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The Anatomy of the Temporomandibular Joint in Humans

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THE ANATOMY OF THE TEMPOROMANDIBULAR
JOINT IN HUMANS

by
Nicholas Chris Choukas

A Thesis Submitted to the Faculty of the Graduate School
of Loyola University in Partial Fulfilment of
the Requirements for the Degree of
Master of Science

June
1958
Nicholas Chris Choukas, was born in Chicago, Illinois, on September 5, 1923. He graduated from Nicholas Senn High School, Chicago, Illinois, June, 1941 and from Wright Junior College, June, 1943. He continued his pre-dental education, at the University of Chicago until June, 1944.

He began his dental education at Loyola University in September, 1946 and received the Doctor of Dental Surgery degree in June, 1950.

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In September, 1955, he was the first student to be enrolled in the department of Oral Anatomy in the Graduate School of Loyola University.
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This research project was completed under the direction of Dr. Harry Sicher, of the School of Dentistry of Loyola University. I am deeply grateful to Dr. Harry Sicher for his kind and generous assistance, also for his many helpful suggestions. I am indebted to Dr. Patrick Toto and Dr. Frank Wentz, for their patience and constructive criticisms. To Dr. Joseph G. Kostrubala, I owe a special debt for his continued encouragement and advice.

I would also like to express my appreciation and sincere thanks to Dr. Maria Gyllys who prepared all the microscopic sections; and to Mr. John Blickenstaff, for his photographic assistance in preparing the plates used in this thesis.
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CHAPTER I

INTRODUCTION

Much has been written in the literature on the anatomy of the temporomandibular joint and of the effect that the anatomical architecture has upon its physiology. Many clinical concepts have evolved, that are based on inadequate knowledge of the normal anatomy of this joint. Lack of uniformity of good results in the treatment of pain and dysfunction of the temporomandibular joint may be in part due to an incomplete understanding of its normal anatomy. Perusal of the literature reveals an abundance of reports on investigations on various aspects of the temporomandibular joint. Although there is general agreement on much of the anatomy of the temporomandibular joint, some details, though important for function have been neglected. They are as follows:

a) The shape of the disc
b) Attachment of the capsule

The controversial points in the anatomy of the temporomandibular joint are as follows:

a) The relation of disc to capsule
b) The relation of disc to condyle
c) The relation of external pterygoid muscle to disc and capsule
This study has been undertaken in order to add some hitherto unknown or neglected details of the structure of this complex joint and to clarify some of the controversial statements.
A study of the recent literature on the temporomandibular joint showed that general statements are being made and repeated that need amplification. For instance, the disc is generally described as a biconcave oval plate of fibrous or fibrocartilaginous tissue (Fick, 1904; Chissin, 1906; Lubosh, 1906; Prentiss, 1918; Bauer, 1932; Baecker, 1937; Sicher, 1949; Miller, 1952). Ackermann (1953) describes the posterior part of the disc as being adapted to the concavity of the fossa. Since the disc is exactly adapted to condyle and articular eminence the common description is certainly not detailed enough.

New findings and new ways of describing the articular structure pertain mainly to the disc, its relation to the capsule and the condyle. These findings also pertain to the relation of the external pterygoid muscle to capsule and disc. While Sicher (1949) describes the loose connective tissue attaching the disc to the posterior capsule, Rees (1954) maintains that the posterior margin of the disc has a separate attachment to the temporal bone and condyle, thus not recognizing the presence of a fibrous capsule posteriorly. He divides the disc into four zones or bands. The anterior band, he describes, as being moderately
thick but relatively narrow from before backwards. The intermediate band is much thinner and narrower than the others. Of the four bands the posterior band is thickest and widest. The fourth band is called the bilaminar zone which consists of an upper stratum which is attached to the temporal bone and a lower stratum which is attached to the posterior surface of the mandibular condyle. Krough-Poulsen and Moelhave (1957) found that the disc does not fuse with the capsule on its medial and lateral aspects, but that the disc is independently attached to the two poles of the condyle by short ligaments while the capsule is attached immediately below these points to the mandible. These findings contradict the description of Arstad (1954) who differentiates the capsular ligament into external and internal ligaments and claims that the latter affect the attachment of the disc to the condyle.

