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A Comparative Study of the Temporomandibular Joint Area Using Laminagraphic and Panographic Surveys

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A COMPARATIVE STUDY OF THE TEMPOROMANDIBULAR JOINT AREA USING LAMINAGRAPHIC AND PANOGRAPHIC SURVEYS

By

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An Abstract of a Thesis in Partial Fulfillment of the Requirements for the Degree Master of Science in the Field of Orthodontics

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ABSTRACT

The relative merits of laminagraphic and panographic radiographic images of the temporomandibular joint area have been compared.

Serial temporomandibular joint area radiographs were taken with a panographic unit. A dried human skull was used as the study subject. Wire grids were placed over the temporomandibular joint areas. The linear and angular distortion of the wire grids was measured with the plane of occlusion being serially tipped horizontally from minus fifteen degrees to plus fifteen degrees.

Lateral laminagraphs were then taken of the same skull with the wire grids still in place to determine the accuracy of the laminagraphic technique as compared to the panographic technique.

A second study was done with five dried human skulls. Each was radiographed laminagraphically and panographically. The results were then compared by measuring the differences linearly between the two images of the same condyle head.

The third part involved a clinical study of fifty temporomandibular joint areas which had been panographically and laminagraphically radiographed as part of an orthodontic screening program at Loma Linda University.

The results were as follows:

Magnification, angular and linear distortion of the temporomandibular joint area was present in all panographic radiographs. The least being when the occlusal plane of the study skull was positioned at zero degrees. As the chin is raised or lowered, the linear and angular distortion is increased proportionally.

The lateral laminagraph of the same skull with the wire grids still in place, showed the grid image to be visually distortion-free.

The comparison study using the five skulls which were panographically and laminagraphically radiographed showed an overall magnification of sixteen to seventeen percent of the condyle heads in the panographs. General morphologic similarities of the same condyle head were noted between the laminagraphic and panographic techniques.

The clinical comparison study of the fifty temporomandibular joint areas showed many morphological dissimilarities in the condyle heads between the two techniques. This was felt to be caused by the laminagraph operators failing to take a deep enough "cut" or section through the condyle head, therefore; the laminagraphic image of the condyle head was more narrow and shorter than the panographic image of the same condyle head as it failed, in many cases, to show the true anterior and posterior borders of the condyle head.

Both the laminagraphic and panographic techniques have their merits and drawbacks. The value of each technique depends on the knowledge, skill and care that the operator excercises when obtaining either kind of radiographic survey of the temporomandibular joint area.

Because of the ease of reproducibility and standardization, the laminagraph appears to be superior for measuring the position of the condyle in the fossa, i.e. for ascertaining anterior, superior or posterior displacement.

When one considers the amount of standard deviation present in the clinical comparison study of both laminagraphic and panographic surveys, it is evident that in only a few cases is it possible to correlate a panographic survey of the same area with a laminagraphic survey of the same area on a one to one basis. At best, one could predict that the panographic survey will be magnified when compared to the laminagraphic survey and that morphologically, the shapes of the same condylar head will likely be dissimilar comparatively and no correlation is likely to be made between the two different methods.

However; if proper care is excercised, both types of radiographs may be of diagnostic value. From the findings obtained in this study, the writer thinks that the panographic technique is the most valuable for screening for temporomandibular joint pathology due to its ease of use, its readily availability and low patient dosage of radiation. When more definition is required of the temporomandibular joint area, a laminagraphic survey, using the proper techniques, is indicated.

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Each person whose signature appears below certifies that this thesis in his opinion is adequate in scope and quality, as a thesis for the degree Master of Science.

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INTRODUCTION

Statement of the Problem:

As the level of dental care has been improved, increasing emphasis has been placed on the temporomandibular joint area not only by the dental profession, but by the medical and legal professions as well. The incidence of temporomandibular joint disease has been the subject of much dispute over the last three decades and will continue to be a much studied area for many years, (Blair et al 1973), with primary interest being placed on the interpretation of radiological data of this area.

It is important to take the evaluative tools presently available and attempt to utilize them more effectively by critically analyzing data obtained from them. It is also vital to effectively interpret this information and apply it to formulating a correct diagnosis and treatment plan.

The three most readily available and useful tools for radiographically evaluating the temporomandibular joint area by the dental practitioner are the Updegrave method which uses a specially constructed headboard to position the patient's head so that a slightly-modified dental x-ray machine may be used to make radiographs of the temporomandibular joint area (Updegrave 1953), The plane-surface laminagraph machine, henceforth referred to as the laminagraph, and the curved-surface laminagraphic machine, which will be referred to as the panograph. The Updegrave method causes significant image enlargement as the distance from the object to the film is greater than either the laminagraphic or panographic techniques. Therefore, the scope of this study will include only the laminagraphic and panographic techniques.

Laminagraphy has been in use since 1929 and when properly executed has been demonstrated to be a very accurate and helpful diagnostic method. (Blair et al 1973, Stanson 1976). The major drawback of laminagraphy is that the unit itself is bulky and the expense of purchase and installation of such a machine in a private office is nearly prohibitive.

The introduction of panographic laminagraphy is a relatively recent development in the field of dental radiology. The first clinical machine (the Panorex) was marketed in the United States in 1957. (Hudson et al 1957). The machine has been improved throughout the years and is presently sold by the S.S. White Company. The original panographic machines were not without limitations but were found to be particularly adaptable to placement and use in the offices of oral surgeons and orthodontists. (Kraske 1961, Kite 1962, Mitchell 1963). The many panographic machines available today have been greatly improved, their cost is less than half that of a dental laminagraphic machine and as a result, their use is widespread in the dental and medical professions.

Although the panographic machine was not designed primarily for evaluation of the temporomandibular joint area (Coin 1974), it could lend itself well to this task as this area is usually included in each panographic radiograph. (Grieg 1973). There are techniques for taking specific surveys of the temporomandibular joint area with most of the panographic machines available today but most operators are not aware of them. (G. E. Panelipse operating manual, 1977).

