

ORIGIN OF CENTRIC RELATION.

Holic (1948) states that at about four to five months of age the teeth begin to erupt and with more and more eruptions the arches lengthen posteriorly. The growth of the jaws keeps pace with the demands for more space. This continues until the permanent dentition is complete. Thompson and Brodie (1942) have stated: "The pattern of the head of the individual is laid down before the third month of post natal life, probably very much earlier and thereafter does not change. The mandible assumes its pre-ordained relation with the rest of the face and head long before any of the teeth have erupted and this position is constant and characteristic for the individual." Moyers (1956) claims only the postural position is consistently observed prior to the eruption of the teeth. The teeth erupt into a fixed intermaxillary space and occlusion develops with jaw relations already established. Occlusion develops as a result of jaw position. The occlusion of the teeth does not determine intermaxillary relations. Ballard (1955) feels the dento alveolar structures grow vertically into a genetically pre-determined intermaxillary space until their inherent power of growth is balanced physiologically by masticatory and other mandibular activities. Labially, buccally and lingually the teeth are held in their arches by the limiting structures the lips, the cheeks and the tongue. Teeth are said to be in active eruption until they come into their functional positions. But what stops this eruption since the teeth are in positions of equilibrium, this force of eruption must be opposed by an equal one.

Mandibular position and its relation to the rest of the face and head are determined basically by the musculature attached to it. Force generated by these muscles acting on the mandible is equal to the force of eruption when the arches come into centric occlusion. The forces involved must be very light because two teeth in contact are sufficient to maintain a normal interocclusal clearance. A reflex mechanism is almost certainly involved.

Sillman (1940-48) spoke about the development of an occlusal sense

on the erupting primary teeth first met their antagonists of the opposite jaw. This is the formation of the neuromuscular reflex establishing centric relation.

As the teeth occlude different impulses of touch and pressure are transmitted through the mesencephalic root of the fifth cranial nerve to the brain where they may alter and affect the motor impulses being transmitted to the muscles controlling the position of the mandible. After the teeth have erupted the muscles learn one position of occlusion providing a maximum of occlusal contact and minimum of tongue or lateral stress and strain on roots of the teeth. This is the beginning of centric relation. The muscles alone could not establish so precise a mandibular position. Centric relation is established during the early stages of the primary dentition when occlusal anomalies are at a minimum. At the beginning centric occlusion and centric relation are synonymous. Centric relation is the first established neuromuscular reflex concerning mandibular position when the teeth are in occlusion.

The centric relation reflex is controlled, not only by the stretch receptors in the muscles of mastication but by the receptor organs in the periodontal membranes as well.

The antero posterior limits of centric relation are defined first since the primary incisors erupt first and restrict mandibular movements in this one direction only. Later the teeth in the lateral segments of the dental arch inhibit mediolateral position and thus help localise the limits of centric relation in this other direction. The vertical limits of centric relation are never so precisely defined. This helps explain the more precise limits of centric relation antero posteriorly and medio-laterally. It also explains why we have somewhat more latitude in changing vertical dimension than in shifting the mandible horizontally.

## MANDIBLE'S CAPACITY FOR MOVEMENT:

Posselt (1952) states if one wishes to analyse the arrow point relation of the mandible to the maxilla, it seems to be suitable at first to investigate the mandible's capacity for movement, and further to investigate if any of the habitual movements are carried out as border movements. The mandible has great freedom of movement in so far that a certain point on the mandible is freely moveable within certain limits."

Graphical recordings of mandibular movement date back to 1860; they were then used by Langer. Photographic recording was used by Ulrich in 1896 and the cinematographical method by Thouren in 1914. Radiographic examination was used as early as 1910 by Breuer.

The examinations of the capacity of the mandible for movement, seem to indicate that the condyles and thus the mandible as a whole can be moved along border paths or into border positions which seem to be quite constant in the individual subject. Movement may occur in all three directions, that is vertically, antero-posteriorly, and lateromedio-laterally. The latter two directions are usually considered on one plane, the horizontal."

### Vertical Movement:

This plane of motion involves a consideration of the opening and closing phases of mandibular movement."

The ideas of movement in this median plane from areas as described as being convex anteriorly and concave posteriorly in 1860 to the more modern idea as illustrated by Hayek in 1937 (see Figure 8). Posselt in 1952 recorded the border movements, in the median plane, for mandibular motion (Figure 7.). The upper line A illustrated the protrusive glide of the recording film. The curved line C farther to the left in the figure corresponds to the path of the anterior border opening, and the line E-E<sub>2</sub> which is broken at the obtuse angle X farthest to the right, represents

the posterior opening path and the posterior path of closure. With maximal opening the recording pin at the lower acute angle Y in the figure. These border movement paths thus seem to be reproducible. The movement areas recorded with the subject C conscious and under anaesthesia could also be made to cover each other. The obtuse angle X occurs when the condyles begin their protrusive gliding and Posselt found that the most variable path of movement occurred between  $E_2$  and X.

After resection of the temporo-mandibular ligaments, the angle X seems to almost disappear and at the same time the movement area becomes somewhat wider and longer.

Posselt feels his experiments have shown that habitual closing movements until contact is obtained, with the registration slide, takes place with much greater variability than does the posterior border movement. It might be imagined that habitual closing movements would be influenced rather readily by biting in wax, even if the latter has been softened. A posterior closing movement is probably less readily affected by this factor.

The action of opening and closing the jaw and the action of the masticatory stroke will, on this plane, take place within this envelope of movement. It will involve both rotation and translation of the condyle together with integrated muscle action.

Of great importance to the <sup>th</sup>prosedentists is the closing movement from rest position. Sicher (1954) says that opening movement, to bring the jaw from occlusal to the rest position, is almost a purely hinge movement. It is assumed that he believes the reverse to be correct, that is closure from rest to occlusal centric position is also almost hinge movement.

This theory is supported by quite a few workers. Walsh (1951) claims the mandible closes to the terminal functional position by simple hinge closure, the gnathion moving in an arc of a circle upwards and slightly forwards from rest position. The mandible returns to rest position by a simple hinge movement. M Thompson in 1954 states the normal movement of the mandible from rest to occlusal position is almost that of a hinge with the common axis located in the vicinity of the condyles or lower portions

of the joints; there may be slight bodily movement of the condyles but slight movement of the condyles should still be considered to be within the normal range.

Alexander in 1952 has indicated that his experiments reveal the movement of the condyle when the mandible moves from rest position to initial contact and full occlusion through an acceptable free way space with the patient sitting in an upright position may be rotary or translatory.

Posselt on the other hand quite categorically states that rest position is not situated on the hinge movement path. A glance at his outline of movement figure will indicate his belief as to the location of rest position.

In 1952, Page has claimed that closure from rest position is almost always completely translatory. He is supported later by Schweitzer (1957) a follower of his concepts, who points out that if a hinge bow is observed closely when it is used to locate the hinge axis, it may be observed that when the mandible drops to its rest position, translation and not rotation takes place.

Kurth (1954) quotes Anderson, who by means of a cephalometer, demonstrated that in the short distance from physiological rest position to centric occlusion only 50% of the patients studied, moved their mandibles as hinges. He also quotes Posselt as saying: "I can only consider that these results show that the mandible performs a bodily movement between the two positions. The axis of such a movement cannot at any rate pass through the condyle."

Nevakari in 1956 in his analysis of movement from rest position to centric relation found his recordings to coincide with the findings of Posselt. In Nevakari's experiments the condyle always carried out a translatory movement upon the mandible moving from rest position to occlusal position. This condyle displacement showed great variation

between individuals in both magnitude and direction, and in some cases considerable variation occurred within individuals. The amount of translatory condyle displacement averaged 1.06 m.m. and the average direction being 47.4 degrees backwards and upwards in relation to the Frankfurt Plane.

Nevakari summarises his findings on this movement thus:

1. In the cases examined here, in the movement of the mandible from rest position to occlusal position there has never been a pure hinge movement with the axis through the condyles.
2. The geometrically constructed theoretical axis for the said movement has in all cases been situated outside the condyle and its location has exhibited considerable individual variation. On the average the axis of the movement has been located near the processus mastoideus.
3. Upon the mandibles closing from rest position the deviation from pure hinge movement measured at the canine point, has on the average been about 1 m.m. in the distal direction.
4. The condyle has in all cases also undergone a translatory movement, the magnitude of this movement upon the mandibles closing, from rest position being on the average about 1 m.m. backward and upward.
5. The direction of the path of closure measured at the canine point has averaged about  $11^{\circ}$  in relation to a perpendicular of the Frankfurt plane, or upward and slightly forward.

Kirth (1954b) divides mandibular movement into functional and non-functional classification. The functional movements towards centric occlusion are, he claims, the most powerful. This involves a combination of both rotation and translation.

Trapezzano (1952) has stated that when closing movement is made the general direction of range of closure may vary greatly. Both translation and rotation may be intermixed or may be used separately. Since the mandible is capable of making both types of movement, unquestionably it will function in such a manner as to utilise its full potentiality of movement

at some time or other during both masticatory and non-masticatory function.

<sup>1954b</sup>  
Kurth's non-functional movements have also been called mandibular glides.

Their direction is determined by the inclined planes of the posterior teeth, the lingual surfaces of the upper anterior teeth and by the condyle path.

Schwetzer in 1957 claims that the mandibular body, in the early phases of closure during the period in which the condyles are translating, has its axis in the mandibular angle. The masseter and internal pterygoid muscles form its sling. The fibres of these muscles, being directed inward and forward, tend to arc the body of the mandible upward and slightly forward while the condyles are moving upward and backward along the anterior fossal slope, being aided in this movement by the posterior fibres of the temporal muscles. When the working condyle reaches the hinge position the axis changes to within the condyle and the condyle can only rotate while the closing musculature applies the power.

Posselt in 1952 feels that the most stable closing movement is the posterior border movement, rather than the habitual closing movement. This habitual closing movement can be expected to reach the occlusal level at approximately one to one and a half millimetres anterior to the position of centric relation. This is the point to which the patient will close during normal non-pressure mastication and in such physiologic acts as swallowing. If, however, pressure is exerted during mastication then the relative occlusal position will revert to that of the apex of the gothic arch.

#### Opening Movements:

Brandrup-Wogensen (1952) reports the experiments of Fischer, who found that two types of opening movements were possible. The first, physiologic, in which there was translation as well as rotation right from the start of the movement; and the second which he called central opening movement in

which there was only rotation. These ideas were confirmed by his fellow countryman, Beyron<sup>1942</sup>, using both graphic and roentgenomographic examinations.

Updegrave in 1957 classifies the types of openings according to the bone structure of the jaws as related to Angle's Orthodontic Classification. A patient with Class I occlusion, in opening from the occlusal position to the rest position, the condyle rotated; from rest to one inch opening the condyle rotated and moved downward and forward to a position directly below the articular eminence. And from one inch to maximal, translatory movement predominated.

In a Class II malocclusion the opening from occlusion to rest; the condyle moved downward and forward, and, with translatory movement predominating, continued in this downward and forward path to the one inch opened position where the condyle was below the articular eminence. Then the condyle moved forward to a point slightly anterior to the eminence when the mandible was in a position of maximal opening.

In Class III cases, From occlusion to the one inch opened position the condyle notably rotated with little noticeable translatory movement. From this point to one of maximal opening, translatory movement predominated and the condyle moved downward and forward to a position slightly distal to the eminence.

Nevakari (1956) did not base his material on Angle's Classification as he felt that such classifications do not reveal the functioning of the masticatory apparatus. It would seem to me, however, that variations in the maxillo-mandibular bony relationship would both cause and necessitate variations in the pattern of movement and a classification according to these relationships appears quite valid.