The relations of the disc to the capsule anteriorly are described differently in the recent literature. While many authors (Fick, 1904; Prentiss, 1918; Brodie, 1939; Goss, 1948; Shapiro, 1950; Miller, 1952) speak of a fusion of the anterior border of the disc with the capsule, Arstad (1954) claims that the disc has a direct attachment to the anterior border of the articular eminence.

The relation of the external pterygoid muscle to the disc is still controversial. Prentiss (1918) claims that the
entire superior head of the external pterygoid muscle is attached to the disc. On the other hand Arstad (1954) claims that there is no attachment of the external pterygoid muscle to the disc. Most investigators among which are: Piek, 1904; Chissen, 1906; Lubosch, 1906; Steinhardt, 1934; Bauer, 1937; Sichel, 1949; Shapiro, 1950 found that at least some fibers of the superior head of the external pterygoid muscle are attached to the disc. Recently Moffett (1957) in his studies of human embryos and fetuses confirmed earlier findings that a small medial portion of the disc is derived from the posterior extension, referred to as a tendon, of the external pterygoid muscle.

From a functional consideration two papers have to be mentioned, because they reflect upon the structure of the temporomandibular joint. The first is a claim by Landa (1954) that in protrusion of the mandible the disc does not move as far forward as does the condyle. The second paper is that of Murphy (1956) who claims that a facet found on the anterior slope of the postglenoid process acts as a fulcrum in the lateral movements of the mandible. This claim is a revival of claims already made by Meyer (1865) who believed that contact could take place between condyle and postglenoid process during lateral movements of the mandible. Subsequently Ulrich (1896) stated that the condyle and postglenoid process do not fit together.
CHAPTER III

METHODS AND MATERIALS

The specimens used for this study were obtained from cadaver material. Three gross dissections were made of the temporomandibular joint and adjacent structures. Twelve temporomandibular joints were removed and used to study the gross anatomy of the disc and capsule and their relation to the head of the mandible and the area of insertion of the external pterygoid muscle. The articular discs were removed from three of these twelve specimens to study their microscopic anatomy. Six specimens were removed from embalmed cadavers by means of an intracranial approach, in order to preserve the integrity of the joint. The calvarium was removed and a triangular section of bone was cut overlying the joint (Fig. 1). The posterior side of the triangle reaches from the lateral wall of the skull along the edge of the pyramid of the petrosal bone to the foramen lacerum. The anterior side of the triangle extends from the foramen lacerum through the oval foramen and forward to the lateral end of the lesser wing of the sphenoid bone. A sagittal and horizontal cut leads from here through the uppermost part of the temporal squama and joins the lateral end of the first cut. The condyle was removed from the ramus of the mandible and the external pterygoid cut near its
point of origin. The remaining soft tissue was then freed by means of blunt and sharp dissection and all the excess tissue removed from about the joint.

The six specimens removed by the intracranial approach, were placed in five percent nitric acid for decalcification. After the specimens had been decalcified they were washed for a period of twenty-four hours. Since the specimens were considered too large for ordinary paraffin technique they were embedded in celloidin. The technique is as follows:

A. Washing for twenty-four hours.

B. Dehydration
   1. 75% alcohol for 24 hours
   2. 95% " " " "
   3. 100% " " " "
   4. 100% " with ether for 24 hours.

C. Saturation in celloidin
   1. Thin celloidin for one week
   2. Medium celloidin for one week
   3. Thick celloidin for one week

D. Embedding and mounting of specimen

E. Staining
   1. Distilled water as wash
   2. Hematoxylin for two hours
3. Distilled water for two rinses
4. Tap water for thirty minutes
5. Acid alcohol for fifty seconds (one or two dips)
6. Distilled water
7. Tap water for thirty minutes
8. Alcohol 75% for one minute
9. Alcohol 95% for one minute
10. Eosin for one dip
11. Alcohol 95% for two rinses
12. Terpinol two changes for fifteen minutes
13. Mounting on Canadian Balsam