Since the temporomandibular joint area is usually at the outer perimeter of each film, it follows that there will necessarily be some distortion present. (Christen 1968). The questions now arise; Can the amount of distortion of the temporomandibular joint area be quantified? If so, can the panographic temporomandibular joint image be correlated to the laminagraphic image of the same temporomandibular joint area in a way which would be considered to be relatively accurate? (Coin 1974). And further, can serial panographic films be taken in a standardized position to quantify pathologic or growth change?

Objectives of this Study:

1. Attempt to measure the amount of linear and angular distortion of the temporomandibular joint area on the radiographs taken with the General Electric Panelipse panographic laminagraphy machine. These radiographs will be analyzed and the best position of head placement which produces the least amount of distortion to the temporomandibular joint area will be ascertained.

2. Attempt to correlate, under controlled laboratory conditions, laminagraphs and panographs of the same temporomandibular joint areas using the condylar heads of the mandible as a reference point.

3. Attempt to clinically demonstrate a correlation between laminagraphs and panographs of the same temporomandibular joint areas using diagnostic records which have been made for orthodontic screening purposes at the Department of Orthodontics at Loma Linda University.

CHAPTER II

REVIEW OF THE LITERATURE

History of Laminagraphy:

Most of the early work in laminagraphy was done primarily in Europe. The first reference found in the literature is when a Frenchman, Bocage (1922) applied for a French patent in June 1921. This patent described the methods of "planigraphy", as it was then called.

Bocage's methods were described four months later by Portes and Chause (1922). It was proposed that this method be used for deep therapy treatment.

Pohl (1927), in Germany, described the principles of laminagraphy on a 1927 patent application.

In 1922 in the United States, Keiffer (Andrews 1936), working independently, derived these same principles of laminagraphy and designed a practical machine in 1929. He claimed not to be aware of the work of Bocage, Portes, Chause and Pohl.

Until 1931, the early work in laminagraphy in Europe was largely theoretical in nature. Vallebona (1931), put laminagraphy into practical use by making body section laminagraphs, or "stratigrams" as they were then called. Vallebona's method differed from those of other investigators in that the object and film moved rather than the target and film.

Another independent investigator, Ziedes de Plantes (1931), arrived at the principles of laminagraphy in 1921-1922 but did not work out the mechanism until 1928-1931. When his first paper was published in 1931, he was made aware that Bocage had taken out a patent in 1921 and Pohl in 1927. However; niether of these men had put the principles of laminagraphy to practical use. Later, in 1933, Bartelink (1933) demonstrated results obtained by the principles described by Ziedes de Plantes.

Grossman (1935) made further refinements in the methods of laminagraphy and made an extensive study of the mathematical and geometric principles of laminagraphy. He constructed one of the most simple and practical laminagraphic machines up to that time.

Laminagraphy of the temporomandibular joint area was reported by Petrelli and Gurley (1939), Their paper contained laminagraphs of the temporomandibular joint area which were of excellent quality. Later, the principles of laminagraphy were reviewed by Ricketts (1962) and according to him was the most effective means of observing the condylar head of the mandible and associated structures. Ricketts (1950, 1952) has also done prolific research in which laminagraphy was used for the study of orthodontic treatment and temporomandibular joint dysfunction. Yale (1961) and associates have also researched the mandibular condyle on dried human skulls using the principles of laminagraphy.

It has been found by Williamson (1976), that some condyles may be distorted to an exaggerated degree by simply changing the angle of exposure on the laminagraphic machine from the standard twenty degree exposure angle. It is felt by Yale (1961), that the standard angle of twenty degrees between the condylar head and the laminagraphic film plate cannot be used to accurately assess condylar morphology since this method does not demonstrate the true anterior and posterior condylar borders. He maintains that the central ray does not pass through the mediolateral axis of the condyle head and a mistaken view of the structure may be assumed. Both Williamson and Yale advocate the use of a submental vertex x-ray prior to the laminagraphic series so that the proper angle between the condyle head and the film plate may be ascertained.

History of Panography:

According to Blackman (1960), a young German, Hekman, was the first person to apply the principles of laminagraphy to curved surfaces, such as the head. Unfortunately, his work was interrupted by the outbreak of World War II.

Paatero (1948), a Finnish researcher, continued with the work started by Hekman. His first work was published in 1948 and outlined the theoretical principles of laminagraphy as applied to curved surfaces. He called this technique "pantomography". In 1949, he produced the first "cranial chart", a radiograph of the human head on a flat sheet of x-ray film. By 1950, Paatero had constructed a prototype of the forerunner of the modern panographic machine. He used a straight moving film and a hand rotated chair. (Paatero 1961). He was active in the field of curved-surface laminagraphy until his death in 1963 and made many refinements in the techniques and machinery of this method.

In the United States, Nelson and Kumpula (1952), adapted an x-ray machine to produce panoramic radiographs of the maxillary and mandibular arches. Kumpula later helped develop a rotational laminagraph at the National Bureau of Standards Dental Research Laboratory in cooperation with the United States Air Force School of Aviation Medicine. (Hudson 1955). The prototype was constructed and tested by 1957 and was used for mass dental surveys. (Hudson 1957). Later the X-Ray Manufacturing Corporation of America refined this prototype and produced it under the name of Panorex. Later the manufacturing rights were sold to the S.S. White Company which still markets the machine.

Blackman (1960), has been one of the pioneers of curved-surface laminagraphy in England. He was instrumental in the development of the Watson Rotograph which differs from conventional panographic machines in that all three units, the dental chair, the craniostat and the flat film table rotate synchronously during normal exposures at exactly the same speed, the dental chair and craniostat in a clockwise direction and the film table in the opposite direction.

The techniques of curved-surface laminagraphy have been developed and refined over the past twenty years and many different brands of machines are available to the professions today offering many improvements and refinements as a result of this continued investigation. In a report by the American Dental Association Council on Dental Materials and Devices (JADA, Jan. 1977), the advantages and disadvantages of the use of panographic techniques are listed as follows:

<u>Advantages:</u>

- -It is a simple procedure to perform.
- -It is convenient for the patient.
- -It can be used on patients with intractable gagging problems.
- -The time required for the procedure is minimal.
- -Those portions of the maxilla and mandible lying within the focal trough of the machine can be visualized on a single film.
- -The patient radiation dose is relatively low but not negligible.
- -Panographs taken for diagnostic purposes also can be useful as a visual aid in patient education.