There is some controversy as to which muscles are involved in the initial stages of mandibular opening. A full discussion on this topic is not felt to be relevant here, but electromyographical evidence as found by Hickey in 1957, and again confirmed by this worker in conjunction with

Woelfel (1957b) would seem to indicate that in uncontrolled opening movements there occurred increased electrical activity from both digastric muscles and external pterygoid muscles, within the same tenth of a second. On retruded hinge mandibular openings, an instantaneous increase in electrical activity from both digastric muscles is noted. However, the external pterygoid muscles exhibit no significant change or increase in electrical activity from their rest pattern, as recorded on the electromyogram. Activity from these muscles was observed at the instant the maximal hinge opening was exceeded.

Collett in 1955 feels that when the suprahyoid muscles have moved the mandible as far as they can, the external pterygoids take over and pull the condyles forward. When this happens the opening axis changes to about the region of the mandibular foramina.

This concept, well supported scientifically as it is now, does not conform to the ideas of earlier workers. Such as Lord (1937), Thompson (1941), Prentiss (1923), Brodie, Wilson (1922), although some of these, notably Thompson, conceded that in cases of loss of function of the internal pterygoids as in condylectomy, the digastric and suprahyoid muscles can take over the function of mandibular opening.

#### Movements on a Horizontal Plane: (Fig 6)

Investigators agree that on a horizontal plane the border movements of the mandible will scribe a trapezoid figure. It would seem that for a given degree of bite opening there is no statistical difference in the measurement "B". When recorded in the unconscious state with complete muscular relaxation, there was no difference at a bite opening of 15.5 in. but there was at an opening of 7.6 in. It appears that the opening movement areas in all the subjects with increased posterior bite opening are at first enlarged and then reduced. With regard to the shape the horizontal movement areas in the three subjects can be characterised as follows:-

1. Laterally they are limited by two acute angles and anteriorly and posteriorly by obtuse angles.

2. In general there seems to be a purely rhomboid shape.
3. In the same subject the essential shape of the movement areas seems to be fairly constant, though the size varies with different degrees of posterior bite opening.
4. Each of the two movement paths which form the posterior angle seem to follow a straight or almost straight course.
5. In the case of passive movements both when the subject is conscious and when the movements are recorded under anaesthesia, the anterior border seems to be formed by slightly curved lines with the convexity anteriorly.

In the post mortem preparation the movement paths were reproducible within each series of experiments and the size and shape seem largely to correspond to the movement areas recorded in the living subject.

Robinson (1946) points out that the mandible can be retruded beyond what we consider centric, into a strained centric position. There is space distal to the condyle which contains soft tissue and the nutrient supply to the temporomandibular joint when the mandible is in normal rest position and occlusal position. This can be encroached upon by retrusion.

### HINGE AXIS.

#### Introduction:

Page (1952) an advocate of the hinge axis technic, feels that without first locating the condylar rotational or hinge axis and utilizing measurements taken therefrom, efficient articulation of human teeth cannot be achieved. Unless the patient's hinge axis is related and used on the articulator the head centric and the articulator centric will occupy entirely divergent positions and relationships.

Lucia (1953) agrees pointing out that without an axis mounting you cannot check or prove a centric relation record, and conversely "a hinge

axis mounting makes possible the checking or proving of centric relation record." Without an axis mounting,

1. You cannot intelligently diagnose an articulation, because the teeth on the casts will not meet the same as they do in the mouth.
2. You cannot check or prove a centric relation record.
3. You cannot accurately adjust an articulator to reproduce jaw movement.
4. You cannot fashion an articulation that has cusps meshing in the same arcs of closure as the patient.

McCollum (1939) feels that the main value of the hinge axis movement is in regard to a change of vertical dimension. The hinge axis is of prime importance in regard to change of vertical dimension. By no other means can an articulator possibly be made to reproduce the relations of the jaws and in no other way can a study of vertical dimensions be made, and the efforts at articulating the teeth be preserved and carried through to a satisfactory completion. This advantage is also commented on by Collett (1955), who believes in its existence because it allows a recording of centric relation at a level above the place where the proprioceptive reflex occurs and transference of our recording to an articulating instrument where this latter may be closed down to the occlusal level.

(1952b)

Sloane says the value of mounting cases to the mandibular axis is not restricted to diagnosis - it can be of estimable value in all phases of dental treatment.

#### Definition:

Clappin 1952 defined "axis" as a stationary structure or line around which something rotates. Eberle in 1951 had stated the hinge axis is conceived as an imaginary line which is a pivot point of all motion.

Granger in 1952 applies this definition of axis to the mandible - in pure vertical motion the condyle revolves about a horizontal axis. In pure horizontal rotation it revolves about a vertical axis. All of these axes meet at a point within the condyle. When these points in two condyles are connected by an imaginary line, it forms the hinge axis. Since the

hinge axis is located within the condyle during any bodily movements of the mandible the hinge axis will move with it. An accurate definition was achieved in 1952 by the Official Nomenclature Committee, who defined hinge opening position as: "The position of the condyle in the temporo-mandibular joint from which an opening by hinge movement is possible beyond the amplitude of the rest position."

McCollum as early as 1939 has pointed out that some anatomists seem to believe that a hinge action is a pivotal action between an edge and a surface such that the axis of rotation lies on the surface. He feels they are confusing pivotal action with hinge action.

#### Practicability of User

Trapezzano (1957) indicates it is not always possible to locate a transverse hinge axis with the fidelity of a true hinge. Frequently when attempting to make this registration it will be found impossible to obtain absolute rotational movements of the stylus because of asymmetry of the condyle.

Earlier in 1952 Granger had pointed out that the mandible is never symmetrical so that the hinge axis would never be at right angles to the saggital plane, either vertically or horizontally.

Borgh and Fosselt in 1958 have also experimented with hinge action indicating that a true pin point accuracy, hinge axis recording will necessitate an articulator which permits an asymmetrical arrangement of the mechanical condylar apparatus.

As <sup>M</sup>Thompson in 1954 has pointed out: "The axis indicators cannot be manipulated to suit the articulator and an articulator which can be made adjustable to fit the face bow is required."

Another problem with hinge axis is the ability to accurately locate it within the limitations of mandibular movement.

Kurth and Feinstein (1951), working on an articulator, found it was impossible to exactly ascertain the centres of hinge movement when the articulator was opened only  $\frac{3}{4}$ ". An area of about two millimetres dimension could be located within which the hinge axis point was positioned. The authors then constructed a model, twice normal size, and found that once the mandible was opened  $1\frac{1}{2}$ " it could be returned to a position of normal occlusion using as centres of rotation points four and four and a half millimetres away from the actual axis of opening. This would be equivalent to about two millimetres error in the patient. It would seem that a fixed point or centre of rotation cannot be precisely determined, however "more research will have to be accomplished to set these limits, as individual perception is the greatest factor in its delineation." These authors conclude that since more than one point may serve as a hinge the value of such a point in the clinical phases of dentistry is extremely questionable.

Borgh and Posselt in 1958 in their experiment had similar results and found, working on an articulator, the hinge axis point could be pinpointed within 1.5 m.m. for a ten degree opening and within 1 m.m. at a 15 degree opening.

It seems obvious, therefore, that the accuracy of the hinge axis location depends upon the patient's ability to open his mouth, with condylar rotation only, to a maximum extent.

#### Degree of Hinge Opening

Total evidence to date would seem to indicate that a hinge axis does in fact exist when the mandible opens and closes in posterior border movement. One would expect an individual variation of extent of these movements and most investigators allow quite a wide margin in their reports. Kurth and Feinstein (1951) state that the proponents of the hinge axis theory have shown that some patients open one and a half inches in pure hinge movement, but the average appears to one half to three quarters of an inch or about eleven degrees.

In 1922 McCollum reported: "We have proved to our entire satis-

faction that the mouth may be opened as much as one half an inch in the incisor region in every case, and in some cases as much as an inch without compelling the condyle heads to move forward in the fossa, as happens in opening the mouth wide."

In Woolfel and Hickeys experiments (1957) their subjects were able to execute at least 12 m.m. hinge opening movement. Posselt (1957) states it has been shown that the human mandible can carry out an opening movement to a distance of up to 20 m.m. between the incisors, while both condyles remain in their most retruded positions. This movement is remarkably constant unlike simple relaxed opening and closing.

In 1952 Posselt had found in recording radiographically the mandible's anterior and posterior movement, it could be ascertained that a posterior bite opening of 20.6 m.m. plus or minus 2 m.m., with a range of 17.4 to 24.2 m.m. can be obtained without any anterior shift of the condyles. This implies the first part of a posterior opening movement can apparently be effected as a rotation around a transverse axis through both condyles. When the degree of bite opening was raised to 27.8 plus or minus 2.4 m.m. some degree of anterior shift of the condyles occurred in all 15 cases examined. This seems to cause a tilting of the mandible around a limited part of the neck of the mandible.

Concerning the reason for the limitation of the hinge axis opening we have Langer (1837), Meyer (1873), Breuer (1910) and V. Hayek (1937), who feel that the stretching of the temporo-mandibular ligaments is the reason why the condyles, after a certain degree of posterior hinge opening, do not remain in their original positions but slide downwards and forwards. Sicher and Tandler (1928) and Sicher (1929) consider that compression of the soft tissues between the condyles and the mastoid processes after a certain degree of posterior hinge opening forces the condyles in an anterior direction. In general, Posselt feels that the mandible at the start of the second phase of the posterior opening movement, turns around a part of the mandibular neck which corresponds to the insertion of the temporo-mandibular ligament.

Contention over Presence:

Some difference of opinion exists as to the actual being of a hinge axis rotation. Posselt (1952) claims the problem has been investigated by graphical methods; photographic and roentgenographic, both profile and of the joint techniques, have been used. Breyron employed tomography and clinical observation was used by Schwartz (1928/28) and Angel (1948).

Post mortem examinations have been made by Langer (1860), Meyer (1865), Henle (1872), Ghissin (1906), Fick (1911), Braus (1929), Hayek (1936), McCollum (1939) and Loos (1946).

Amongst those accepting the theory of hinge axis opening are Page,<sup>(1952)</sup> Posselt,<sup>(1952)</sup> Nevakari,<sup>(1956)</sup> Sloane,<sup>(1952)</sup> Schwitzer,<sup>(1957)</sup> and McCollum.<sup>(1939)</sup>

Sloane (1952) feels that mandibular function should be considered as a fixed factor presented by the patient. The mandibular axis is not a theoretical assumption, but a definitely demonstrable bio-mechanical fact. He states it is the axis upon which the mandible rotates in an opening and closing function when comfortably not forcibly retruded.

Trapozzano (1955) quotes: "The presence of a terminal hinge axis and centre of rotation from occlusal position and in many instances greatly beyond the rest position level has been demonstrated repeatedly. Quite properly the position of the condyles during the making of this registration has been labelled a border or terminal position. As with centric relation it is precisely because the hinge axis represents the border position that it is capable of being recorded repeatedly with unflinching accuracy. The importance of hinge axis is predicated on the conviction that registration of condylar paths which include the Bennett Movement should be made from the hinge axis position. These ideas are supported by Needles (1927), Wadsworth (1925), McCollum (1927), Thompson (1954) and Shore (1959).

<sup>(1952c)</sup> Page defines hinge axis "as a theoretical axial centre that pierces the condyle transversely". Schweitzer<sup>1957</sup> says each condyle has its own axial centre and this is not a point centre. Each axial centre is independent. He does not claim that the hinge axis is scientifically constant to the mandible or to the articular disc, even in simple rotation, not to mention a combination of rotary and lateral movements. The irregular condyles make it impossible for the various individual axes to be constant even in simple rotation.