The removed discs were embedded in paraffin, sectioned and stained with routine Hematoxylin and Eosin.
CHAPTER IV

FINDINGS

The temporomandibular joint is formed by the articular eminence and articular fossa of the temporal bone superiorly and the head of the mandible with the articular disc interposed. It is therefore, an articulation between the mandible and cranium. With the exception of the joints between the auditory ossicles, the temporomandibular joint can be considered the only true joint among the bones of the head. The fact that an articulating disc is found between the two joint surfaces makes it a complex type of joint with an upper and lower compartment. Sagittal sections through the joint show that the upper articular chamber is larger than the lower (Fig. 2).

The temporomandibular joint is a specialized joint and is different from most other articulations in that the articulating surfaces are not covered by hyaline cartilage but by a fibrous connective tissue which may contain a number of cartilage cells or chondrocytes.

Actually the mandibular fossa of the temporal bone does not receive the articulating head of the condyle, but only the posterior parts of the interarticular disc.

The posterior slope and the summit of the articular
eminence form the anterior wall of the mandibular fossa. The saddle shaped eminence is convex in a sagittal plane and slightly concave in a transverse plane. The medial and lateral borders of the articular eminence are at times accentuated by slight bony ridges. Anteriorly the articular eminence continues into the infratemporal surface of the temporal bone. There is no anterior slope to the eminentia articularis but it is often demarcated by a fine shallow sulcus. The articular eminence is covered with fibrous connective tissue which may contain scattered cartilage cells in its deeper layers and thus may be referred to as "fibrocartilage". The fibrocartilage covering the articulating surface of the temporal bone is thin in the articular fossa and much thicker on the posterior slope and the summit of the articular eminence (Figs. 3, 4). In this area the fibrous connective tissue or fibrocartilage is arranged in two layers. In the outer layer the fibrous bundles appear to be arranged parallel to the surface of the bone. Connective tissue fibers of the inner layer appear to be perpendicular to the bony surface. In some specimens a definite line of calcification can be noted in the layer adjacent to the bone (Fig. 5).

The posterior wall or border of the articular fossa is formed by the postglenoid or preauricular tubercle of the squama of the temporal bone. The tubercle in profile is cone-shaped between the mandibular fossa and the tympanic bone. It may be
considered a protective arrangement for the external acoustic meatus from backward displacement of the condyle. Any backward displacement of the mandible is never directed against the tympanic bone itself.

A fissure separates the articular fossa from the tympanic bone. This fissure is the squamotympanic fissure in its lateral part. More medially a small plate of bone intervenes between the tympanic bone and the squama. This bony plate is the inferior process of the tegmen tympani which is a part of the anterosuperior surface of the petrous pyramid of the temporal bone. Therefore, the medial part of the squamotympanic fissure is divided into an anterior part, the petrosquamous fissure and a posterior part the petrotympanic (Glaserian) fissure.

The inner wall of the mandibular fossa is formed by a portion of the squamous temporal which is connected with the angular spine of the sphenoid bone. The roof of the fossa is formed by a thin, translucent part of the squamous temporal. The thin fibrous covering of the fossa and the weakness of its bony roof are proof that the fossa is not a functional part of the temporomandibular joint.