<u>Disadvantages:</u>

- -Areas of diagnostic interest out of the focal trough may be visualized poorly or not at all.
- *-Panographs inherently show magnification, geometric distortion and poor definition.
- -Overlapping of the teeth commonly occurs, particularly in the bicuspid areas.
- -The anterior teeth register poorly when they have pronounced inclinations.
- -The spinal column may interfere with the production of the radiograph.
- *-The amount of vertical and horizontal distortion varies from one part of the film to another.
- -The ease and convenience of obtaining a panographic survey may encourage careless evaluation of a patient's specific radiological needs.
- -Artifacts are easily misinterpreted.

We may surmise from the above report that distortion * is one of the disadvantages of the panographic technique. Kite, Owen et al, (1962), published an article on panographic image distortion; they concluded that the variation from region to region and from film to film was statistically too great for correlation. Thus, it is felt by some that panographic films cannot be measured directly, for the amount of distortion is too great without some method of correction.

In another article Kite, Swanson et al, (1962), published an article on panographic image distortion; they attempted to assess linear image distortion of the jaws using calibrated wires intraorally. This survey indicated that variation in image distortion did occur and a single correction factor could not be applied even to the small segments with clinically acceptable accuracy. Variation in actual measurements occurred because of differences in overall size and shape of the areas compared.

In an unpublished thesis, Conley (1962), described a method for measuring the amount of distortion in the dental and tooth-bearing areas of panographic radiographs. Metal implants were used to measure linear distortion. They were placed at the external periphery of a plastic bite fork which was used as a means of standardizing head placement in the panographic machine.

Christen (1968), used metallic markers on dried human skulls which were then panographically radiographed for evaluation. He showed that vertical enlargement of the mandibular ramus could range from 10% to 14% under normal positioning and vary even more when the head was eccentrically placed. Horizontal compression could be as much as 34% with extremely eccentric positioning of the head.

Coin (1974), gives high marks to the usefullness of panographic surveys of the teeth and tooth-bearing areas but maintains that laminagraphy is the method of choice for studying the temporomandibular joint area. This concurrs with Ricketts' paper which was published in 1962.

In a study published by Blair et al, (1975), laminagraphy was visually compared with panography using patients with temporomandibular joint pathology as the area of study. It was found that the laminagraphic radiographs were diagnostically superior to the panographic radiographs but there was a high degree of concordance (94%) between the two methods for diagnosing temporomandibular joint pathology.

It is obvious from reviewing the literature on the subject of interpretation of the amount of distortion found in panographic radiographs of the temporomandibular joint area that the investigators are hardly in agreement. Many questions are still unanswered and further study must be done to ascertain the relative accuracy of the radiographic image to that of the actual temporomandibular structure.

CHAPTER III

MATERIALS AND METHODS

A General Electric Panelipse panoramic radiograph system was used for obtaining radiographs for the curved-surface laminagraphic study. Exposures were made at 8 ma., 45 Kv., and at 8/10 second. Kodak RP-X-Omatic film was used for all exposures.

A Quint X-Ray Sectograph machine was used for the plane-surface laminagraphic surveys. Exposures were made at 100 ma., 82 Kv. and at 3 seconds. DuPont Cronex Hi-Plus film was used for all exposures.

An S.S. White Auveloper was used to process all exposed film.

Five dried human skulls were obtained from the Loma Linda University Department of Anatomy and were used in this study. They were selected with emphasis being placed on their having stable centric occlusions and their temporomandibular joints free from pathosis.

Description of Positioning Device for Skull:

Only one of the skulls was used for the first part of the study. A one-forth inch grid, galvanized wire mesh was placed over both the temporomandibular joint areas. These grids were positioned so as to be parallel to a line drawn through the body of the ramus of the mandible. (Fig. 1).

The skull was then mounted on a custom-made base which had two horizontal spirit levels attached; one to level the plane of occlusion in the anteroposterior plane and the other to level the skull in a mediolateral plane. (Fig. 2). This device was then in turn mounted on an adjustable tripod. With both spirit levels centered, the skull was positioned with the occlusal plane level to the Earth and with its' mediolateral axis also level. The purpose of this method of standardization was to accurately reposition the skull within the cephalostat of the Panelipse machine for each series of films taken.

The hinge on the tripod governing the vertical movement of the chin within an arc was calibrated in increments of five degrees. (Fig. 3). Level was considered to be zero degrees as suggested by Blackman (1960) who espoused using the occlusal table as a horizontal reference point. The five, ten and fifteen degree increments with the chin going up were considered to be plus degrees and conversally, the three increments of downward movement were considered to be degrees of negative movement.

