an experienced operator to prepare a good tracing and the work, unfortunately, cannot usually be delegated to auxiliary personnel.

Using time to the best advantage in clinical practice has become increasingly important to all those in the profession. The clinician has sought faster methods of moving teeth, increasing assistance from auxiliary personnel, and a more streamlined method of practice administration. The researcher has been faced with the problem of obtaining data from large numbers of headplates rapidly and without damage to the original radiographs.

The positive translucencies as described in this paper can save the orthodontist the time spent in tracing, as the translucencies can be easily produced by auxiliary personnel who have been trained in the usual processing procedures for cephalometric radiographs. The technique embodies many other advantages for the clinician, teacher and research worker. Being simply a contact print made on a matte surfaced translucent film, it shows all the anatomical details of the original radiograph and can be marked or drawn upon with considerable ease. The type of translucency described in this paper is made by placing the original negative cephalometric headplate in contact with an 8 x 10 inch sheet of matte surfaced film. The film is exposed to a suitable light source for a predetermined time after which it is developed using standard equipment and chemicals (Figure 1).

Thurow's[1] excellent technique using positive translucencies was reported at a time when the writers were experimenting with a similar photographic method. Subsequently, the writers adopted Thurow's methods with some modifications. The clinical advantages of the positive method over the usual training technique include the presence of all the anatomical detail of the original headplate plus the added versatility of combining both positive and negative headplates. Thus the

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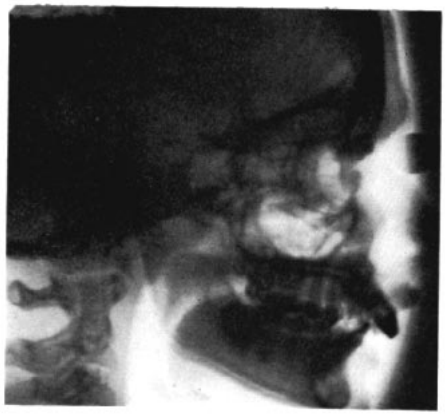

Figure 1 Shows an example of the positive translucencies described in this paper.

combination of a positive translucency made from the original headplate of a patient when superimposed by a new negative cephalometric radiograph will show, strikingly, the changes due to growth or treatment as bas-relief areas. Comparisons of different individuals can also be made by superimposing positives from one individual with negative headplates from another.

The use of a positive translucency on which a construction can be drawn, measurements made and still retain other anatomical details besides those of immediate interest to the operator is of value in diagnosis. This is especially true when the exacting task of tracing does not have to be performed. However, any method requiring the reproduction of an original headplate in order to undertake a cephalometric analysis requires that the accuracy and errors associated with the method be known.

This paper deals with the technique, possible modification, and with its critical appraisal in regard to accuracy as compared with the tracing method. Little stress will be placed on the numerous clinical advantages to be gained by making positive translucencies as these are discussed in detail in the literature.

Materials and Methods

The use of a printing box consisting of a standard printing frame combined with a suitable light source and electric timer ensured standardization of the procedures (Figure 2). Kodak commercial matte film was used for reproducing the negative cephalometric headplates. This film proved most satisfactory and may be processed using the usual x-ray film developer, the developing time being approximately double that of the regular headplate film. While Kodak Matrix film gives good positives which have a matte surface on both sides, this film cannot be satisfactorily processed in x-ray developer.

The optical density of the headplate to be printed may be determined using a densitometer. However, while working with the technique, it was found that a densitometer was not required as the exposure time could be determined quite accurately by assessing the density of the original headplate from a simple "grey scale". A suitable exposure time was computed by comparing the headplate to be printed with a series of four other headplates with graded optical density, the exposure

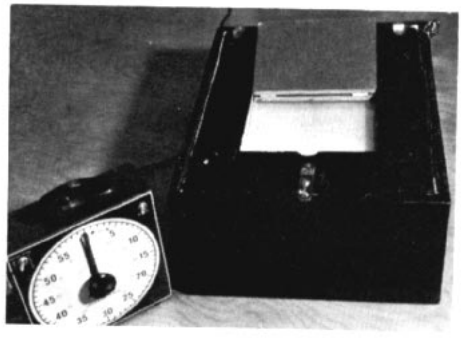

Figure 2 Showing the printing box used to produce the matte positives from the cephalometric radiographs.