<sup>(1952-56)</sup> Page has pointed out that the condyle has three rotational axes, transverse, vertical and saggital, which do not intercept at a common point.

Brandrup Wognsen (1952) states: "In the lower half of the temporo-mandibular joint, a rotation takes place involving the condylar head. Nor does this rotation as a rule work around a fixed mathematical axis, through the centres of the two condylar heads, because the condyle head transversely does not have a circular shape, being slightly irregular, and because the longitudinal axis of the two condylar heads do not run along the same straight line. However, the deviations as regards the movement concerned, in this connection, are so slight as to be negligible in practice. Generally a rotation is taken into account which is assumed to occur around an axis through the centres of the two condyles, being termed the condyle axis."

Hjortsjo and Page<sup>(1953a)</sup> also comment upon the lack of symmetry, but feel that the inconsistency in rotation is slight during jaw motion within the terminal functional orbit.

Frank in 1952 in his roentgenographic studies of condylar position reported that no one condyle was found to be placed symmetrically in relation to its opponent. Posselt (1957) also agrees with the concept of lack of symmetry of the condylar rotational points; he states that the points fall within the outline of the condyles, but not in any regular relationship to any definite part of the latter. Posselt in his experiments

used:-

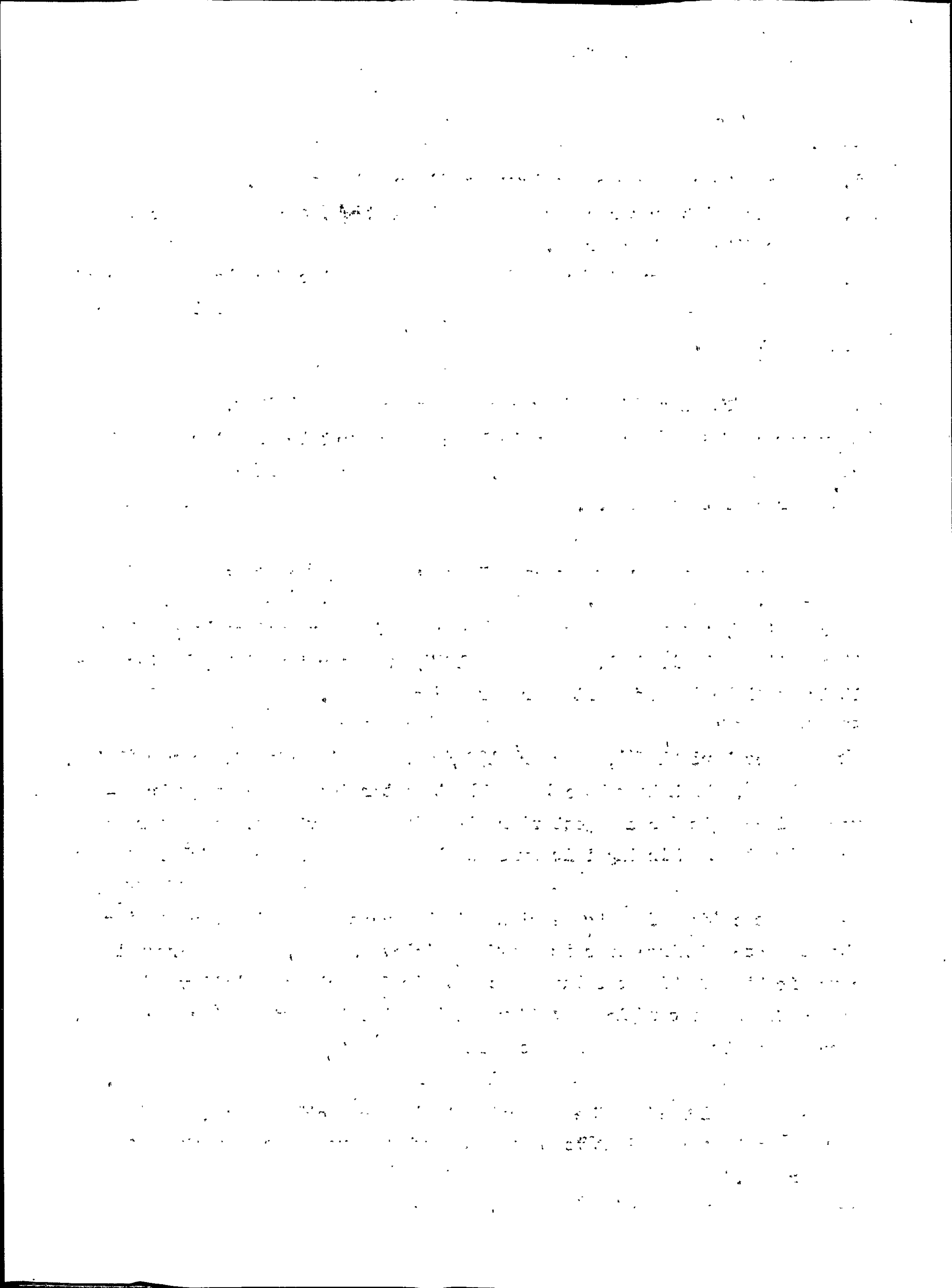
1. Geometric construction from profile roentgenograms.
2. Axis points recorded by means of kinematic face-bow and checked by profile roentgenograms.
3. Hinge axis established by means of a kinematic face bow and checked by gnatho-thesiometric measurements to analyse the terminal hinge movement.

The results obtained by each technique were similar, in so far as they showed the axis of the terminal hinge movement to pass through both condyles or make only minor shifts. This is true for hinge openings to the degree of 15 to 20 m.m.

Ulrich (1896), Eitner (1911-1912), Andressen (1913), Schwartz (1926-27), Needles (1927), Sicher et Tandle (1928), Fischer (1935) and Beyron (1942) consider a posterior hinge opening movement to be possible in the living individual, and Hayek (1937) and McCollum (1939) believe it is possible in post mortem preparations as well.

Navakari (1956), Fischer (1935/39), McCollum (1939), Beyron (1942), King (1951), think they have been able to determine a stationary transverse hinge axis for the posterior hinge opening movement, and according to their way of thinking this axis is situated within the condyle.

Some idea of the confusion and differences of opinion regarding the presence of hinge axis is noted by Higley in 1940. In a personal communication to him McCollum says: "It is fallacious to believe that the heads of the condyles move forward immediately upon opening the mouth. Face bow tests show that the incisal opening is always at least  $\frac{1}{2}$ " and may be as much as an inch and a half before the condyles start forward. This is accomplished by the patient only in a conscious state. Reflexly when you tell the patient to open his mouth he automatically puts the jaw forward."



Higley also reports the writings of Chissin: "The contraction of the upper head of the external pterygoid pulls the meniscus forward and since this is fastened to the back of the condyle causes the condyle to roll and come forward. This head seems to be the one that is principally concerned with the first phase of opening while the strong downward and forward gliding of the second stage finds the lower head playing the major role."

Wilson (1922-23) quotes Gysi who wrote in 1910: "Exact experiments have shown that when the jaw opens, the small distances necessary to correspond to the height of the overbite, the condyles remain in a normal condition."

Bennett in 1908 demonstrated that by very exact experiments on himself, in his case the condyle came forward immediately the teeth started to separate. Wilson tends to support this theory of Bennett.

Contradicting the concept of hinge opening movement, Clapp in 1952 in an article entitled "There is no Vertical Opening Axis in the Mandible" quotes Gysi's experiment and illustrates with his diagrams that mandibular movement records could not be produced from one centre; they were too unlike and too irregular. (~~see figure~~). Also the anatomic construction of the mandible is against the condyles as original centres of rotation. The condyles are integral parts of the mandible. They have no independence of movement. He takes several points A, B and C, as possible centres and compares the regularity of the opening curve from one of these centres to the irregularity of the actual opening curve. He then proceeds to show the axis of rotation for the opening at various degrees of jaw opening. There is much variance of axis position. Clapp concludes that all the axes for this movement, except the one used for extreme opening, are located outside the mandible.

Ulrich (1959), using a photographic technique in studying jaw movements, stated that in opening the condyles start their forward movement immediately and only a changing axis can be responsible for the opening movement. In discussing the possibility of terminal hinge opening Ulrich

asked three of the subjects to retrude while opening maximally. Two could not suppress the forward movements of the condyles, but the third did carry out an opening movement to almost half of its extent without any significant forward glide of the condyles. The condyles did not remain stationary but moved downward and backward on a convex curve.

Amer, as quoted by Kurth in 1959, feels that the concept of hinge axis opening is contrary to all ideal engineering principles, because a line bisecting the two condyles as a hinge axis would do, invariably passes through the smallest portion of the condyle. The theory that hinge axis is not a fact, is subscribed to by such workers as Moyhan (1953), Bennett (1958), Beck (1959) and Shepard (1958).

Langer, Meyer, Hente, Chissin, Fick and Braus (1860-1929) consider that a posterior hinge opening and closing movement is possible in post mortem preparations, but not in the living individuals. Luce (1946) does not consider that this movement is possible even in post mortem preparations. According to Luce (1889) and Higley et Logan (1941) a posterior hinge opening movement is not possible in the living individual. Also Luce (1889), Walker (1896), Chissin (1906), Gysi (1910) are amongst those who take the view that the axis of the first phase of the habitual opening movement is located outside the condyle.

Early hinge axis experiments were performed on a cadaver. Levao (1955) points out that hinge opening is not necessarily the normal path of opening. It can readily be demonstrated that a hinge axis recording will show one spot in the preauricular region wherein movement of the stylus occurs, when the mandible is voluntarily depressed and elevated. The area demonstrated by the stylus may denote the radius of the arc described by the condyle and may not necessarily exist within the condyle.

The inferences drawn appear to negate the value of the hinge axis recordings, but not withstanding the possible fallacies in the principle

THE DETERMINATION

it is assumed that the possibility definitely exists for a demonstration of a valid hinge axis passing through or near both condyles. Thus it would seem that there are two trains of thought regarding hinge axis presence and location. It would appear to me, however, that the hinge axis does in actual fact exist, although not with pin point accuracy. Thus hinge action seems to occur but is not clinically estimatable to an accuracy greater than a 2 m.m. area in the immediate region.

#### Technique for Location:

Granger (1952) states that the precise location of the hinge axis is obtained by means of an axis bow attached to the mandibular teeth or clamped to the edentulous ridge. It is similar in form to a conventional face bow, except that the side arms are adjustable horizontally and vertically and carry pointed styluses located outside the condyles. The hinge bow is attached and the patient is coached to open and close the mouth with a pure hinge movement. Now as the lower jaw is dropped open and closed, the stylus is adjusted until a point is located outside the condyle where the point of the stylus remains stationary as the mouth opens and closes. This is carried out on both sides simultaneously and the points so located are transferred to the skin. These two points are now used to make a conventional face bow transfer. All techniques for obtaining the hinge axis points are similar.

Sloane's, in 1952, technique is outlined to demonstrate the similarity. The system described is for dentulous cases and is as follows:- A mechanical extension to the mandible is provided by means of a cast aluminium clutch. A stable background is provided by graph paper fitted to the ear pieces of an adjustable ear muff frame. The cross bar of the face bow is attached to the clutch. The adjustable arms of the face bow are added to the cross bar. The axis indicators are adjusted as the patient opens and closes, until they no longer move in an arc but rotate on a single point. The point of reference is marked on the skin.

This face bow relationship can now be related to an articulator. Sloane uses the axis nasion line as the horizontal reference, the nasion in general being on the right side of the nose at a level of  $\frac{1}{4}$  to  $\frac{1}{2}$  inch below the inferior orbital pointer.