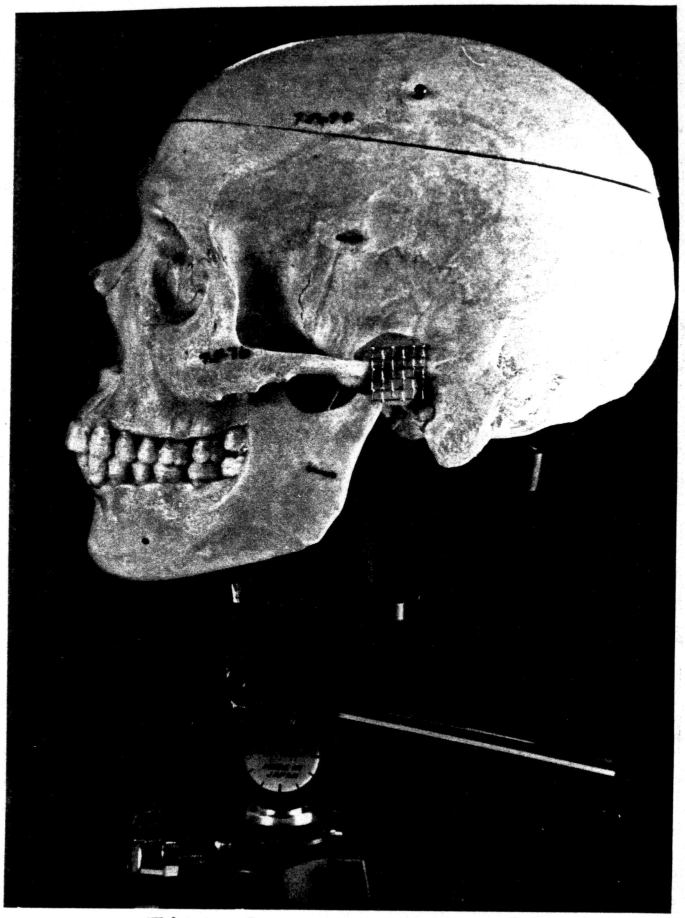


Fig. 1

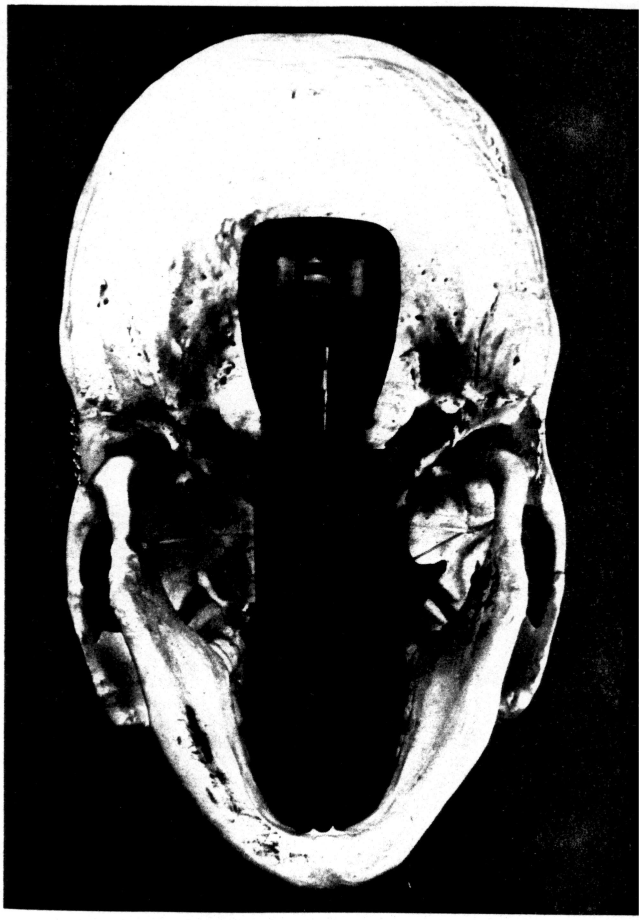


Fig. 2

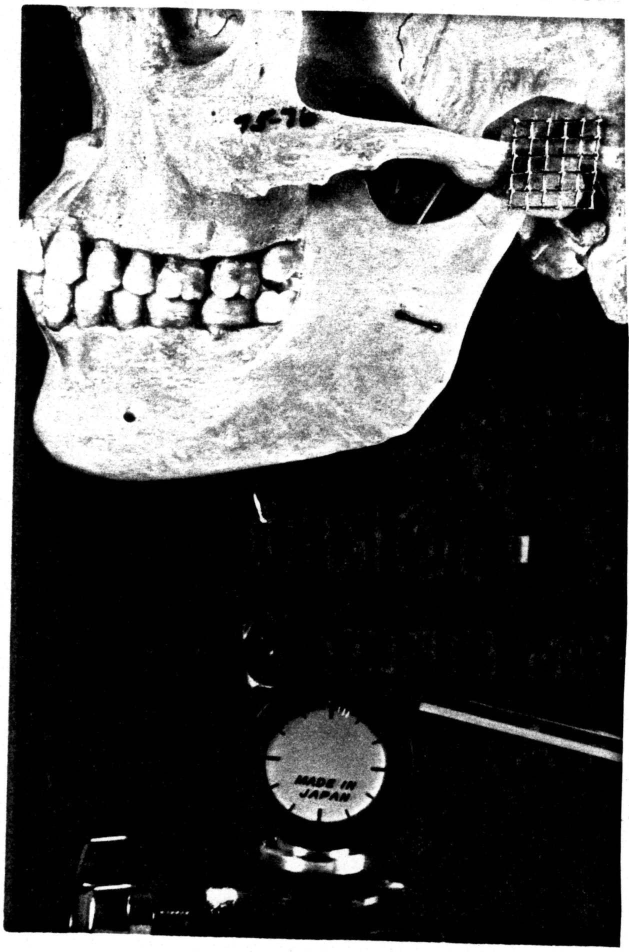


Fig. 1 Skull with wire grid mounted.

Fig. 2 Spirit levels mounted on base.

Fig. 3 Tripod hinge with calibrations

Description of Methods:

Part I

The skull with the wire grid mounted lateral to the temporomandibular joint area was placed in the cephalostat of the Panelipse machine. It was then placed in a two-axis level position by means of the spirit levels mounted under the base. With the occlusal plane of the skull at zero degrees angulation, two exposures were made; one with the x-ray head moving left to right and the other with the x-ray head moving right to left. These films were developed and anatomically superimposed on each other. They were found to be almost perfect images of each other. Thus, it was established that there was no concentric error within the Panelipse machine.

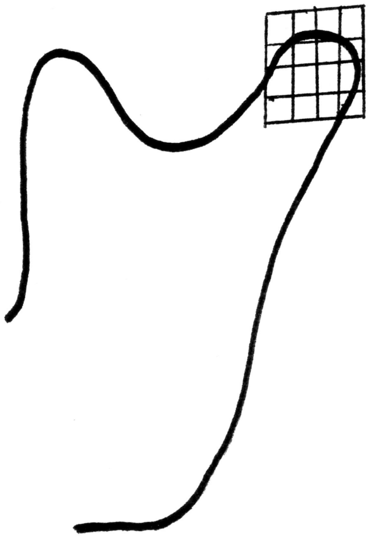
Next, the same skull was used with the wire grids still in place. The initial exposure of the series was taken with the occlusal plane of the skull at zero degrees angulation. This was used as a Control. Then a series of six exposures was taken with the occlusal plane at minus five, ten and fifteen degrees respectively and with the occlusal plane at plus five, ten and fifteen degrees respectively. The apparatus was then completely taken down, reassembled and the skull was then replaced in the Panelipse cephalostat in the same horizontal orientation. A control film was again taken at zero degrees and then the same series of six exposures at different vertical angulations, as described above, was made. Between each series of films which were made, the apparatus was taken down and then repositioned for the next series of exposures. This was repeated until ten series of films had been made for analysis.

