Oriented Lateral Temporomandibular Joint Laminagraphs

Symptomatic and Nonsymptomatic Joints Compared

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Lateral temporomandibular joint laminagraphs are aligned with the condyle axis on the basis of a submental-vertex radiograph. Condyle positions in nonsymptomatic and symptomatic joints are compared, revealing a wide range in patients with temporomandibular joint and myofascial pain dysfunction syndromes, with significant differences from nonsymptomatic patients.

Radiography is the only means for clinically examining the morphology of the temporomandibular joint (TMJ), yet many still see little clinical value in such a radiographic examination.

One reason is the difficulty in consistently differentiating the important details of the anatomical structures of the joint from adjacent bone structures in conventional radiographs. It is obviously difficult to draw conclusions from radiographs that are neither clear nor accurate, but recent technique refinements more accurately reproduce those three-dimensional objects on a two-dimensional medium.

Zech (1959) and Weinberg (1972) considered radiography one of the most important diagnostic aids for studying diseases of the temporomandibular joint.

Rogers (1935) went so far as to imply that radiographs of the temporomandibular articulation should be a routine practice in orthodontic offices.

Lindvall *et al* (1976) indicated that radiographic examination of the TMJ is widely accepted and used in all parts of the world, especially in the examination of patients with symptoms related to that region.

Many authors have written about the wide variations in temporomandibular joint morphology. Maves (1938) found a great variation in the horizontal angulation of the long axis of the fossa on skulls. Yale (1969) examined more than 1,700 condyles and classified them into 32 different groups based on the anterior, superior and posterior surface curvatures. He further examined horizontal condyle angulation and found it to vary from 0° (perpendicular to the midsagittal plane) to 30°, while vertical condyle angulation was found to range from −45° to +35°.

Variation has also been found in the same condyle with age. The process of articular remodeling is a morphological adaptation to functional loads (Moffet, 1966). As long as there is an equilibrium between form and function, this remodeling process can be regarded as normal. When that equilibrium is lost and bone loss becomes excessive, the previously normal remodeling process becomes destructive.

Normal articular remodeling is a part of growth, development and lifelong adaptation. It is manifest by postnatal changes in the contours of both condyle and fossa. There is a general increase in the posterior slope of the articular tubercle up to at least the fourth decade, with a corresponding increase in the depth of the articular fossa. On the condyle, the superior surface tends to flatten progressively with increasing age.

It is pathologic remodeling with its attendant pain and dysfunction that has aroused most of the interest in the diagnostic use of TMJ radiographs. Many radiographic projections and techniques have been described and recommended to gain information about the shape, size, structure and relationships of the mineralized joint components. These radiographs also provide some indication of the function of the joint.

The most commonly used methods for radiographic examination of the TMJ are:

(1) Conventional Radiography, such as oblique lateral transcranial projections.
(2) Tomography
(3) Panoramic Radiography
(4) Cephalometric radiography
(5) Arthrography

Tomography

Only the second of those techniques will be considered here.

The history of tomography has been well documented by Rosenberg (1967). The technique was essentially initiated in 1930 by Vallebona, who called the projections of his body-sectioning radiographs *stratigrams.* Grossman modified this procedure in 1935, using a different method and calling his equipment a *tomograph.* In 1936 Sherwood Moore designed an instrument which he called a *laminagraph* (Dunn *et al* 1981). More recently, dental panoramic radiography uses a tomographic motion to image teeth and jaws.

Tomography by any name reduces the blocking effect of the superimposition of the images of other structures, by blurring those outside the plane of the selected section.

The plane of sharpness ("focus") is established by the relative motion of x-ray source and film during the exposure. These motions are controlled by a pivoting mechanical bar connecting the x-ray tubehead and the film carrier, with the center of rotation positioned in the selected plane (Rozencweig 1975).

The relative motion of x-ray tube and film can be accomplished in a variety of patterns, including linear, elliptical, circular and hypocycloidal paths (Klein *et al* 1970). The first tomographic machines used a straight-line movement, and this is still used in some current instruments. Later variations use various more complex paths of movement to achieve more effective blurring of obstructing structures.