Such a technique is advocated by Lucia (1953), Thompson (1954), McCollum (1939), who devised the first kinematic face bow in 1937. McCollum feels that there is no possibility of correlating the position of the hinge axis by use of facial landmarks. The hinge axis position may vary from side to side in the patient. As there is no satisfactory technique of X-raying the temporo-mandibular joint, the only available way of locating the axis is by trial and error method as previously described. In the case of the edentulous patient a stabilizing device may be attached to the bite rim for positive fixation. Such a clamp is the Granger or Lauritzen chin clamp for the edentulous patient.

The examination by Fischer in 1935 to 1939, and Beyron in 1942 seems to have shown that the hinge opening movement is best performed as a passive movement, or as an active movement after certain training. Posselt in 1952 agrees with this concept and has not found anything to support the view that this type of movement should be performed as an habitual movement.

Page (1952 to 1956) feels that it is the natural involuntary closing stroke that gives the desired functional condylar hinge position and the jaw motion that revolves around the hinge axis.

Cohen in 1960 advises the use of a variation of the Hickok chin strap apparatus to train the patient to use the hinge axis opening.

It is interesting to note that Collett in 1955 has pointed out that in empirical face bow transfer carefully accomplished, is within a few millimetres of the kinematic transfer. The occlusion is about 100 m.m. in distance from the opening axis, therefore, it is questionable if the

additional accuracy warrants the additional effort. This must be considered together with the fact of the inaccuracy of the kinematic face bow which may be as much as two m.m.

CENTRIC RELATION CONCEPTS.General:

In attempting to locate and record centric relation there are many problems confronting the operator, as Hughes<sup>1960</sup> points out, anyone who knows exactly where centric relation is for all patients, just has not met enough patients. We are just beginning to comprehend the role of muscle action and jaw position, our concepts are conflicting and much research will be required in order to place a firm foundation under this very important phase of denture construction. A better understanding of centric and eccentric relations may influence our concepts of posterior tooth form and arrangement.

Basically there are technical problems and psychological problems. But it must be remembered that centric relation, until recorded, is only one position that the edentulous mandible may assume. Any mandibular position is governed by connections to the skull, that is the muscles and the temporo-mandibular joint, and in studying this topic the role of these mentioned factors must be given due consideration.

Musculature:

In 1939 Wright pointed out the recording of balanced centric relation not only consists in registering a point in space, but it also involves perfect balance between the jaws in centric relation.

Kazis in 1954 claims that from the understanding of physiology of mastication it is obvious that a dynamic balance of the muscles involves and of the forces and stresses being constantly activated is essential if the true centric relationship of the mandible is to be recorded and registered. If the centric relation that is recorded does not reflect a true balance of the muscles and forces involved, then functional requirements will not be satisfied and the established centric position and occlusal pattern will not represent a true functional occlusion.

### Joint Involvement:

Sicher in 1951 indicates that in centric position the head of the mandible is opposed to the posterior slope of the articular tubercle and is not situated in the deepest part of the articular fossa. This seemingly labile equilibrium is maintained mainly by the interlocking cusps of the occluding teeth which prevent further movement of the mandible upward and backward despite the contraction of the masticatory muscles. The articular disc aids in stabilising the position of the condyle, filling the space between the mandibular head and articular fossa. The varying thickness of the posterior part of the disc in individuals with high or low articular tubercles explains why, in centric position, the head of the mandible is in a fairly similar relation to the height of the articular tubercle regardless of the depth of the articular fossa. The deeper the fossa and the higher the tubercle, the thicker the posterior part of the disc. However, the disc is only a relative or accessory support of the mandible in occlusal position, because the disc itself is moveable against the temporal bone and can act as an additional support only if the upward and backward movements of the mandible and disc are checked by normal occlusion or normal muscular action.

That the teeth participate in determining the position of the mandibular head should not be interpreted as meaning that there is not pressure in the joint itself.

Sheppard (1959b) does not feel that the importance relegated to the condyles in the function of occlusion is warranted.

During mastication excessive occlusal contact is rare, light and fleeting in nature. Thus he claims the wisdom of introducing pathways for masticatory movements which do not occur in mastication, and of governing them with abnormal condylar movement and from a potentially hazardous condyle position is questionable.

This concept would seem to be supported by Silverman (1956), who points out that patients with bilateral condylectomies perform quite

adequately. They have a centric relation which can be recorded and duplicated as if they had a temporo-mandibular joint.

However, the importance of the condyles cannot be overlooked. Apart from the mechanical irritation they received if the centric relation is incorrectly recorded, they provide autonomic impulses, initiated in the capsular proprioceptive units, which play an enormously important part in mandibular positioning. This is particularly so in the edentulous case.

That the mandible may assume a centric relation consistently without periodontal or capsular proprioceptors is a tribute to nature's mechanisms of adaption, rather than an indication of lack of importance of these structures.

#### Position:

Shore (1959) says there seems to be no single anatomic reason for centric relationship of the mandible. The joint capsule and the ligaments are loose, the muscles are in various states of tonus, and there seems to be no fulcrum posterior or superior to the head of the condyle. Nevertheless, the interaction of the neuro-muscular mechanism, the temporo-mandibular joint, the teeth and the ligaments creates a basically accurate and constantly reproducible posture and pattern of movement.

Posselt (1958) emphasises that it is a position of harmony between the components of the masticatory system.

Kingery (1959) points out that whether the patient uses this point frequently or not, and this is a matter of some contention, it must be accommodated in our plan of occlusion. Therefore, he likes to think of centric relation as this reference point. It is the reference point for the development of the plan of occlusion and also for the determination of occlusal interferences in centric occlusion. This introduces the problem concerning the necessity of centric relation. Being a border position it is of significance in planning occlusal rehabilitation.

Posselt (1952) was able to prove the reproducibility of the passively retruded position, with a variation of only 0.08 m.m. within the degree of posterior bite opening of 2.6 to 0.8 m.m. He considers that such a degree of reproducibility of position of the mandible in relation to the maxilla justifies the term, border position. Under practical conditions the arrow point is generally recorded actively.

Between the position thus obtained and the one achieved by means of passive arrow point tracings difference of less than 0.1 m.m. were ascertained. Posselt does not think that such a difference can be of practical importance. He has also shown that a retruded position of the mandible in the individual case, leads to a much less varying inter-maxillary relation in the sagittal plane than does habitual closing movements even when performed with the head reclined or in the sitting position.

Boos (1959b) demonstrated that as centric relation is a perimeter or border relation, all movements of the mandible are forward or lateral from it.

Thus it would seem that centric relation owes its importance to the fact that it is reproducible, recordable, and being a border position all occlusal movement must be anterior of it, and it, therefore, provides a reference point for the harmonising of the occlusion.

It is used as such a reference point by the McCollum School, for example Stallard (1937), McCollum (1939), Stuart (1939-40), McClean (1939), and Granger (1945-50). These authors consider a position of the mandible corresponding to the arrow point to be the reference. They believe the arrow point contact corresponds to the inter-cuspal position.

We have come to realise that centric relation is the border position of maximum retrusion. However, is further retrusion obtained if distal pressure is applied to the mandible? That is, is centric

relation obtained in a strained or unstrained manner?

Ulip in 1955 feels that in his opinion there seems to be no middle ground in the argument of strained versus unstrained jaw relationships. The function having by far the greater number of adherents favours the unstrained concept. In making maxillo-mandibular records this group is careful to avoid any force against the patient's chin as he closes. This is based upon the belief that force exerted by the operator against the jaw will create a conditioned or reflex movement resulting in an unnatural jaw position.

Anthony (1942) also points out that methods utilising unusual force are open to criticism as this tends to encourage protrusion.

Ulip feels that such a condition of protrusion must depend for its validity upon the elasticity of the involved muscles and ligaments, the compressibility and viscosity of the joint tissues and the flexibility of the bones of the mandible and cranium. If none of the involved muscles, ligaments, alveolar tissues, or bones are subject to appreciable distortion while in function then it would appear that a strain of the relationship would not produce an incorrect position.

The anatomy and physiology of the jaws tend to refute the conditioned movement theory. The only muscles of the jaw that could possibly be affected by the operator's effort to retrace the jaw artificially are the external pterygoids. But these muscles play no part in closing function. During the final power closure they are relaxed while the masseter, internal pterygoid and anterior fibres of the temporal, move the mandible along a combined medial vertical and protrusive area. A patient left to his own devices will consistently deliver a maxillo-mandibular record that is grossly anterior to his normal jaw relationship. Therefore, it seems to be not so much a question of creating a conditioned movement, or a possible mal-position, as of counteracting an abnormal protrusion.

Centric relation is, however, a position of dynamic muscle balance and must apply to all the muscles connected to the mandible. A distal pressure causing activity either isotonic or isometric, of the external pterygoids must be antagonised by other muscles of the system, thus jeopardising the balance and resulting in the registration of an incorrect relationship.

Moyer's (1956) experiments have indicated that in the most retruded position of the mandible 76% of the subjects observed demonstrated muscle imbalance and straining. Such supports the work of Ricketts (1950). It would appear, however, that such hypertonicity would be indicative of a patient's over zealous attempts to retrude the mandible or may indicate the presence of eccentric reflexes which may have been used by the patient previously.

It would thus seem that such a position dictated by the muscular action can only be realised if no force is applied to dislocate the muscle force. Thus centric relation should be an unstrained position. The definition itself involves the word "unstrained" and Trappozzano (1955) points out that since the individual can assume this most retruded position voluntary by the action of his mandibular musculature the position is, of course, unstrained. He is supported here by Hanau (1929), who also chooses to define centric relation as an unstrained position.

#### Functional Position:

There is another mandibular position which must be considered. It presents on the same vertical plane as centric relation and is known by various authors as the functional position. Evidence is at hand which indicates that this is the position at which the mandible contacts the maxilla during such physiologic actions as swallowing, in speech. It is also believed to be the bracing position of the mandible against the maxilla and some authors consider it to be the contact at the termination of the masticatory stroke.

Boos has found that in 35% of his patients there is a tendency for the jaw relation to be forward of the posterior terminal position.

This was indicated by the gnathodynamometer recording of maximum biting force in a free horizontal range. These registrations recorded as much as 20 pounds greater force in other positions than in the posterior position. Some of these areas were as much as 7 m.m. protrusive from the jaw position. But Boos feels that the functional position is coincident with the position of maximum pressure on that plane.

Posselt in 1952 studying the habitual closing movement found that the posterior retruded position corresponded with the maximum intercuspation in only 12% of his patients. He found recorded habitual positions, dependant on the condition of the experiment, to be on the average of 0.5 to 1.7 m.m. anterior of the retruded position of the mandible. The recording of this anterior position, however, yielded much less consistent results than the recording of true centric position. Posselt stated that on this basis he would not consider that a retruded relation of the mandible should be attempted as the optimal starting point in side to side gliding movements. It seems to him to be precarious to cause the mandible's lateral gliding movements to start from its retruded position, as the intermaxillary relation seems to coincide so seldom with the intercuspal position.

Schuyler states that since 1929 he has been advocating the advancing of the mandibular member of the articulator from 0.5 to 0.75 m.m. when arranging teeth for complete artificial dentures. Patients seem to accommodate themselves to the dentures more readily and require fewer adjustments.

This is in accordance with the Hall Group, Kurth (1938), Denen (1938), Edmond (1938) and Boos (194)-43), who prefer a mandibular position that is situated about 1 m.m. anteriorly of the arrow point. They consider the latter to correspond to a retruded or strained relation while more anterior position is often characterised as true or functional.

Thus it would appear that there are two position on the one plane that various authors design as being the position of maximum intercuspation.

With reference to the posterior point the movement paths of which have been recorded, the measurements show a relatively great difference anteroposteriorly between the registrations of the passively retruded mandible and the habitual positions which were recorded with the subject in the sitting position. The difference between these groups averages 1.2 m.m. and has been statistically established. With the patient in the dorsal recumbent position, however, this same difference amounts to only 0.7 m.m.