A contact exposure was then made of the wire grids on the film cassette. The film was then developed and acetate tracings of the wire grids were made. From the acetate tracings, celluloid transparancies were made. These transparancies were the actual size of the wire grids, and were superimposed over the panographic images so that any amount of distortion could be ascertained. The linear and angular distortion was then recorded for each series of films. (Fig. 4).

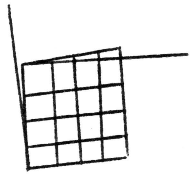
Part II:

In order to determine the accuracy of the laminagraphic machine, an additional procedure was done which consisted of taking right and left laminagraphs of the same skull with the wire grids in place over the temporomandibular joint area. When the films were developed, the celluloid transparancies of the actual size wire grids were superimposed over the laminagraphic grid images. There was found to be no angular or linear distortion present in our research. The laminagraphic machine used was considered to produce an accurate image.

Laminagraphs were then taken of each temporomandibular joint area on each of the five dried skulls. Special care was taken to assure that the mediolateral axis of each condyle head was perpendicular to the film cassette of the laminagraph and that the occlusal plane of each skull was at zero



Tracing of wire grid superimposed over temporomandibular joint area on panographic film.



Same wire grid which has been measured for angular and linear distortion by superimposing actual size grid on the celluloid transparancy and tracing the distortion.

This particular grid has:
+1.5mm. vertical linear elongation.
0mm. horizontal linear elongation.
4 degree distal angular distortion.

Figure 4.

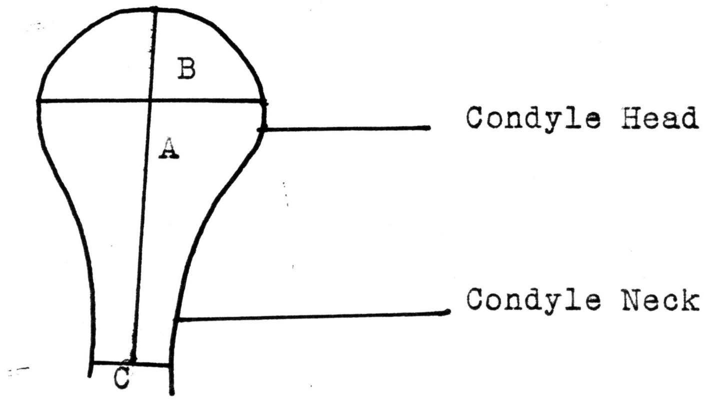
degrees to horizontal and that each skull's midline was centered correctly within the cephalostat.

Acetate tracings of each condyle head were then made from the developed laminagraphic and panographic films. Then the laminagraphic and panographic tracings were compared and linear distortion was measured. The measurements used in the vertical plane were the distance from the narrowest point on the condylar neck to the top of the condyle head. In the horizontal plane, the widest distance anteroposteriorly on the condyle head was measured and the narrowest distance on the condylar neck was measured. (Fig. 5).

Part III:

For the actual clinical comparison of panographic and laminagraphic radiographs of the same temporomandibular joint areas, fifty cases were selected from the Loma Linda University Department of Orthodontics. Each temporomandibular joint studied had been surveyed both laminagraphically and panographically. Acetate tracings were made of the condylar heads of each patient from the panograph and the laminagraph. These acetate tracings were then compared using the same measurements as outlined in Fig. 5.

Figure 5.



-Line A: Vertical measurement from the narrowest point on the condyle neck to the highest point on the condyle head.

-Line B: Widest anteroposterior point on the condyle head.

-Line C: Narrowest point anteroposteriorly on the neck of the condyle.

CHAPTER IV

OBSERVATIONS

Part I:

The panographic radiographs obtained appeared, for the most part, to be as any other panographic radiographs with the following exceptions:

1. The wire grid screens placed over the temporomandibular joint areas on the skull produced visible images on the film.
2. The metal screw on the skull base/tripod mounting device produced visible images on the films which varied according to the angulation of the skull at the time of exposure.

Part II:

The laminagraphic radiographs obtained from the five skulls appeared to be much the same as any other laminagraphic radiographs with the following exceptions:

1. Certain metallic images were present on the films. These were images from various wires and hooks attached to the skulls to hold sectioned parts together. Their presence was due to the fact that these were anatomical study skulls.
2. Parts of the tripod supporting the skulls is also to be seen on the laminagraphs.

Part III:

There was some variation in the quality of the radiographs, both laminagraphic and panographic, which were obtained for the clinical comparative study. It should be kept in mind however; that these films were taken for orthodontic screening purposes, rather than for research. This variation is largely due to the differences in techniques of the operators of both the laminagraph and the panograph machines. Also, since the films were taken and processed over a period of time, differing strengths of developing solutions caused a slight amount of difference in the contrast of the stryctures on the films.

CHAPTER V

DISCUSSION AND INTERPRETATION OF FINDINGS

Part I:

Developing a technique for accurately repositioning a skull for each series of panographic films was not without challenge. After the first two trial series, it was determined that so large an amount of variation from series to series was present that the results obtained were not remotely significant. The major factor causing this variation was due to the lack of accurately repositioning the skull in its horizontal rotating axis. This problem was eliminated by modifying the anterior bite tab which is normally used with the Panelipse cephalostat. The tip of the tab was ground to a point which was placed at the midline between the lower central incisors of the skull. In addition, several reference points were scribed with a pencil on the right and left temporal bones of the skull in relation to the lateral head supports on the cephalostat of the panographic machine. By paying careful attention to these reference points, the results of each series of films were much more closely related. It must be kept in mind that the Panelipse machine was not developed as a temporomandibular joint area research tool, but rather as a screening device. Had live human subjects been used rather than dried human skulls for this endeavour, serial repositioning of the head would have been extremely difficult, if not impossible, using the above described method. This difficulty would have been due to soft tissue compression and flexibility. A positioning device as described by Conley (1962) and Hymer (1965), utilizing a bite fork would have had to been employed.