The articulating surface of the mandible is formed by the mandibular condyle or capitulum of the mandible. The condyle measures approximately 2 cm. transversely and 2 cm. antero-posteriorly. The long axis of the condyle runs in the same direction.
as that of the articular eminence and at right angles to the plane of the ramus of the mandible. The extended long axes of the condyles cross each other in the anterior part of the foramen magnum. They thus form an obtuse angle of about 150 to 160 degrees. The condyle is convex antero-posteriorly and medio-laterally. The articular surface of the condyle points upward and anteriorly. A lateral view of the condyle shows it bending forward from the neck of the condyle. The condyle rests against the posterior slope of the articular eminence and movement occurs between condyle and disc along the surface of the eminence. The articular surface of the condyle is covered with dense fibrous connective tissue. The fibrous tissue or fibrocartilagenous covering of the mandibular condyle is of fairly even thickness. Its superficial layers consist of a network of strong collagenous fibers. Basophilic cartilage cells may be present and have a tendency to increase in number with age. These cartilage cells can be recognized by their capsules which stain blue with a basic dye. Between the fibrous tissue or fibrocartilaginous covering of the condyle lie the thin remnants of the growth cartilage of the mandible.

There were many variations noted in the size and shape of the condyle. Many of these variations were obscured by the thick covering of the fibrous connective tissue.

The interarticular disc is located between the articulating condyles and the articular eminence. The disc is composed
of strong and interwoven bundles of fibrous connective tissue with scattered basophilic cartilage cells.

The central part of the disc is considerably thinner than the periphery. It is about 1 - 2 mm. thick in the center and approximately 3 mm. thick in its posterior border. The disc is fused to the capsule only at the anterior border. The posterior border was found to be continuous with a thick layer of loose connective tissue that provides the attachment of the disc to the posterior part of the articular capsule. The retro-discal pad is covered on its upper and lower surfaces with a synovial membrane that shows many folds when the condyle rests against the posterior slope of the eminence. When in anterior movements of the condyle the retro-discal pad stretches and the folds of the synovial membrane disappear. Laterally and medially the disc is attached independently to the lateral and medial poles of the condyle (Fig. 6). The upper surface of the disc is saddle shaped, concave antero-posteriorly and slightly convex medio-laterally. The lower surface of the disc is concave in both directions for adaptation to the ovoid shape of the condyle.

The capsule, which encases the temporomandibular joint, is rather loose and has a funnel-shaped configuration. On the temporal bone it is inserted in the anterior border of the articulating eminence and laterally it follows close the corresponding articular margins.
Posteriorly it is not inserted to the edge of the postglenoid lip but in a broad area on the anterior surface of the postglenoid process. Medially the capsular attachment extends to the base of the angular spine of the sphenoid bone.

On the mandible the lateral and medial parts of the capsule attach to the lateral and medial aspects of the mandibular neck below the point of attachment of the disc. Anteriorly the capsule attaches to the rather sharp ridge that bounds the articular surface of the mandibular condyle anteriorly. Posteriorly the attachment of the capsule on the mandibular neck is at a lower level than on the anterior surface. There is no fusion of the disc and capsule, at the medial and lateral aspects, but rather an independent area of origin (Fig. 7).

The lateral surface of the capsule is reinforced to form the strong temporomandibular ligament, the only true ligament of the temporomandibular joint. The temporomandibular ligament is triangular in shape with its most posterior fibers in an almost vertical position. These fibers converge with the oblique anterior fibers to attach just below the attachment of the disc to the lateral surface of the mandibular neck (Fig. 8).

The synovial membrane lines the inner surface of the capsule and the upper and lower surfaces of the retro-discal pad. Posteriorly it follows the fibrous capsule to its attachment to the mandibular neck and then is reflected upon the bone to end at
the posterior boundary of the articulating surface of the condyle.

Our specimens showed clearly the separation of the superior and inferior heads of the external pterygoid muscle. The superior head originates from the infratemporal surface of the greater wing of the sphenoid. The inferior head, which is the larger, originates from the outer surface of the lateral pterygoid plate.