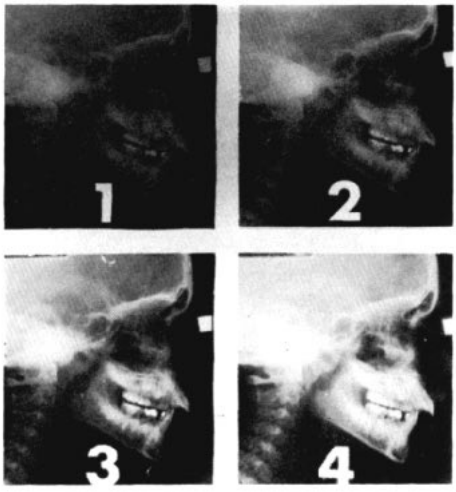

Figure 3 This series of radiographs form a "grey scale" which is used for comparison to determine the exposure time for any radiograph to be copied.

times to five good positives from each radiograph of this series being predetermined (Figure 3). The exposure and subsequent processing were undertaken under safe light illumination.

Having decided on a workable technique, the writers became obligated to test the method in regard to accuracy as compared with the usual tracing methods. A study was set up to determine the subjective impression of clinicians as to the value of the procedure, the relative accuracy of positive translucencies as compared with records prepared by the tracing method, and the errors associated with both methods.

Ten operators trained at the same institution performed a Downs analysis plus the length of S-Na, and the upper and total face heights on the records made from two lateral head radiographs (A and B). A series of questions was given each operator to determine their subjective impression of the value of the two methods being studied. In order to maintain uniformity a strict sequence was followed when the operators analyzed the tracings and the positive translucencies. On the first day tracings were made of the two negatives and the measurements were recorded. After completing this task they drew reference lines on the positive translucencies made from the negatives and recorded the measurements. A period of between six hours to twenty-four hours elapsed between the analysis of the tracings and the positives. Fourteen days later the operators repeated the tracings and positive analyses. They also answered the questions for the subjective appraisal.

The data obtained from this study were analyzed statistically. The difference between the values obtained with the positive translucency technique and the negative tracing method was obtained for each combination of operator and radiograph. A persistent difference between the methods would indicate a "bias" associated with one of the methods; or a differential between the methods if neither were to be considered absolute. Average differences and estimated standard deviations of the average differences were obtained and are presented in Table 1.

In order to compare the two techniques further, a more sophisticated analysis of the errors and their component parts was made. Each procedure was analyzed separately. A technical error and a total error was postulated for each method. The technical error is a measure of the lack of repeatability of an individual operator when making repeated observations on the same radiograph at weekly intervals. The total error includes the technical error and also measures the lack of repeatability among operators. The total error is an overall measure of error associated with a single observation by these operators. In the analysis these errors were measured in the sense that their standard deviations are estimated and presented in Table 2.

TABLE 1

DIFFERENCES BETWEEN NEGATIVE AND POSITIVE TECHNIQUES

Variant	Mean for 10 operators Two observervations—1 Wk. Apart per operator				Mean difference between Negative and Positive Techniques		
	Radiograph A. Neg.	Pos.	*Radiograph B.* Neg.	Pos.	Diff. A.	Diff. B.	S.D. of Diff. A. or B.
Facial Angle	90.70	90.90	83.13	82.05	–0.20	1.08*	0.51
Angle of Convexity	19.60	20.50	11.13	10.98	–0.90	0.15	0.48
A-B Plane	–18.10	–18.70	–7.90	–7.68	0.60*	–0.22	0.25
Mandibular Plane	17.18	17.50	29.88	30.20	–0.32	–0.32	0.33
Y-Axis	50.92	51.20	58.38	59.65	–0.28	–1.27*	0.45
Occlusal Plane	5.23	5.08	9.60	10.21	0.15	–0.61	0.39
Interincisal	113.33	112.82	136.43	136.18	0.51	0.25	0.68
$\overline{1}$: Occlusal Plane	29.63	29.39	21.48	20.74	0.24	0.74	0.55
$\overline{1}$: Mandibular Plane	17.28	17.60	1.35	0.83	–0.32	0.52	0.62
$\underline{1}$: A-P (mm)	9.73	9.42	3.28	3.53	0.31	–0.25	0.71
S-Na (mm)	75.23	74.75	73.09	72.68	0.48+	0.41+	0.27
UFH (mm)	49.49	49.84	46.80	46.18	–0.35	0.62*	0.31
TFH (mm)	104.38	104.50	107.93	107.53	–0.12	0.40	0.30

* Difference significant at the 0.05 probability level

\+ Differences large and with same direction for both original radiographs.