Moyers in 1950 points out that although most frequent movements of the mandible during occlusal contact do not occur with their condyles in the most retruded position, condylar movements will, nevertheless, take place in immediate vicinity of the position. Because we are able to record this retruded position of the condyles we shall count ourselves fortunate and we shall avail ourselves consistently of the opportunity and use our registration as a base of operations from which we plan and construct the occlusal pattern of dentures. Most techniques for this registration can be severely criticised on the grounds that the problem has been viewed from a purely mechanical aspect while no assessment has been made of the neuro-muscular conditions for correct registration. If viewed from a purely anatomical point of view there will generally be a well defined difference between a retruded border position during occlusal contact and a position of maximal intercuspation in a person with a full natural dentition. But if viewed from a neuro-muscular aspect there will be no such fundamental difference, neither position is primarily preferable to the other. They are just two different responses to two different sets of impulses and in most individuals both sets will be elicited. Consequently when impulses arise that move the mandible into a retruded position the occlusal pattern of their dentures must be so constructed that the dentures are not displaced when contact is made in this position; on the basis of the centric registration and registrations of condylar path inclinations we shall be able to construct the occlusal pattern in such a manner that the whole of the requirements of the reflexes are being met in those patients whose condyles are in the most

retruded position during the initial and terminal phases of occlusal contact.

Brill in 1957 also feels that neither of these two groups are entirely correct or incorrect. He feels that complete dentures must be made on a registration of the mandible in its most actively retruded position. If necessary this registration must be modified to the extent that the occlusal pattern will compromise registration of prevailing functional occlusal position.

#### Variations in Centric Relation:

Silverman in 1956 points out that for clinical purposes centric relation may be considered as constant in the erect posture for short intervals of time in the life span. It must be considered, however, as a slowly but constantly changing phenomenon which in the long view is part of the dynamic vital process ranging from the embryo to cessation of life.

Moyers (1956) feels that most denture patients do not demonstrate clinically important changes in centric relation attributable to the ageing process. He points out that the reversion to the use of centric relation in place of eccentric relationship occurs only when the precipitating mechanisms for the eccentric reflex are lost. Though the periodontal membranes go quickly when the teeth are extracted the muscles may rely on memory for awhile. On this basis he feels that it is important to allow a maximum of occlusal freedom in immediate dentures. He also points out that centric relation is not the same when one is tense and tired as when one is refreshed and relaxed; It is different when one is afraid than when one is quite at ease. This is in accord with the theory that centric relation is a position of muscle balance.

Walsh in 1951 has indicated that the centric relation position becomes more stable with age, but the concept of a fixed and unmitable centric relation is contrary to all that is known of neuro-muscular physiology.

### The Concept of Transcranial:

This is a theory which has been introduced to dentistry in the last decade whose followers do not believe in the idea of centric relation as a reference point for denture construction.

Rader in 1955 in an article entitled "Centric Relation is Obsolete" states the feeling of the group that centric relation is unsound in principle. This is because it is a static position of the jaw that is useless in functional occlusion.

Papa in 1952, the founder of the concept, points out that articulation is not static, but a moving or kinematic relationship. When centric relation is transferred to any instrument its static relationship is lost. The articulator joints, representatives of the temporomandibular joints, assume a new and entirely different relationship to the occlusal surfaces. The rotational centres of these articular joints, not centric, now govern the kinematics that in turn dictate how teeth shall be opened.

Rader continues that cusps will intrude upon the vertical dimension. There will be cuspal interference on opening and closing because the articulator cannot function in exactly the same manner as the mouth. A further error is added due to the inability to compensate for the disparity of radii between the articular hinge axis that dictates how the teeth will be set in the instrument, and the condylar hinge axis that controls those same teeth meeting in the head however apparent. He feels that the face bow "usually erroneous" does not frequently come within 5 mm. of producing correct condyle to alveolar ridge radius and an error of less than 2 mm. will be disastrous. His remedy for the problem has been found in transcranials. This process begins with jaw function and operates with an articulator that supposedly captures and duplicates jaw movement. Centric relation is discarded and condylar rotational control centres are used as reference points.

The technique is based upon the use of a "Transograph", which is a specific adjustable type of articulator which purports to allow for the asymmetry of condylar head position and therefore, the different centres of rotation. The users claim that the condylar slots are not connected, but in actual fact they are both attached to the upper model and thus are firmly fixed in relation to each other. The subscribers to this theory also believe that the torsion which is produced when the appliance is opened produces flexion of the structure of the articulator. Such torsion is avoided in the natural case because of the looseness of the suspension of the mandible in the capsular ligament sling and the accessory muscles.

Page (1952-56) feels that the unsatisfactory results that occur from the dependence upon centric, and neglect of the hinge axis are that the areas of closure upon which the teeth were set on the articulator in no way agree with the areas of closure required for the patient's mouth. A clashing of cusps is the unavoidable result.

Page in 1952 indicates, according to his theory, any gothic arch tracing can do no more than indicate that both condyles were in coincidental terminal relationship at some point in the scribing. Out of the head the apices relate to nothing except occlusal apposition in one plane only, the horizontal, and at one vertical opening. Nothing is gained by combining a face bow with a gothic arch tracing. Since the position of the face bow is located by guess work it hides an inaccurate relationship and transfer, while it creates an illusion of accuracy.

Page in 1955 claims that when centric relation is used the arc of closure in the articulator fails to coincide with the mouth arc of closure that made the paths in the wax originally. Teeth mounted in the articulator are not being guided correctly through the slips cut in the wax and will drag or refuse to close at all. Cusp tips and inclines being set up and formed by these same erroneous closure arcs in the articulator will repeat this same interference when the denture is installed in the mouth. In contrast to the infallibility of the centric relation bite it

should now be apparent, according to Page, why a hinge bite does not invite trouble when the jaw position or vertical dimension is changed.

The question is at what horizontal position, laterally and sagittally, does Page select for the position of maximum occlusal contact?

It is difficult in the literature to find information concerning this phase of transographic ideals.

Schweitzer in 1957 indicates that an important objective in this theory is that the so-called hinge bite be made with the mandible in its most retruded position. Adherents of the transographic theory use manual pressure in obtaining these records. But it would seem that the proponents of transographics record a retruded relationship, which at the correct vertical dimension for occlusion, is in actual fact what is claimed to be centric relation.

Cohen in 1960 also uses the hinge axis as a starting point for centric relation and states that the most important maxillo-mandibular relationship to record is centric relation. This is directly opposed to Page's theory.

McCollum (1960) upon whose ideas of hinge action the transographic principle is supposed to be evolved, says the movement of the mandible are in three dimensions:-

1. Up and down.
2. Forward and back.
3. Right and left.

All of these movements have a common starting point which has become known as centric relation.

PREPARATION FOR RECORDING.

In attempting to record the centric relation of a patient, there are two factors which must be assessed. The anatomical position of the mandible and the psychologic adjustment of the patient. The former embraces both cranio-mandibular connectors, the condyles and the musculature.

Condylar Connection:

Patients who are wearing or needing dentures, in the majority of cases have experienced some years of occlusal disharmony with resultant arthritic changes of the temporo-mandibular joint. Moyers (1956) had indicated that any patient presenting for complete denture prosthesis has suffered from a poor occlusal history or he would not be needing prosthetic service. Also as a rule these patients are in an age group in which clinical manifestations of a chronic or latent arthrosis are now becoming apparent. Regardless of the presence or absence of symptoms, however, in all cases the joint should be assessed as to its normality. This can be done by palpating the condyles, by acoustic examination and by reference to the patient's denture history. It is this writer's belief that little or no damage is inflicted upon the condyles when the patient is wearing dentures with occlusal disharmony. Regardless of the lack of consideration that these dentures may have on the physiologic structures, damage seems to be experienced by the alveolar ridges rather than the articulating surfaces. In cases where the edentulous state has been arrived at gradually, occlusal interferences can be expected to have caused some disturbance even though it may not be sufficient to produce an arthritis.

The arthritis may be of the deforming type, where the irritation to the structures of the joint has caused proliferation of the osseous structures causing a restriction and malformation of the joint surfaces. Such a type of arthritis is commonly found in cases of long standing over-closure.

There may be inflammatory type of arthritis usually due to micro traumas which may be initiated by occlusal interferences in the natural

dentition and continued by full dentures constructed at an habitual bite registration. In some cases this arthritic condition, inflammation, will be so severe that it will be impossible to record centric relation.

Block in 1954 indicates that in such cases there will be associated muscular imbalance. Regardless of the cause of pain or tension, first step is to relieve the pain. It is only when the patient is pain free that we can hope to record and restore normal jaw movement. The treatment for pain will vary with its severity, but usually relief can be noted within a few days by prescribing:-

1. Wet hot packs for 15 minutes, three times daily.
2. A soft diet, giving joints and associated structures as much rest as possible.
3. Anodynes, according to the specific needs of the patient.
4. Sedation, to assist in relaxing the patient.
5. In extreme cases injection of hydro-cortisone into the glenoid fossa.

This will give us a patient who can be studied, diagnosed and treated with more accuracy and less discomfort.

Another possibility exists when a patient remains edentulous for a considerable time. The meniscus and other tissues around the head of the condyle within the capsular ligament, gradually fill in the space created by a continually protruded mandible. The tissues surrounding the capsular ligament press the ligament inward to help fill the space created by the continuous protrusion of the mandible. This condition prevents the immediate placement of the mandible into its most retruded position. For that reason the dentist must expect to spend considerable time in establishing centric relation because these tissues work back into their normal position rather slowly.

Swenson in 1953 has pointed out that it often takes a good part of an hour in cases of badly mal-positioned structures in the condylar joint to re-position these tissues. It would seem that in some cases even more time must be devoted to this re-positioning and it may be

advisable to prescribe muscular exercises for the patient to perform at home over a period of a week. The time spent in re-positioning the tissues of the temporo-mandibular joint is well spent; if the condition is not corrected the patient works back into the retruded position after the dentures have been inserted. Swenson has indicated that failure to re-position these tissues will result in premature contact in the anterior region of the dentures. The irregular loss of teeth has often shunted the mandible into a slight protrusive or lateral position or both. It is felt that the most favourable position of the mandible for complete dentures is an exact centric relation. The muscles, bones, ligaments and the teeth and all structures grow into what might be termed a muscle centre. To change this muscle centre is to imperil the stability of the dentures.

Tissue around the capsular ligament may be displaced by initiating exercises similar to those described by Boss for muscle therapy.

#### Muscular Connections:

Block in 1954 has indicated that in association with arthritic changes there will be muscular imbalance which may result from:

1. Uneven occlusal contacts which force the jaw into an eccentric relationship, sometimes called a habit bite.
2. Emotional factors which lead to clenching of the teeth and sometimes bruxism, with abnormal and maybe uneven wear on occlusal surfaces.
3. Arthritic changes within the joint, either local or co-inciding with systemic conditions.
4. Traumatic conditions.

Moyers has indicated in 1956 that a poor occlusal history is associated with muscular hyper-tonicity, and is most commonly found in patients of the edentulous category.

Trappozzano in 1955 also points out that unequal tonicity of attaching muscles may produce a registration which does not reveal its

inaccuracy immediately. Tracings or interocclusal records of the position of centric relation can be checked repeatedly with the condyles in this position. Since no indication of the inherent inaccuracy is manifested in the registration, the condylar position thus obtained is registered and utilised in the treatment indicated. After a varying period of time, an examination of the individual's occlusal relation will reveal a disharmony of occlusal relation which can be attributed to no other reason than the regaining of muscle tonicity on the affected side. He points out that the primary aim in registering centric relation in the edentulous patient, is to do away with any eccentric reflexes which might have been used. The memory of previous eccentric positions may persist for some time. However, in the absence of periodontal stimulation those mandibular positions assumed to avoid occlusal disharmony will eventually be forgotten unless perpetuated by dentures constructed to an erroneous mandibular relationship.