The fibers of the upper or superior head run horizontally backward and slightly laterally in very close relation with the base of the cranium. The fibers of the inferior head converge upwards, backwards and laterally to insert in a fovea on the anterior surface of the mandibular neck or condyle (Figs. 9, 10). All of the lateral part of the superior head of the external pterygoid and a variable number of fibers of the medial part are not attached to the disc but to the mandibular neck. Only the medial and upper part of the upper or superior head of the external pterygoid muscle is attached to the medial anterior corner of the fused capsule and disc (Figs. 11, 12, 13, 14, 15).
CHAPTER V

DISCUSSION

The disc has been described in the literature as a bi-concave plate because it is almost always seen in a sagittal section. This is not a true picture of the disc. The upper surface of the disc is saddle shaped, concave antero-posteriorly and slightly convex medio-laterally, while the lower surface is of course an adaptation to the shape of the eminence that is strongly convex antero-posteriorly but slightly concave medio-laterally. The description in the literature of a superiorly convex posterior part of the disc adapted to the concavity of the fossa (Ackermann, 1953) was not found to be correct. The error evidently is caused by visualizing the retro-discal pad as part of the disc itself.

Rees (1954) divides the disc into four zones or bands. While the anterior three bands can only be separated arbitrarily the fourth posterior zone is not part of the disc but the loose connective tissue attaching the disc to the capsule. However, the division of the disc proper into three bands adds nothing to our understanding of the structure of the disc and its shape. It is merely the expression of the well known fact that the borders of the disc are much thicker than the central zone.

The disc is fused anteriorly to the capsule which allows
for the insertion of muscle fibers into it. Posteriorly it is attached to the capsule by loose connective tissue. The attachment of the disc by this loose connective tissue, or retro-discal pad, is indispensable for the extensive forward movement of the disc with the condyle.

Medially and laterally the disc is not connected with the capsule at all. The independent attachment of the disc to the medial and lateral poles of the condyle was first described by Krough-Poulsen and Moelhave (1957). Our material allows a confirmation of their findings. It seems that this relation of disc to the condyle has been seen previously but has been misinterpreted. Arstad's (1954) deep capsular ligaments seem to have been the direct attachment of the disc to the condyle. Rees's (1954) second zone or band of the disc also seems to comprise not only the middle area of the disc but also its medial and lateral attachments to the condyle.

The traditional explanation of the simultaneous movement of disc and condyle rests upon the attachment of the lateral pterygoid muscle to mandible and disc. This explanation however appears more than doubtful because the retrusive movement of the disc with the condyle cannot be explained by muscular action on the disc. Since the disc evidently follows automatically the retrusive movement of the mandible it is only logical to assume the same mechanism for the protrusive movement. The attachment of
some fibers of the external pterygoid muscle has to be interpreted as serving in a stabilizing function. It has been known that during mastication the mandible itself is held in position on the posterior slope of the eminence by the coordinated action of the external pterygoid muscle with the closing muscles of the mandible. The equilibrium between disc and mandible and between disc and eminence is maintained by the muscle attachment to the disc itself.

Altogether the relations of the disc to capsule and condyle although different, have their peculiar functional significance. Fusion of capsule and disc anteriorly allows for an attachment of some fibers of the external pterygoid muscle to the disc in the service of stabilization during mastication. Direct attachment of the disc to the poles of the condyle not only explains the joint movement of the two structures but also guarantees the proper relation between condyle and disc, the condyle always riding upon the central non-vascular area of the disc. It is clear that only the latter is adapted to bearing pressure. Finally the loose attachment of the disc to the capsule posteriorly allows its free and extensive forward movement in unison and in constant relation to the condyle. Claims that the disc does not move as far forward as the condyle (Landa, 1954) do not seem possible. Anatomically the relation of the disc to condyle forces the disc to follow all movements of the latter. Functionally a lagging of the disc behind the condyle would force the condyle to leave the atherosclerotic,
pressure adapted zone of the disc to ride upon its vascularized anterior rim.

The attachment of the capsule to a broad area on the anterior rim of the post-glenoid process prevents the condyle from coming into contact with the post-glenoid process and, therefore, it cannot be a fulcrum of the masticatory stroke as is pointed out by Murphy (1956).

Rees (1954) also points out that the temporomandibular joint has two ligaments attached to it, as would be the case in any similar hinge joint in the body, a lateral and a medial ligament. However, one must remember that the mandible functions as a unit and that neither joint acts independently. Therefore, the lateral ligaments of the two joints can be assumed to take the place of the two traditional ligaments on either side of one joint.