TABLE 2

ESTIMATED STANDARD DEVIATION OF TECHNICAL ERRORS AND TOTAL ERRORS

Variant	Positive Translucency S.D. of Tech. Error	S.D. of Total Error	Negative Tracing S.D. of Tech. Error	S.D. of Total Error	Differences S.D. of Total Error
Facial Angle	2.69	2.69	1.07	1.89	0.80
Angle of Convexity	1.16	1.88	1.00	1.04	0.84*
A-B Angle	0.51	1.07	1.40	1.52	0.45
Mand. Plane Angle	1.76	1.76	1.19	2.07	0.31
Y-Axis	2.84	2.84	1.06	1.67	1.17
Occ. Plane Angle	1.25	2.20	1.64	2.20	0.0
Interincisal	1.98	3.85	2.12	2.99	0.6
$\overline{1}$: Occlusal Plane	2.31	2.65	1.39	1.54	1.11*
$\overline{1}$: Mandibular Plane	2.54	3.14	1.44	2.04	1.1 *
$\underline{1}$: A-P (mm)	0.73	1.56	1.73	3.24	1.68*
S-Na (mm)	0.56	0.86	0.41	0.95	0.09
UFH (mm)	1.02	1.76	0.92	1.93	0.17
TFH (mm)	2.49	2.49	2.33	2.48	0.01

* Difference significant at the 0.05 probability level.

Results

The results of the subjective appraisal showed that the operators were undecided with regard to which method gave the greatest anatomical detail. Slightly more than half considered the negative to yield better soft tissue detail. The answers showed no bias when consideration was made as to the overall ease of making measurements. The operators were unanimous in considering the positive method less time consuming.

Table 1 reveals that there are no significant differences between the two methods in most of the variants considered. In some cases, however, there are anomalous differences that reveal themselves in one or other radiograph. Though probably real, these differences are all small when compared with the average value for the negative tracing technique. Thus in making the facial plane measurement, the positive translucency method gives a reading about 1.1° lower on the average with Radiograph B. This is a bias of only about 1.3% when compared with the average reading of 83.1° for the negative tracing technique on this radiograph. This bias is not evident on the other radiograph. Likewise, a difference of 0.6° or 3.3% is revealed on the A radiograph when measuring the A-B plane. In none of these cases is there a concomitant difference in the other radiograph even though the magnitude of the measurement is about the same. These differences are considered by us to be small real biases. In the light of the errors of either technique presented in Table 2, they are considered almost negligible. Of course, they would be of no importance if comparative measurements are to be made using a single method—either positive translucencies or tracings from negatives.

Table 2 indicates the comparative size of the errors for the two methods for each variant. Out of thirteen variants considered, four show a significant difference in the magnitude of the total error between the two methods. In three out of four cases the negative

TABLE 3

SHOWING ERRORS ESTIMATED SEPARATELY FOR EACH RADIOGRAPH

Variant	Posistive Translucencies S.D. of Total Error Radiograph *A*	Posistive Translucencies S.D. of Total Error Radiograph *B*	Tracings S.D. of Total Error Radiograph *A*	Tracings S.D. of Total Error Radiograph *B*
Facial Plane	1.52	3.46	2.98	1.44
Angle of Convexity	2.34	1.26	1.02	1.07
A-B Angle	1.27	0.82	2.06	0.61
Mandibular Plane Angle	1.94	1.46	2.48	1.55
Y-Axis	1.98	2.49	1.78	1.55
Occlusal Plane Angle	2.72	1.50	2.54	1.79
Interincisal	3.54	4.13	2.69	3.27
$\overline{1}$: Occlusal Plane	2.90	2.38	1.34	1.81
$\overline{1}$: Mandibular Plane	3.78	2.33	1.93	2.14
$\underline{1}$: A-P (mm)	1.30	1.78	4.48	0.95
S-Na (mm)	1.07	0.58	0.66	1.17
UFH (mm)	1.43	2.03	2.26	1.53
TFH (mm)	2.54	1.81	3.22	1.36

tracing technique has the smallest total error. In the other case the procedure using the positive translucencies has the smallest total error. There seems to be little basis for choosing one method over the other as regards the size of errors.