In the hypocycloidal motion, the film and tubehead follow synchronous paths which resemble the shape of a pretzel, so the x-rays traverse the object at a broad range of continuously changing directions and angles. This produces the clearest images, because it most effectively blurs and sees around structures lying outside the selected plane (Eckerdal 1973).

Eckerdal (1973) published an extensive manuscript examining the reliability and usefulness of TMJ tomography. Using sagitally oriented tomographs of block tissue specimens, he compared the radiographs to later microtome sections.

He found aberrant radiographic images produced by three morphological variations; horizontal condyle angulation, angulation between the medial and lateral pole, and irregularities in morphology. He concluded by saying that "Tomographic reproduction of details is good in the central parts of the joint components," and stated that the middle third of the condyle and fossa best represent the functioning region of the TMJ.

Bean *et al* (1977) examined twenty cadaver TMJs with standard and individualized oblique lateral transcranial projections, a transmaxillary projection, lateral skull and frontal tomography. Each joint was then inspected macroscopically.

They found lateral tomography to be superior to other radiographic techniques for disclosing structure and form of hard tissue joint components. Similar conclusions have also been reported by Klein *et al* (1970), Eckerdal (1973), Omnell and Petersson (1976), Lindvall *et al* (1976), and Eckerdal and Lundberg (1979).

The purposes of the present study are to review the findings of recent studies on techniques for linear laminagraphic radiography of the TMJ and apply those techniques to a comparison of normal and symptomatic joints.

Methods and Findings

Laminagraphic alignment

The first study to be considered here was reported by Beckwith, Monfort and Williams in 1980. That study evaluated the accuracy of the submentalvertex projection described by Williamson and Wilson (1976). They considered correction factors for magnification, identifying the mid-sagittal plane and establishment of depth of cut for a lateral tomograph.

Significant differences were found, with the technique of Beckwith, Monfort and Williams producing the most accurate results.

Material for that study was selected to include condyles with unusually high or low angulations. In 51 adult subjects, they found right condyle angulations ranging from $-22°$ to $+45°$,

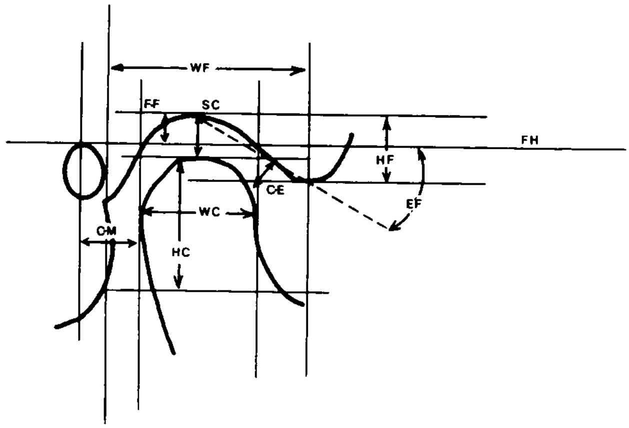

Fig. 1 Temporomandibular Joint measurements (from Aslanides)

FH	Frankfort Horizontal	WF	Width of Fossa
SC	Superior Condyle space	HF	Height of Fossa
C-E	Condyle-Eminence	F-F	Fossa-Frankfort distance
WC	Width of Condyle	E/F	Eminence to Frankfort angle
C-M	Condyle-Meatus		

with a mean of 24.1° ± 1.7° and left condyle angulations ranging from −30° to +47° with mean of 24.5° ± 1.3°. The differences between right and left were not statistically significant.

Those mean values are considerably higher than the 15° standard angulation recommended by Ricketts, Updegrave and Cook. They are also higher than the values found by Wilson on skeletal material.

Only the standard 25° condyle angulation recommended by Shore approximated the mean angulation found by Beckwith *et al*, but it is important to note the broad range of angulations underlying those mean values. Such large variation should not be ignored in clinical radiography.

Normal joint dimensions

The second tomographic study was by Aslanides in 1980. This was an effort to determine ranges of normal morphology of the joint.