Analysis of the temporomandibular joint areas with the grids over them was done by superimposing the celluloid transparancies, made from the actual wire grids, over the screen images on the panographic radiographs. (Fig.4). The criterion for analysis was a lengthening or shortening of the horizontal or vertical members of the wire grids which was called linear distortion. A change in angulation of the vertical members of the wire grids either in a mesial or distal direction was called angular distortion. Basic patterns of distortion were noted:

1. There was a tendency for the left temporomandibular joint area to be slightly more enlarged, (3% horizontal and vertical enlargement at zero degrees of occlusal angulation), (Table 1.). This phenomenon was also encountered by Kite (1962), who determined it to be due to improper centering of the midline of the panographic unit itself. The left side was farther from the film cassette than the right, thus producing image enlargement. This slight amount of variation would be of no clinical significance for the screening purposes for which the panographic unit was designed. This

Table 1.

Percentage of Linear Distortion

Occlusal Plane Position	Right Horizontal	Right Vertical	Left Horizontal	Left Vertical
+15	-19.0%	+13.9%	-23.0%	+21.9%
+10	-14.3%	+12.1%	-18.5%	+18.0%
+5	-10.6%	+10.0%	-13.5%	+13.5%
0	-5.8%	+4.8%	-8,8%	+8.0%
-5	-10.1%	+9.0%	-13.8%	+13.5%
-10	-12.1%	+11.2%	-19.2%	+15.4%
-15	-14.5%	+12.7%	-23.0%	+21.5%

Percentages of linear distortion of the G.E. Panelipse panographic unit on wire grids over the temporomandibular joint areas of a dried skull at serial angulations of the occlusal plane.

Table 2.

Linear Distortion in Millimeters
With Standard Deviations

Occlusal Plane Position	Right Mean	Right S.D.	Left Mean	Left S.D.
+15	-2.5 H	0.54	-3.0 H	0.82
	+2.3 V	0.53	+2.8 V	0.78
+10	-2.3 H	0.41	-2.4 H	0.52
	+2.0 V	0.41	+2.3 V	0.58
+5	-1.7 H	0.26	-1.7 H	0.26
	+1.6 V	0.24	+1.7 V	0.26
0	-0.9 H	0.28	-1.1 H	0.34
	+0.8 V	0.32	+1.0 V	0.38
-5	-1.7 H	0.35	-1.8 H	0.35
	+1.5 V	0.43	+1.7 V	0.35
-10	-2.0 H	0.00	-2.5 H	0.53
	+1.8 V	0.34	+2.0	0.41
-15	-2.4 H	0.52	-3.0 H	0.78
	+2.1 V	0.57	+2.7 V	0.68

H--Horizontal

V--Vertical

Linear distortion by the G.E. Panelipse panographic unit on wire grids over the temporomandibular joint areas of a dried skull at serial angulations of the occlusal plane.

Table 3.

Degrees of Angular Distortion

	Right		Left	
	Mean	S.D.	Mean	S.D.
+15	4.2 M	0.63	4.9 M	0.74
+10	3.4 M	0.52	3.6 M	0.52
+5	2.4 M	0.39	2.7 M	0.41
0	0.8 M	0.51	1.0 M	0.43
-5	2.5 D	0.43	2.6 D	0.42
-10	3.4 D	0.53	3.7 D	0.48
-15	4.4 D	0.52	5.2 D	0.92

Occlusal Plane Position

D--Distal movement of vertical grid members.
M--Mesial movement of vertical grid members.

Mean degrees of angular distortion with standard deviations. Taken by a G.E. Panelipse panographic unit of wire grids over the temporomandibular joint areas of a dried skull at serial angulations of the occlusal plane.

further bears out the fact that the Panelipse machine was not necessarily designed for the purposes of temporomandibular joint research, and that correct head positioning is of the utmost importance.

2. With the skull's plane of occlusion at zero degrees, there was the least amount of linear and angular distortion of the temporomandibular joint area. It should be noted however; even at this relatively optimal setting of zero degrees, there is still linear compression of 5.8% on the right side and 8.8% on the left side.in the horizontal plane and linear elongation in the vertical plane of 4.5% on the right side and 8.0% on the left side. (Table 2). The amount of angular distortion is not so pronounced at zero degrees angulation but is still present in the amount of one degree of mesial distortion. (Table 3). Christen (1968) indicates that overall, a low chin placement produces better panographic images of the teeth and their supporting structures than does a high chin placement. This indicates therefore, that special positioning techniques should be used for temporomandibular joint surveys on panographic units.

3. As the angle of the occlusal plane was raised from zero degrees in increments of five degrees, it was noted that the vertical component of the square wire grid would change angulation increasingly toward the midline. At plus fifteen degrees of angulation there was a 4.2 mesial degree change on the right and a 4.9 mesial degree change on the left. The

reverse proved to be true as the occlusal table was lowered from horizontal. The vertical component of the square wire grid would move increasingly away from the midline. At minus fifteen degrees of angulation there were 4.4 degrees of distal degree change on the right and 5.2 degrees of distal change in angulation on the left side. (Table 3).

4. In none of these films were any of the lines on the wire grids distorted into a curve. Although different lengths and angles were found to be present at different settings, the lines remained straight.