The results of a preliminary analysis of error in which standard deviations for the total error were estimated for each method and radiograph are presented in Table 3. From this information, compared with Table 1, it was observed that there was no systematic dependency of the total error on the radiograph used, i.e., on the magnitude of the variant being measured. It was felt by the investigators that it was possible to "pool" the error estimates and present a single estimate for each variant and each method as has been done in Table 2. In fact, one thing that impressed the investigators was the constancy of the standard deviation of the total error over the variants as well as the methods. The error seems to be about the same for all variants and for both methods—a figure of about 2.1 sufficing for both methods, and all variants whether angles or linear measurements.

It should be pointed out that although the total error, as measured by the standard deviation, remains fairly constant, the *relative error,* as measured by the ratio of standard deviation of the errors to the average value, will vary immensely. Thus, a measurement of the lower central incisor to the mandibular plane averaging 1.1 as it did for radiograph B will have a *relative error* expressed or a percentage of $\frac{3.14}{1.1} \times 100 = 285$ per cent by the positive manner and $\frac{2.04}{1.1} \times 100 = 185$ per cent by the negative tracing technique. Similarly, large relative errors would be obtained for the upper central incisor to A-P plane if this measurement were as low as 3.3 to 3.5 mm, as it was on radiograph B. In this case, however, the positive method would have the smaller relative error.

Discussion

As a result of this study it may be concluded that the errors associated in both the tracing method and the technique using positive translucencies are fairly large. However, as no consistent bias was found in the statistical analysis, it appears that both methods are comparable with regard to accuracy.

Various modifications may be made to the basic procedure rendering the method very flexible. If one has access to a photographic enlarger, it is possible to superimpose a photograph of the patient's profile on to the positive films by a double exposure technique. This procedure consists of projecting the image of the profile at the correct magnification on to the negative headplate in the tracing box. A sheet of matte film is placed over the negative in the box, and an exposure is made first of the headplate and then of the profile. The basic technique may be varied slightly in order to make provision to record the results of the analysis directly on the positive. This is done by preparing a negative of the standard analysis and placing this over a clear area on the negative headplate before an exposure is made in the printing box. A narrow, clear area is easily made on each headplate by simply attaching a strip of lead of convenient width to the front surface of the cassette before the original cephalometric headplate is exposed. Similarly, profile and frontal photographs of the patient may be printed in place of the analysis blank.

Pencil lines drawn on the matte positive are easy to see, but if a more permanent record is required, certain reference lines may be placed photo-

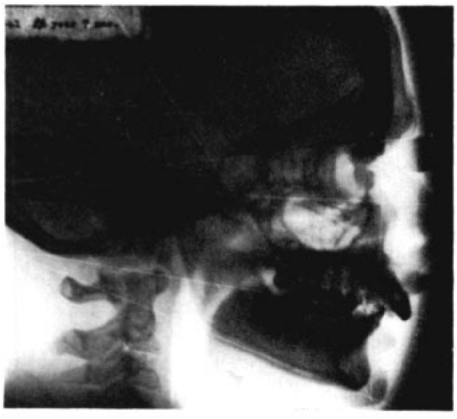

Figure 4 Showing grid lines superimposed on a positive translucency as an aid to the subsequent analysis.

graphically on the positive. This is done by localizing an adjustable wire grid in the printing box on the original negative headplate before an exposure is made (Figure 4). This otherwise excellent procedure, unfortunately, involves the clinician in locating anatomical landmarks and adjusting the wire grid before the positive can be made.

Conclusions

1. Positive translucencies have proved to be a useful method of reproducing headplates for the purpose of analysis. The technique has also been shown to have considerable flexibility.
2. The positive translucency method discussed here introduces no large bias (as compared with the negative tracing method) in any of the variants considered. In fact, there is no evidence of any bias whatsoever in most of the variants.
3. The errors introduced by the lack of repeatability in an observer and among observers are not consistently different for the two methods.
4. The lack of repeatability (called errors here) associated with either method may be very large. This is so particularly if the error is considered relative to the average size of a measurement.

Summary

Positive translucencies have been shown to have numerous advantages over the usual tracing method and some modifications to the basic technique have been mentioned. A critical analysis of both methods has been made with regard to the accuracy and errors associated with both methods.

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