Posselt in 1958, indicates that in the diagnosis of abnormal function and the restoration to normality, it is of paramount importance that we start by eliminating muscle spasms. This may include one or more of the following measures:

1. Muscular relaxation.
2. Therapeutic exercises of muscles.
3. Occlusal adjustment by grinding.

#### A. Muscular Relaxation:

The Shpuntoffs (1956) found in their electro-myographical analysis that in 15% of patients, neuro-muscular relaxation was needed to produce the relatively quiescent electro-myogram of centric position. A combination of Mephenesin and Dormison proved most effective in reducing the tensions which interfered with the production of the myogram.

<sup>(949)</sup> Trapezano also found drugs such as Mephenesin effective and he includes patient relaxation by such techniques as jiggling the chin to effect a temporary erasure of the unwanted reflex.

Uccellain (1960) listed the requirements that would be necessary for muscular relaxation drugs:

1. Interruption of abnormal reflex excitability allowing normal stretched muscle activity without causing concomitant weakness or otherwise altering the normal functioning of the central nervous system.
2. Minimal toxicity with a wide range of safety in dosage.
3. No untoward side effects, which might contra-indicate its use for the average ambulatory dental patient.
4. Ease of administration.

Probably the most commonly used drugs are those previously mentioned, Nephensin and Dormison. Uccellain experimented with a drug Robaxin, which is a methocarbamol. He set up a controlled test. The drug was used in a 250 mg. dosage and an hour was allowed for the drug to take effect. The patients were divided into a fast group (those who required 1 - 10 minutes to scribe the arch), a medium group (11 - 24 minutes), and a slow group (25 minutes and over). However, the author was unable to arrive at any conclusion regarding the drug and no significant pattern could be found.

#### B. Therapeutic Exercises of Muscles:

Boos in 1956 described an exercise which is excellent in conditioning the musculature. Conditioning may be accomplished by this exercise which stretches the muscles and allows them to come back to rest position. A complete exercise is to have the patient hold the head in an upright position and go through a series of movements of the mandible. First the patient opens wide for about half a minute, then relaxes and lets the mandible come to rest position. Do not attempt to position the jaw. The teeth should never come together so there will be no guidance by the existing occlusion. Next, the patient moves the jaw to the right as far as possible in a slow continuous stretch and then lets it drop back to rest position. Then he moves his jaw to the left and lets it drop back; then forward, back to rest, retruded as far as possible and then to rest, and then open and back to rest. The forward position and dropping back to rest as well

as opening wide and coming to rest will often help in bringing about a normal unstrained mandibular position. The exercise may be used by prescription by requiring the patient to follow the prescribed movements for two or three minutes four times a day. The patient should be cognizant of maintaining a space between the teeth. If the denture interferes they should be removed during these exercises, whenever the patient finds himself biting on his teeth he should open and stretch the muscles to relieve the tension. The exercise is in no sense a method to develop muscle power. It is a procedure to relieve tension and produce relaxation.

It would seem to me that these muscular exercises are so desirable that it is indicated that they should be prescribed to all patients before recording of the centric relation. In lesser cases of hypertonicity Kile (1955) used a functional chewing procedure and then, with the muscles tired by such an action he feels a sufficiently accurate occlusal centric relation can be obtained for mounting of the tracing arches.

Swenson (1956) has also indicated that the use of a central bearing point is an excellent aid to exercising a forward and backward movement, because the patient has a sliding surface against which to rest while exercising the reposition the joint tissues and relieve hypertonicity of the muscles.

Floyers in 1954 feels that in mouths in which an extreme eccentricity or series of eccentricities have been used, it may be good practice to teach the patient a completely new mandibular closure pattern and position, for example using the hinge axis even though the patient may not have used such a closure pattern previously and the position may not necessarily be the true centric relation.

### Psychologic Preparation of the Patient:

Kingery (1959) points out that regardless of the technique used, one must guard against errors of patient origin which are those caused by tension, habit and moods of the patient and the influence of the dentist's attitude, irritation caused by denture bases or general tenderness of supporting ridges.

The problem of securing centric relation is in large measure the psychologic problem of encouraging in the patient at the time of closing, processes of mind which habitually or ordinarily accompany this closing movement. In the case of the patient whose attitude remains at cross purposes with that of the prosthetist the most perfectly constructed dentures will not give their satisfaction.

In securing centric relation the prosthetist desires to have neither the unhelpful or the helpful attitude assumed by the patient. The desired closing movement is an unconscious habit. If any single phase of this method (e.g. squash bite) of securing centric relation may be said to be the most important then the absence in the anterior portion of the mandible of anything upon which to bite constitutes this factor. The idea is that it eliminates the possibility of the patient biting on his anteriors and thus prevents the protrusion of the mandible during the recording. For this purpose the word "Clinch" is better than "bite".

Furnas (1935) emphasises the importance of taking the patient's mind off the bite taking operation. He also allows time for the patient to condition himself to the bite blocks so that these may not present a mental block to the positioning of the mandible.

GOTHIC ARCH TRACING.

The Gothic Arch tracing has been known as a system of recording jaw movements for some time. The phenomenon of right and left intersecting arcs from right and left condyles was known and fully described and illustrated by F.H. Blakwill in 1866. The first needle point tracing device for applying this knowledge in denture construction, seems to have been introduced by Hesse in 1897 and given greater prominence by Gysi in 1910. It was then found that the stylus traced a figure in the wax or soot layer of the table resembling a rhombus. When the pin is at the anterior point of this rhombus the lower jaw is in central occlusal position, that is, the condyles are at rest in their most retrusive position in the fossa mandibularis from which lateral movements can be made.

In his original appliance Gysi used modelling compound occlusion rims, in order to maintain the vertical dimension during the needle point tracing procedure. Phillips<sup>1927</sup> later pointed out various errors produced by this technique and stated that "if one occlusal rim is allowed to touch the other during the lateral extreme positions, undue pressure is bound to be exerted on the contact side, and on account of the resiliency of the underlying tissues, the side not in contact will be unseated just enough to cause a false reading for the horizontal inclination of the condylar path."

Smith<sup>1941</sup> has pointed out that shifting of the bases may easily occur and under such conditions it is difficult for the patient to make accurate recordings. Phillips<sup>1930</sup> introduced the central bearing point to maintain vertical dimension as well as to centralise forces.

Stansbury introduced the use of plaster of paris for fixing mandibular and maxillary rims in 1928, and Sears later devised a means of extra-oral fixation incorporated in his Sears Trivett.

Another change in the graphical method resulted when the central bearing point used for centralising forces and stabilizing the lower occlusion rim also served as a tracer to register the intra-oral Gothic arch. Various intra-oral tracing devices have been described by

Blanchard, Messerman, Coble, Hardy and Wastrow.

Another early type of intra-oral registration was afforded by the Needles technique in 1923, in which three cutting pins were attached to the maxillary occlusion rim. This author suggested the use of spherical occluding surfaces on the modelling compound occlusion rim.

Hight, Sears, House and Terrell and many others have devised tracing mechanisms of their own design which enable them to secure dependable registrations.

Maves points out that up to 1928 there were two techniques of establishing centric relationship of the mandible to the Maxillae; the first is the gothic arch tracing after Gysi, and the second was Needles' Method. The latter technique was supposed to establish three important fundamentals, the central relationship, lateral movements of the mandible and condylar inclination harmonious to the case.

#### Mechanism

In the use of the gothic arch tracing by one of the several techniques the mandibular border movements on a particular plane are recorded and a tracing the shape of a rhomb is developed. If central protrusive movement is made the excursion will cause the scribing of a diagonal. The point of intersection of this diagonal and the two distal arcs of the rhomb is considered to be the position of centric relation on that particular vertical plane. The only purpose of the gothic arch tracing is to establish a visual point of reference. The applicability of the graphic tracing is best understood and the tracing is most valuable if treated as an independent part or operation in technique. If we respect the graphic tracing of the jaw movement as an indexing factor from which to start our work, we realize the full value of the tracing.

Sears (1952) indicates that what the operator wants to find is a single position on a horizontal plane.

The scribing of arcs, he feels, occurs because the tissues, just back of the condyles act as stops. When both the condyles meet their stops, the needle point can move from here to the right and back only until the left condyle again meets its stop; it can move also to the left only until the right condyle again meets its stop.

Aprile and Saizer (1947) believe that the gothic arch tracing depends solely upon the mechanical possibilities of movement governed by structure and the relation of bones and ligaments, thus it is not the position of the muscles that move the mandible which determines the placement of the point around which the mandible rotates. They experimented on a cadaver and performed the tracings first normally, then with the cheeks removed and then with the ligaments removed. It was found that there was a progressive enlargement of the rhombus of movement but the position of centric relation remained constant.

They indicated that the tracing only ceased to be rhomboid when the condyles were removed. Aprile and Saizer therefore concluded:

1. The tracing form of the rhombus of the horizontal movements of the mandible results from the disposition of the osseous formations of the temporo-mandibular articulations.
2. The inter-articular fibrocartilages, capsular ligaments and internal and external lateral ligaments, limit the extension of these movements and determine the length of the sides of the rhombus.
3. The so called accessory ligaments do not appear to have any influence on the tracing of the gothic arch.
4. The muscles and other soft tissues appear to have no influence on the tracing.
5. Severe alterations may occur in the temporo-mandibular articulations without interfering with the patient's ability to trace a perfect gothic arch tracing or rhombus.

#### Significance:

Kazis (1954) says it is generally agreed that centric relation is

indicated by the apex of the gothic arch tracing. He points out that this statement is true in essence, but modification of the concept is necessary for it is possible to obtain a gothic arch tracing with instrumentation, that does not take into account the functional aspects of mastication and hence the apex of the gothic arch tracing does not represent the true functional relationship. This position may represent a balance of the muscles operating only in one plane. In order for a gothic arch tracing to be representative of the true functional relationship of the mandible to the maxilla a functional balance of the forces constantly operating in both vertical and horizontal planes must be obtained.

Granger (1952) on the other hand feels that there are several reasons why the apex of the gothic arch is not a reliable guide to centric relation. Firstly, the centric relation is a vertical rotational relationship, whereas the gothic arch is merely a position on a horizontal plane. Equally important is the fact that the centric relation is an extremely precise relationship, but the so-called apex of the gothic arch usually does not exist. Granger feels that a curve and not a point is effected. As the condyle rotates in lateral excursion of the mandible, the centre of rotation is sliding across the trough of the fossa in the Bennett Movement. The combination of rotating and sliding sideways makes it impossible for the mandible to produce an apex at a point where the two lines meet.

In 300 cases Granger found that only rarely was a sharp apex presented on the gothic arch tracing.

But Trapozzano (1955) has indicated when making a needle point tracing for establishing centric relation on a patient with a normal temporo-mandibular joint the apex of the initial tracing will be rounded frequently instead of having a definite apex. This may result from the patient's failure to understand what is required when the right and left lateral movements are made or it may be due to a slight filling in of

tissues behind one or both of the condyles. In such cases he feels that persistence will produce the needle point tracing. Had a rounded tracing been used, the resulting area of mal-occlusion would produce an inevitable shifting and sliding of the denture bases which would result in instability of the dentures and all of its undesirable sequelae.