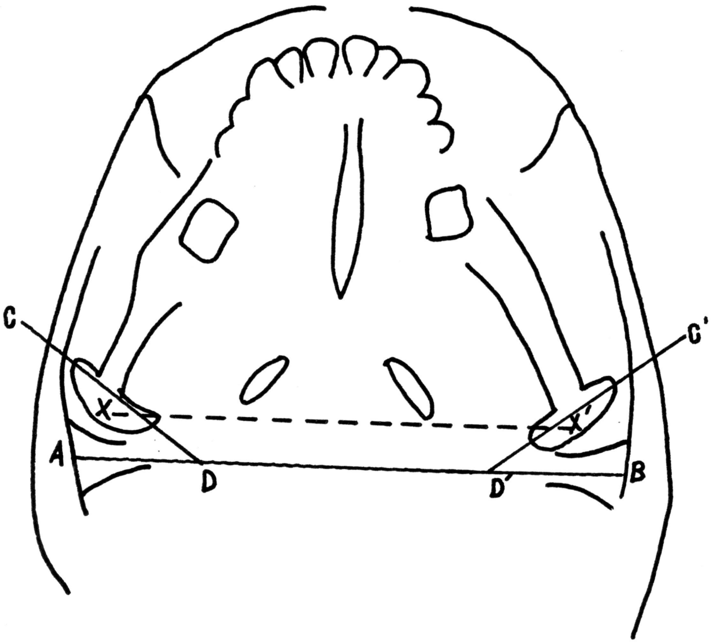
The results of this experiment clearly show that even under controlled conditions, the distortion inherent within the panographic unit itself precludes locating one head position where there will be accurate imaging of the temporomandibular joint area and simultaneous optimal angulation for showing the teeth and tooth-bearing structures on the same panographic radiograph. Both angular and linear distortion were present in each film taken in every series of this study of the panographic results. On the one particular skull used for this investigation, which was of the mesofacial facial type, a setting of the occlusal table at zero degrees was found to be the best compromise position for minimal linear and angular distortion. It should be noted however; that each person, and particularly each different facial type, will have their condyles at different angles to the plane of occlusion. The writer would suggest that other studies be done to establish optimal head positions for the three facial types.

rt II: In order to clinically compare laminagraphic radiographs of the temporomandibular joint with panographic radiographs of the same area, the laminagraphs must demonstrate the true anterior and posterior condylar borders. If the central x-ray beam passes through the axis of the condyle head mediolaterally, a true view of the structure will be gained (Yale 1961). On human subjects, the best way to effect this is not by using the standard setting of positioning the head at twenty degrees from the midline, but rather by doing calculations from a submental vertex analysis as described by Williamson (1976). The submental vertex radiograph is made by taking an exposure of the entire mandible from beneath the chin. From this film, the mediolateral axés of the condyles are plotted in relation to the transporionic axis. Their intersections give the angle at which the cephalostat is placed for the laminagraphic survey of the condyle. Fig. 6.

The laminagraphs were taken at serial depths of cut within the condyle heads to make certain that the anterior and posterior borders of the condyle heads were identified.

Comparing the acetate tracings of the ten laminagraphic condyle heads yielded general similarities in size and morphology from the laminagraph to the panograph of the same temporomandibular joint. Magnification, or linear distortion, was noted on the condylar heads on the panographic radiographs. In the vertical plane, a 16% mean increase from the narrowest point on the condylar

Fig. 6.



Tracing of the submental vertex radiograph with
Analysis lines displayed.

Line A-B represents the transporionic axis.

Lines C-D and C'-D' represent the condylar axis; their intersections with A-B are the angles at which the cephalostat is placed for the lateral laminagraph.

neck to the top of the condyle head was observed. On the horizontal plane, there was a 16% increase in the width of the condyle head and a 16.7% increase in the condylar neck width calculated. (Table 4).

Part III:

In the clinical comparison study between laminagraphs and panographs of actual orthodontic patients, in the investigator's opinion, the condylar heads showed a more normal anatomical profile morphologically in the panographic technique in spite of the magnification inherent in the machine.

Some condyle heads in the laminagraphs tended to be narrower in the anteroposterior plane and shorter in the vertical plane. The explaination for this phenomenon is that the panographic image of the condyle head is showing the entire anteroposterior profile. (Tammisalo 1964). While the laminagraphic projection has been taken of a section of the condyle head which is lateral to the greatest anteroposterior width. Thus, the image appears to be narrower and shorter. (Fig. 8). This bears out the findings of Ekerdal (1973), who found that the part of the temporomandibular joint that is accessable in the mediolateral plane for laminagraphic analysis varies. One-half to two-thirds of the joint may be demonstrated with good definition. This part is situated centrally with lateral displacement. The more medial aspects of the condyle head tend to be blurred by surrounding dense bony tissues. It would be possible to minimize this with a wider "cut" or section.

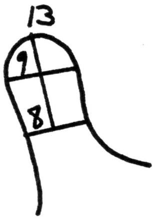
PRECENTAGE INCREASE IN MEASUREMENTS OF PANOGRAPHS VERSUS LAMINAGRAPHS USING THE SAME CONDYLAR HEAD FOR COMPARISON

% increase of condyle height	% increase of condyle head	% increase of condylar neck
26%	15%	12%
31%	22%	14%
35%	27%	25%
35%	25%	25%
8%	30%	10%
8%	31%	10%
15%	12%	12%
19%	14%	21%
21%	14%	20%
14%	14%	20%
17.3%	16.0%	16.7%

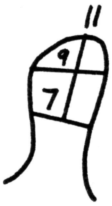
Table 4.

Fig. 7.

Laminagraph

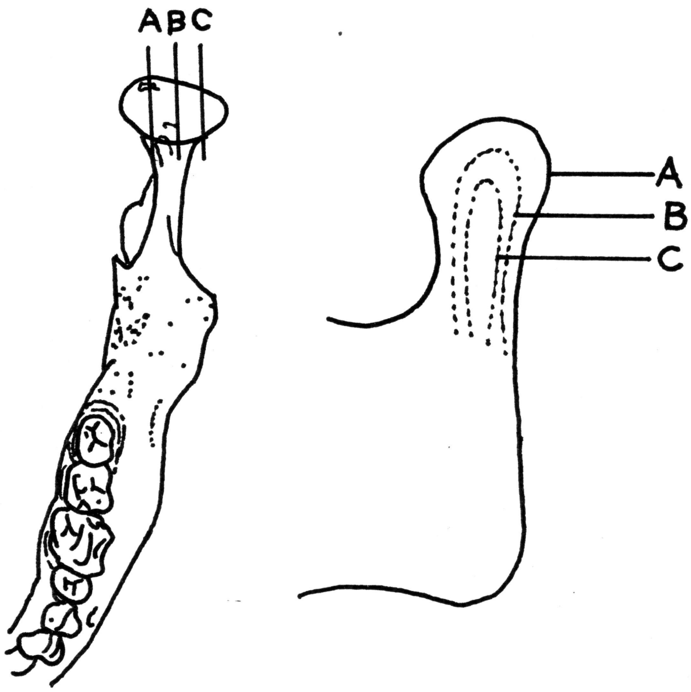


Panograph



Differences in measurements between laminagraphs and panographs taken of the same condyle heads.