Thirty-one (31) adult patients were chosen from the files of the Orthodontic Department of the College of Dentistry of the Ohio State University, and from the office of the author. Selection was based solely on the following prerequisites.

(1) Caucasian over 18 years of age
(2) No history of TMJ dysfunction or orthodontic treatment
(3) Lateral laminagraphs angulated on the basis of a submental-vertex film, with teeth in centric occlusion and a 12 cm. distance between the film and the center of the headholder

Laminagraphs of the left and right TMJs were traced and the measurements recorded twice, at least one week apart (Fig. 1). The two measurements that showed the smallest standard deviation and standard error, regardless of the size or shape of condyle or fossa, were the Condyle-Emi-

TABLE 1

Mean, Standard Deviation, Range and Standard Error for C-E and SC Dimensions of 40 Asymptomatic and 40 Symptomatic Temporomandibular Joints (Right and Left combined)

	Range	*Mean*	*S.D.*	*S.E.*
Asymptomatic				
C-E	1.1—2.8	1.82	.48	.08
SC	1.1—3.1	2.10	.46	.07
Symptomatic				
C-E	1.0—4.6	2.61	1.01	.17
SC	1.2—4.1	2.95	.75	.13

TABLE 2

Mean, Variance, Standard Error and Significance (P) of Differences between Symptomatic and Asymptomatic Joints for Condyle-Eminence (C-E) and Superior Condyle Space

	Mean	*Variance*	*S.E.*	*P*
C-E				
Asymptomatic	1.82	.23	.08	
Symptomatic	2.60	1.03	.17	
				0.0001
SC				
Asymptomatic	2.10	.21	.07	
Symptomatic	2.95	.57	.13	
				0.0000

TABLE 3

Comparison of mean differences between Right and Left Joints for C-E and SC as reported by Aslanides (A) and Williams (W)

	Mean Diff. (R-L)	*t*	*P*	*Sig.*
C-E				
A	.25	2.57	.015	+
W	.19	1.68	.107	NS
SC				
A	—.20	—1.87	.068	?
W	—.30	2.88	.010	+

NS = Not Significant
? = Marginal
\+ = Significant

nence (C-E) and Supracondyle space (SC) dimensions.

Symptomatic joints

Those findings led to the present investigation, which compares the measurements in asymptomatic and symptomatic TMJs of adults.

Condyle-eminence and supracondyle dimensions of the TMJ from 20 symptomatic and 20 asymptomatic patients were compared. The means found for the asymptomatic subjects were similar to those reported by Aslanides (Table 1). Comparing the dimensions in asymptomatic and symptomatic joints, we found a highly significant difference in both the C-E distance and in the SC dimension ($P < 0.0001$) (Table 2).

Comparison of findings of this study with those of Aslanides for differences between right and left joints was inconclusive (Table 3). In Aslanides' study the differences between C-E on right and left sides showed a moderate statistical significance ($P < 0.015$), while this study found negligible significance ($P < 0.10$). Opposite differences were found for SC, with Aslanides reporting a P value of 0.068, while this study found a somewhat more significant 0.01 P value.

Discussion and Summary

A definite difference was found between the condyle positions found in tomographs of asymptomatic and symptomatic TMJs. The sample of the symptomatic joints in this study included many types of problems, such as anterior displaced disks with double clicks, single joints clicking on either opening or closing, displaced condyles with limited movement, and others.

Further investigations grouping similar clinical symptoms together to determine characteristics of each type could add to the diagnostic value of such tomographs.

Eckerdal and Lundberg (1979) reported that a 5° rotation of the condyle can change the image sufficiently to alter an interpretation. In another sample of 104 TMJs, we found the range of ±5° on either side of the 20° advocated by many investigators would only include 42.3% of the sample. Using a mean of 15° ±5° would classify only 33.7% in the range of optimum radiographic reproduction.

Accurate lateral laminagraphic reproduction of the functioning portion of the condyle in the temporomandibular fossa can best be obtained by first using a submental-vertex view to determine actual horizontal condyle angles and establish depth-of-cut settings. This increase in quality is achieved with an actual reduction in the number of x-ray exposures required for diagnosis.

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