The relation of the superior head of the external pterygoid muscle to the disc is still controversial. Prentiss (1918) claimed that the entire superior head of the external pterygoid muscle is attached to the meniscus. He gives this portion of the muscle a special name and calls it the sphenomeniscal muscle. Arstad's (1954) investigations led him to believe that there is no attachment of any fibers of the external pterygoid muscle to the disc. Most investigators are of the opinion that there is a partial attachment of fibers of the superior head of the external
pterygoid muscle to the disc. This last description is borne out by our studies. But, our findings enable us to be more specific. We found that only the most medial and superior fibers of the superior head of the external pterygoid muscle are attached to the medial anterior corner of the disc. This was ascertained only after very careful dissection and close observation of our specimens. These findings are in agreement with those of Moffett (1957) who found that a small medial portion of the disc is derived from the posterior extension of the external pterygoid muscle.

All of the investigators who found fibers of the superior head of the external pterygoid muscle attached to the disc attributed the forward movement of the disc to the contraction of the muscle. Evidently this attachment to the disc is not so much in service of movement but more in the service of maintaining the balanced position of the disc during mastication.
CHAPTER VI

SUMMARY AND CONCLUSIONS

This study was undertaken to ascertain the normal anatomy of the human temporomandibular joint, in particular, the relations of the external pterygoid muscle to the articular disc and to the capsule of the joint. Special attention was paid to a correlation of structure with function.

The following conclusions were derived from our study:

A. The upper surface of the disc is saddle shaped, concave antero-posteriorly and slightly convex medio-laterally to adapt to the saddle shaped articular eminence. The lower surface of the disc is concave in both directions to adapt to the ovoid shape of the condyle.

B. Medially and laterally the disc has a direct and independent attachment to the medial and lateral poles of the condyle. This attachment is by strong short ligaments comparable to collateral ligaments of a hinge joint.

C. The disc is fused to the capsule only at its anterior border. The posterior border was found to be continuous with a thick layer of loose connective tissue that provides the attachment of the disc to the posterior part of the articular capsule. This tissue can be termed the retro-discal pad.

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D. Only the medial and superior part of the upper head of the external pterygoid muscle is attached to the fused capsule and disc.
CHAPTER VII

REFERENCES CITED


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Figure 1. Photograph of the base of the skull showing triangular area removed.

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B. Pyramid of the petrosal bone
C. Temporal squama
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PLATES

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PLATE II

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B. Articular disc
C. Upper articular chamber
D. Lower articular chamber
E. Articular eminence
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PLATE III

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B. Articular eminence
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Figure 5. Photomicrograph showing arrangement of the fibrous connective tissue or fibrocartilage into two layers, with a line of calcification adjacent to the bone.

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PLATE VI

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C. Condyle
PLATE VII

Figure 7. Photomicrograph showing an independent area of origin of the disc and capsule

A. Capsule
B. Disc
C. Condyle
PLATE VIII

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B. Superior head of the external pterygoid
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Figure 13. Photomicrograph of high power view of the superior head of the external pterygoid muscle inserting into the disc.
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B. Superior head of the external pterygoid
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Figure 14. Photograph of a dissection demonstrating the insertion of only the most medial and upper part of the superior head of the external pterygoid muscle to the medial anterior corner of the disc.

A. Articular disc

B. Superior head of the external pterygoid
PLATE XV

Figure 15. Photograph of a dissection demonstrating the insertion of only the most medial and upper part of the superior head of the external pterygoid muscle to the medial anterior corner of the disc.

A. Medial anterior corner of the disc
B. Medial and upper part of the superior head of the external pterygoid muscle
C. Mandibular condyle
APPROVAL SHEET

The thesis submitted by Dr. Nicholas C. Choukas has been read and approved by three members of the Departments of Anatomy and Oral Anatomy.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Science.

\[\text{May 23, 1958}\]

[Signature of Adviser]