Furnas (1935) has stated that at times the apex of the tracing is flattened or squared off, which shows that the condyles have assumed a new and forward position usually due to abrasion, extraction, or the wearing of ill fitting dentures when the bite has been abnormally closed. Occasionally the tracing will show two well defined lines converging toward an apex or angle. The apex will be missing and in its place will be found a flat or rounded surface connecting the two lines. This information is of great significance because it shows that the condyles can no longer return to their original seat in the glenoid fossa and so the mandible remains in a constant protrusion. This condition is usually found in patients who have lost their natural teeth and have been without artificial dentures for a number of years; or in cases in which artificial dentures have been worn for many years and the bite has closed and thus the vertical dimension is shortened. If a correction of more than 1 m.m. is required Furnas feels the change cannot be accomplished with comfort to the patient, unless it is very gradual.

At times the tracing will appear not as definite angles with a distinct apex, but rather as a straight or slightly curved line; such a tracing indicates that the glenoid fossa is practically a flat surface and that the condyles move almost straight forward during the opening and closing of the mandible. As this looseness of articulation will permit a certain latitude in the location of exact centric relation Furnas feels that any point selected in the near vicinity of the normal apex will be entirely satisfactory.

Some authors have noticed that in a minority of cases the mandible may be retruded past the point of the apex of the Gothic arch tracing, that is the distal border position.

Gysi (1929) and his followers, Brown (1930), Hight (1932), Fischer (1935) and Furnas (1935) are of the opinion that the mandible may be actively or passively moved posterior to the arrow point, corresponding to a strained or forced relation. Meyer (1959) does not feel that this more retruded position represents centric relation, and he disregards it.

Posselt in 1952 states: "In my series of cases I have not found any path posterior of the arrow point angle corresponding to positions of the mandible from which it should not be capable of performing lateral movements. It is true that the path has been recorded on a few occasions with actively performed lateral movements, but its most anterior part in the subject in question has corresponded to the arrow point angle obtained by means of passive movements, and in such cases the angle point actively recorded has not corresponded to such an anterior position as will generally result from habitual closing movements."

It would seem, however, that this condition does exist, possibly due to some temporo-mandibular irregularity. Its significance has not yet been established, but it is certain that the more retruded position is not that of centric relation.

#### Implications derived from the Included Angle:

Furnas (1935) describes the symphyseal angle as varying between 80 and 120°. In 1959, Boos said that the more acute the angle of the Gothic arch tracing the greater the horizontal and vertical overlap required.

Gysi in 1929 pointed out that the included angle will vary in different patients. He placed the average as being 120°. If the arch is registered farther from the incisor point the included angle will be greater. Gysi feels he has proved by solid geometry that the form of the Gothic arch combines with the sagittal inclinations of the condyle and incisor paths, to influence the angulation of the facets which dentists must make on the masticatory surfaces.

A Gothic arch of  $100^{\circ}$  requires the formation of relatively steep facets on the teeth.

A Gothic arch of  $120^{\circ}$  requires facets with average inclinations.

A Gothic arch of  $140^{\circ}$  requires facets with less than average inclinations.

Kurth in 1954, emphasised that the symphyseal angle will vary according to the plane upon which the tracing is developed. He found that the arches traced on variously curved plates and on flat plates and with the natural teeth in contact varied between  $138^{\circ}$  with the flat plane to  $152^{\circ}$  for the concave plane and to  $149^{\circ}$  on the convex plane. He, therefore, concludes that the Gothic arch is not constant when registered under different conditions and cannot be considered a fixed characteristic of the masticatory system. Thus he feels, and indeed demonstrates, that the recorded right and left lateral positions will vary according to the device used for obtaining them, although centric relation will remain constant.

### Clinical Technique:

There are many variations in the application of the arch form for indicating the position of centric relation, or at least the direction and limitations of the mandibular movements on a specific plane.

Individual operators have developed their own approach and incorporated their systems in the design of their appliance. This, of course, leads to a multitude of appliances with many slight variations. Basically, however, one finds two types of tracing devices, the intra-oral and the extra-oral.

### Intra-oral System:

Modern intra-oral appliances consist of a centrally placed pin which doubles in function as a tracing device and central bearing point, and a tracing table attached to the opposing jaw upon which the movements are scribed. The appliances are simplicity themselves.

Amongst the designs of these may be mentioned the names of Coble, Messerman, Seidel and Ballard.

Pleasure in 1955 and Silverman in 1957 both advocated the use of a Coble Balancer to obtain centric relation. This device has the central bearing point attached to the maxillary base plate and the tracing plate is fixed to the mandibular unit.

Other appliances will attach the stylus to the mandibular base plate.

As a discussion of the position of the central bearing point is relevant to both intra-oral and extra-oral appliances it will be dealt with later.

The Ballard tracer involves a spring loaded central bearing point which is capable of delivering tension or pressure upon the underlying mucosa. It would seem to me that this appliance would be valid in its use only if associated with impressions taken under a similar degree of tension. Thus if the operator favours the compression technique of impression it would be suitable to use this appliance to provide the pressure. It would seem that the technique lends itself to obtaining the impressions and recording the bite registration at the one appointment. This technique has much to advocate itself; as it ensures equilibration of pressure during the bite and impression stages. This is necessary to eliminate displacement of the base plates upon the models and will be discussed later.

A type of variation of the intra-oral system was described by Needles in 1929. He used occlusion rims set with a spherical template of radius four inches. This corresponds with the Monson curve theory. Into the upper rim he imbedded three wires which protruded from the rim surface about  $1\frac{1}{2}$  m.m. The molar wires should strike slightly outside the

middle of the lower bite rims. Each of these wires will act as a stylus to trace the paths of the respective points upon the surface of the lower plate. By this procedure a balanced three point contact has been maintained. This technique did not gain very much popularity and gave way to the tracing and recording technique of Stansbery developed at about the same time.

The intra-oral appliance is simpler in use, as pointed out by Bergstrom (1956) and may be capable of producing a more technically precise recording. This is stated in respect to the work of the Sphutnoffs, who feel that the extra-oral extension may interfere with the neuro-muscular reflexes associated with the obtaining of true centric relation.

#### Extra-Oral Systems

This system was developed first by Gysi in 1910-1911, and the movements were of a gliding nature with the bite blocks constructed to glide over each other in as frictionless way as possible while the tracing was made at about the position of the lip. This technique was cumbersome and produced its own set of inaccuracies. Amongst these was difficulty of control of the appliance by the patient, introduction of lateral stresses which may have dislocated the base plates, and difficulty of obtaining equal distribution of stresses.

The Gysi System was replaced about 1928 by Stansbery's technique, which employed the use of a central bearing point sliding against a curved plate. The upper tracing plane was curved on a 4 inch radius according to the research of Dr. Monson. The lower plate of slightly greater convexity (3") secured to the lower bite rim with the convex surface upward. The point of tangency of these two plates should lie as nearly as possible between the area centres of the two casts and the plates themselves should be approximately parallel to the occlusal plane. In the lower plate at the point of tangency, a round headed screw threaded in millimetres is inserted from the underside. This takes the place of cusps in the finished denture, and acts to force the mandible

into a position below that of centric occlusion while the protrusive and lateral positions are being recorded. This screw also allows for variation of vertical dimension, according to the operators desires. The tracing pin or stylus and smoked graph plates are attached to the lateral surfaces of the bite rims.

The next step is at the chair. The curved plates are lubricated to exclude horizontal dislocating forces and the bite rims are inserted. The patient is asked to maintain a constant moderate biting pressure and to put the mandible through protrusive and retrusive movements.

The base plates are now removed from the mouth and the screw is elevated to represent cusp height. They are again placed in the mouth and the movements, before described, repeated. The introduction of the cusp height will cause the arrow design to be advanced 1.5 to 2 m.m. on the smoked plate. Lateral registration and protrusive registrations are then secured.

The introduction of the central bearing point paved the way for greater accuracy and control of many arch tracing appliances. It is interesting to note, however, that the technique of gliding of the occlusion rims has not been entirely discarded. Kile in 1955 advocated such a system in conjunction with his Dento-graph. He feels that during the process of chewing the occlusion rims the muscles of mastication were the guiding factors. The temporo-mandibular joints were the limiting factors. The uneven occlusion rims with the slightly opened vertical dimension were the interfering factors. With the vertical dimension established and the occlusion rims back to the mouth the occlusion rims become the guiding factors and the muscles of mastication furnish the motive power.

Swenson in 1953, however, comments that extra-oral tracings without a central bearing point are not considered very satisfactory because, although they give the antero-posterior position of the mandible, they may not give the maxillo-mandibular relation. It has been found in testing the results of this type of bite relation that it is extremely difficult to get an equalised pressure on blocks of wax or compound.

After the development of the Stansbury Check Bite came variations on the same idea. Hight (1934) produced a tracing appliance which incorporated a central bearing point, together with a flat tracing plane. Terrel (1951) and Sears (1952) both designed devices which record two tracings of the mandibular movement, one on each side of the face. The inclination of the rhomboids thus established is used to compute the amount of Bennett angle included in the patient's mandibular movement.

Kingery (1959) points out that the extension of the tracing arm and tracing plate outside the mouth allows detection of any movement on the part of the patient, and avoids the necessity to lock the patient's jaw in a certain position.

But working on a more precise level, the Shpuntoffs (1956) have demonstrated electromyographically that the attachment of an extra-oral device to the face, or merely touching the patient's face, or the introduction of any device or material to which pressure can be applied, act to produce a high muscular activity. This activity is large enough to prevent registration of physiologic rest position or centric position.

On this latter finding it would be considered that the intro-oral appliances would have more scientific standing and would thus be preferred.

Extra-orally many combinations are possible. The tracings by Gysi were made at or near the incisal border of the anterior teeth. The more recent developments of Gysi are appliances which make an extra-oral tracing on a wax coated metal plate. The instruments are used in combination with the face bow to indicate the vertical change in the condylar path as a dual operation.

Dr. Phillips<sup>(1930)</sup> introduced one of the first appliances to combine central bearing with extra-oral dual tracings, and also recording the vertical change in elevation of respective positions. Sear's Trivet introduced extra-oral fixation by plaster. The tracing is extra-oral

and a central bearing point is used. Stansbery's\* device also has the extra-oral tracing combined with plaster fixation which is intra-oral.

Terrell's\* device employs central bearing, dual tracing, indexing features and a mechanical arrangement that extends the usage of the plaster check bite. McCollum<sup>(1939)</sup> has introduced a most modern instrument for making graphic tracings and records of jaw relations. The instrument records the form and slant of the condyle paths as well as the path of the Bennett movement, together with centric position of the mandible. This is a most efficient procedure and desirable for most careful technique and research work. A central bearing point is used to relieve any interference with physiologic movements.\*

Simpson's<sup>(1939)</sup> device requires no premounting, the bearing screw and tracing pin is contained in the vault of the upper arch.

The extra-oral dual graphic tracing, with the plaster check bite furnishes all the information needed to adjust any fully adaptable articulator or positional relation instrument to relative positions.\*

The use of the central bearing, in taking the graphic tracing, is the best known method of holding the mandible in a state of stable equilibrium controlling the muscular forces and compensating for compression of soft tissues.\*

The position of the central bearing point requires some consideration, from the point of view of equalisation of pressure of the recording appliances.\* It would seem that as the central bearing point is fixed in relation to the jaw to which it is attached, it would be advisable to locate it on the jaw which is most likely to suffer from the effects of an eccentric load. In the majority of cases this would be the mandible as the maxillary base plate covers a wider area and is thus able to disperse such pressures without appreciable displacement. This view is shared by Beckett (1959), who points out that it is better to deviate from the

\* Quoted by Simpson H. 1939.

optimum in the maxilla rather than in the mandible, because by virtue of their thickness and texture the tissues of the maxilla will tolerate an antero-posterior deviation from the balanced loading point much better than the mandibular tissues.