Fig. 8.



Section C would show a more narrow and shorter laminagraphic image than would sections A or B.

Although there was a wide range of variation in morphology of the condyles in both techniques, there emerged a general overall enlargement of the panographic image. (Table 5). In the vertical plane, the height of the condyle when measured from the narrowest point of the neck to the top of the head increased 18.8%. In the horizontal plane, the size of the condyle head increased 19.6% and the width of the condylar neck increased 15.8%. These findings compare favorably with those in Part II where the measurements were made on skulls. (Table 4).

TABLE 5

PERCENTAGE INCREASE IN MEASUREMENTS OF PANOGRAPHS VERSUS LAMINAGRAPHS USING THE SAME CONDYLAR HEAD FOR COMPARISON

% increase of condyle height	% increase of condyle head	% increase of condyle neck
0%	15%	0%
0%	9%	0%
36%	28%	25%
36%	28%	25%
10%	19%	23%
28%	19%	23%
0%	10%	23%
25%	0%	12%
14%	0%	20%
0%	22%	22%
34%	23%	21%
15%	0%	20%
46%	20%	20%
14%	22%	13%
31%	0%	14%
0%	15%	40%
14%	35%	30%
43%	0%	20%
35%	42%	25%
50%	42%	30%
31%	25%	23%
31%	20%	23%
0%	12%	14%
10%	22%	0%
8%	12%	14%
30%	-0%	17%
10%	10%	28%
10%	10%	14%
11%	11%	0%
11%	11%	25%
8%	8%	25%
20%	20%	38%
25%	25%	25%
8%	8%	27%
20%	15%	19%
25%	14%	20%
8%	35%	25%
15%	33%	20%
14%	48%	25%
35%	50%	13%
33%	40%	0%
48%	13%	0%
50%	27%	10%
40%	27%	10%
13%	30%	0%
27%	30%	9%
27%	14%	20%
30%	15%	0%
30%	10%	34%
14%	7%	10%
15%	25%	0%
10%	15%	13%
7%	14%	20%
18.82%	19.62%	15.84%
S.D. 4.39	S.D. 4.56	S.D. 4.56

CHAPTER VI

Summary and Conclusions

The relative merits of laminagraphic and panographic radiographic images of the temporomandibular joint area have been compared.

Serial temporomandibular joint area radiographs were taken with a panographic unit. A dried human skull was used as the study subject. Wire grids were placed over the temporomandibular joint areas. The linear and angular distortion of the wire grids was measured with the plane of occlusion being serially tipped horizontally from minus fifteen degrees to plus fifteen degrees.

Lateral laminagraphs were then taken of the same skull with the wire grids still in place to determine the accuracy of the laminagraphic technique as compared to the panographic technique

A second study was done with five dried human skulls. Each was radiographed laminagraphically and panographically. The results were then compared by measuring the differences linearly between the two images of the same condyle head.

The third part involved a clinical study of fifty temporomandibular joint areas which had been panographically and laminagraphically radiographed as part of an orthodontic screening program at Loma Linda University.

The results were as follows:

Magnification, angular and linear distortion of the temporomandibular joint area was present in all panographic radiographs. The least being when the occlusal plane of the study skull was positioned at zero degrees. As the chin is raised or lowered, the linear and angular distortion is increased proportionally.

The lateral laminagraph of the same skull with the wire grids still in place, showed the grid image to be visually distortion-free.

The comparison study using the five skulls which were panographically and laminagraphically radiographed showed an overall magnification of sixteen to seventeen percent of the condyle heads in the panographs. General morphologic similarities of the same condyle head were noted between the laminagraphic and panographic techniques.

The clinical comparison study of the fifty temporomandibular joint areas showed many morphological dissimilarities in the condyle heads between the two techniques. This was felt to be caused by the laminagraph operators failing to take a deep enough "cut" or section through the condyle head, therefore; the laminagraphic image of the condyle head was more narrow and shorter than the panographic image of the same condyle head as it failed, in many cases, to show the true anterior and posterior borders of the condyle head.

Both the laminagraphic and panographic techniques have their merits and drawbacks. The value of each technique depends on the knowledge, skill and care that the operator excercises when obtaining either kind of radiographic survey of the temporomandibular joint area.

The laminagraphic operator must first ascertain the correct condylar setting before taking the radiographs. Then, he must determine that a deep enough section has been obtained on the film to reflect the true anteroposterior outline of the condylar head. This will assure that the radiograph is of diagnostic quality.

The panographic operator should be sure that the patient's occlusal plane is at the optimal angulation to avoid unnecessary distortion of the condylar head image. Also, the fact that there will be an overall image magnification of fifteen to twenty percent must be kept in mind when the film is read.

Because of the ease of reproducibility and standardization, the laminagraph appears to be superior for measuring the position of the condyle in the fossa, i.e. for ascertaining anterior, superior or posterior displacement.

When one considers the amount of standard deviation present in the clinical comparison study of both the laminagraphic and panographic surveys, it is evident that in only a few cases is it possible to correlate a panographic survey of the temporomandibular joint area with a laminagraphic survey of the same area on a one to one basis. At best, one could predict that the panographic survey will be magnified when compared to the laminagraphic survey and that morphologically the shapes of the same condylar head will likely be dissimilar comparatively and no correlation is likely to be made between the two different methods.

However; if proper care is excercised, both types of radiographs may be of diagnostic value. From the findings obtained in this study, the writer thinks that the panographic technique is the most valuable for screening for temporomandibular joint pathology due to its ease of use, its readily availability and low patient radiation dosage. When more definition is required of the temporomandibular joint area, a laminagraphic survey, using the proper techniques is indicated.

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