I feel, however, that a rule cannot be laid down as to the position of the central bearing point, but the case in question must be examined and assessed by the operator at the time of the initial bite recording stage.

Anthony (1942) has indicated that a central bearing point, correctly placed, distributes contact pressure evenly over the denture supporting areas.

Sears (1926) pointed out that one advantage of placing the needle point on the mandibular rim instead of the maxillary rim, is that the angle formed by the two areas is thus made more acute.

The value of this seems doubtful to me.

#### Practical Factors in Relation to the Gothic Arch Tracing Technique:

##### (a) Horizontal Dislocating Force:

Blanchard (1951) emphasises the importance of selecting an instrument which does not introduce a lateral thrust. This is referred to by Backett (1959) as an antero-posterior dislocating force. This author checks for this dislocation of the base plates before the relation is recorded, by having the patient close until the pin touches the tracing plate. The lower lip should be held down so that any movement of the lower base plate on the mucosa can be observed. A similar observation is made on the upper base plate. If the front of the upper base plate moves up and/or forward and the back of it downwards whilst the lower bite plate appears to stay still (it is difficult to detect base plate movement when the pressure is too near the front of the lower base plate),

move the lower tracing pin back until a slight lift is noticed at the front of the lower base plate, then move it forward a little until the lower bite plate is stabilized. This will give the optimum position in these more difficult cases.

In the occasional case it will be necessary to move the pin sideways in order to obtain stability. This is usually due to differences in the area and/or transverse slope of the bicuspid and molar stress-bearing areas of the mandible.

Cases will present in which the bone in the anterior area of the maxilla is greatly resorbed and there is also a quick upcurve posterior to the molar area of the mandible. In these cases complete stability of both bases cannot be obtained and, as the upper tolerates displacement better than the lower, it is best to establish stability of the lower base.

Another source of a horizontal dislocating force may be developed at the time of recording the relationship. Swaggart<sup>1957</sup> and McLean (1949) point out that if provision is made for locking the point in the apex of the tracing, by indenting the tracing plate, as is commonly advocated, any tendency to movement by the patient will then result in uneven compression of the tissues; the denture base will be tipped, and the cam from the horizontal will be increased. Thus the use of this type of temporary fixation is contra-indicated. In the extra-oral technique it can be observed directly if any mandibular movement has occurred, this is not possible in the intra-oral technique.

Yet another source of horizontal dislocating force is emphasized by Trapezzano (1949), who feels that regardless of ridge relation or the relative amount of tissue displacability, the angle at which the central bearing point strikes the opposing plate must be carefully considered. If the angle is not  $90^{\circ}$  shunting of the bases is likely to occur.

Thus it would seem that this type of error of horizontal displacement may be introduced by incorrect positioning of the central bearing pin, by incorrect angulation of the central bearing pin and by incorrect fixation of the central bearing pin. These considerations must be given due planning when using an appliance dependent upon a central bearing pin.

Stansbery in 1939 indicates that this type of displacement is not directly proportional to the force exerted, but will occur to a maximum even under minimal pressure.

(b). Pressure Equalisation Factors:

Schuyler (1939) has indicated that so often has the necessity of the Gysi Gothic arch as a means of securing centric maxillo-mandibular relation been called to our attention that we have lost sight of another condition of equal importance; that is even contact of occluding surfaces.

It is possible to place a millimetre or more of material between the molars and bicuspids on one side of a natural dentition, and with slight muscular tension bring the teeth together on the opposite side. A similar condition may occur when records are made using compound or wax, if, owing to an uneven thickness or density of the occluding material, greater pressure is required to displace the excess on either side. This uneven pressure or premature contact of areas of occluding surfaces may also disturb the relation of record bases of the relation of finished dentures to the tissues. He points out that this resulting uneven contact in maxillo-mandibular rest position, such as a premature contact on one side, premature contact of anterior or posterior teeth, appears to cause greater annoyance to the patient and more tissue destruction than a position of the mandible slightly anterior to the normal rest relation.

McLean in 1935 has emphasised the necessity of even compression of the oral mucosa during the movements and recording of centric registration.

Errors due to lack of symmetry of the pressure applied during the registration affect all types of techniques. To accomplish equalised vertical contact with the graphic method we must use a central bearing point when recording the position. This central point of bearing must be accurately placed. A technique for recording the correct position of the central bearing point was devised by Stansbery (1929), and advocated by Buckman (1952), and consists of parallel rods attached to the extra-oral tracing arm and plate. If the rods are not parallel it is obvious that tissue displacement with resultant dislocation of the base plates has occurred, and bearing points must be relocated until parallelism of these indicating rods is obtained. Error in placement of the central bearing point could be reduced if more time was spent in careful attachment of the bearing point device to the occlusion rims. A central bearing point is a device which aids us in accomplishing a certain end. It will fulfil its objective only as well as it is made to, by the one who uses it.

Some degree of difficulty may be expected when the ridge relations are not normal. Trapozzano (1949) has indicated that theoretically equalisation of pressure is assured under certain conditions. For example, proper equalisation of pressure may be expected when the ridge relation is normal. This is predicated on the assumption that the centre of the maxillary rim and the centre of the mandibular rim coincide. However, when the ridge retrudes or protrudes, it follows that if the central bearing point were set in a position corresponding to the centre of the bearing area of the mandibular arch, it would not make contact at a point corresponding to the centre of the maxillary bearing area. Under these circumstances the slightest biting pressure exerted by the patient would result in a relatively excessive amount of pressure on the anterior or posterior parts of the ridges, and faulty equilibration of pressure would result, causing dislocation and displacement of the base plates. An analysis by Kingery in 1959 indicates that in cases of extreme mal-position of the ridges, the Gothic arch tracing technique employing a central bearing point may be contra-indicated as a means of obtaining centric relation.

Swenson (1953) indicates that there is, however, a certain latitude so that equalisation is fairly well obtained when the two centres are close to the same point.

(c). Vertical Pressure Relationships

Nagle and Sears in 1958 point out that there are many unstable or variable factors to contend with in the recording of a centric relationship. It has been theorised that to overcome these factors there should be no pressure upon the tissues when the record is taken.

Trapezzano in 1949, for instance, favours the employment of a no pressure technique, pointing out that even despite off ridge relation it would still be possible to register centric equilibrium if the patient would exert no biting pressure at the time the ridge relation was being fixed. Fixing the records with a zero pressure would avoid the possibility of undue tissue displacement or the likelihood of tilting and sliding of the base plates.

Nagle and Sears indicate, however, that in reality it is impossible that there should be no pressure. The mucosa, the sub-mucosa and the capsular tissues all contain soft moveable tissues and with more or less functional pressures associated with normal muscle tonus, sufficient displacement and distortion may be created to alter a record.

Stansbery (1929) does not feel that the registrations should be made at zero pressure, as recommended by Wright, Sears, Tench, &c. This is because of the technical impossibility of making bite rims which do not exert some force and secondly because centric occlusion, he feels, is the position of greatest masticating force which takes place at the termination of each masticating stroke.

Silverman in 1957 tells his patients to bite hard, to bite with dynamic energy and pressure. This author feels that the biting force develops the normal functional direction of the resultant forces of the

musculature, to place the mandible in the most retruded functional position in relation to the maxillae.

Consideration must be given to the degree of pressure exerted on the mucosa during the impression taking stage. Obviously if the impression is taken under minimum pressure and the bite recorded under maximum pressure, the displacement of the tissue that ensues will cause an incorrect mounting to be effected when the base plates are returned to the non-resilient models. So that in evaluating the degree of vertical pressure that should be used to record centric relation, we must take into consideration the impression technique, the amount of pressure under which the dentures will be functioning, and the amount of control which the patient can exert over the vertical pressure involved, in registering the centric relation.

Several of these factors can be overcome if the impressions and centric relation are recorded simultaneously. This can be accomplished using any intra-oral appliance. Some operators, for example Ballard, use a spring loaded central bearing point to produce what they feel is the desired amount of functional stress. They advocate that this appliance can be used to record the impressions and the centric relation registration at the one appointment. I feel that such a device is not physiologically tenable, as it delivers a pre-ordained stress to each and every patient, regardless of tissue tone, condition of mucosa and musculature.

(c). Recording Medium:

Throughout the evolution of the Gothic arch tracing technique there have been many suggestions made to effect connection of the upper and lower base plates at the desired position.

In the days of Gysi, the rims were stapled together with hot pieces of wire. Later authors employed compound forced into keys at the side of the rims. In 1926 Tench advised the use of rolls of soft compound to be used as a recording agent. This material was again advocated in 1936 when

Hight recommended it in conjunction with his appliance, but it does not seem to have been popular since that time.

It was Stansbury who introduced the use of plaster employing the injection technique in 1929. Quick setting plaster still seems to be the most popular material. Its use is advocated by Simpson (1939), Smith (1941), Terrell (1951), Fleasure (1955), Porter (1955), Kingery (1959), Stuart (1959) and Boos (1959). This material is employed in both intra-oral and extra-oral techniques and in both intra-oral and extra-oral fixation.

It is interesting to note that the use of wire staples which was last advocated by Meyer in 1934 has again been indicated by Kile in 1955 to connect the upper and lower base plates. It would seem that this technique is the least desirable of all since the use of hot wire has obvious psychological disadvantages, together with the high possibility of introducing displacement during insertion of the staples.

Sears in 1926 has indicated that for secondary inter-maxillary relations, any material which can be kept in a soft enough state in the mouth to make unstrained records and which will become hard within a reasonable time may be used. Base plate wax, modelling compound and wax are the materials used for this purpose. The material should be of such character that records obtained may be used alternately and repeatedly without distortion. It would seem that present day techniques employ in the majority of cases plaster as the recording medium. Zinc oxide and eugenol impression material which is being advocated for some in the squash bite technique may be employed in conjunction with the Gothic arch tracing, however, I can find no reference in the literature referring to its use in such a technique.

### Indications for the Use of the Gothic Arch Tracing Technique:

The Gothic arch tracing is of inestimable value in the construction of full dentures. Although it specifically may not be used to obtain final centric relation, it provides invaluable information concerning the status of the joints and musculature of the patient.

Furnas in 1939 has pointed out that a perfect tracing is obtainable in only about 50% of patients, and such a statistic surely indicates the value of the tracing. Its use is advised by Meyer (1935), Furnas (1935), Hight (1936) and Pyott and Schaeffer (1954), together with many others.

It is not an infallible technique for it involves the use of a mechanical appliance to record a physiologic status within a physiologic organ, and in this fact lies its limitations.

### Limitations and Contra-indications for the Use of Gothic Arch Tracer:

Kingery (1959) lists the limitations of any appliance which employs a central bearing point:

1. A lack of control over the amount of closing pressure applied by the patient. This is inherent in the clumsiness of the appliance and although Furnas (1935) is quoted as having indicated that the central bearing point allows control, by the patient, of biting pressure, it would seem that reliance on the tactile sense of the patient introduces a doubtful quantity.
2. Patients presenting extreme protrusion or retrusion of the mandible make proper placement of the central bearing point extremely difficult, if not impossible.
3. Patients presenting large clumsy tongues, extreme resorption of the ridges, or extensive amounts of displaceable tissues on the supporting areas, prove troublesome when a central bearing point is used. Shortcomings in this method will be manifested in patients presenting very soft yielding denture supporting areas.

Meyer in 1959 has indicated that arch tracing appliances used in dentistry add to the bulk inside and outside the mouth and tend to make the patient conscious of our efforts, which is not desirable. As a result he will try to help out and thereby emphasise his mandibular movement. For this reason some people's dentures are built posterior of centric relation. This gives them a great deal of discomfort, even more than when the dentures are constructed with the jaw in partial protrusion.