1994

The Insertional Attachment of the Superior Head of the Lateral Pterygoid Muscle to the Temporomandibular Joint Components in Humans: An Anatomic Investigation

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THE INSERTIONAL ATTACHMENT OF THE SUPERIOR HEAD OF THE LATERAL PTERYGOID MUSCLE TO THE TEMPOROMANDIBULAR JOINT COMPONENTS IN HUMANS: AN ANATOMIC INVESTIGATION

by

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

January

1994

DEDICATION AND ACKNOWLEDGEMENTS

This thesis is dedicated to my mother, Violet Anne Dusek, and father, Otto William Dusek, who always gave for their children before they took for themselves. May their childhood teaching of 'hard work and persistence' be reflected in the substance of this study. To my beloved wife, Kimberly Ann, who for fourteen years has patiently supported my endeavours. May her personal sacrifices be remembered by the contents of this work.

I want to thank all of my teachers, professors and counsellors, who throughout my education passed on their wisdom, guidance, and direction. The support and guidance I received from my advisor, Dr. Michael Kiely and other committee members, Dr. Joe Gowgiel and Dr. Lewis Klapper is greatly appreciated. Without their knowledge, guidance and patient understanding, this study could not have been possible.

I want to express my gratitude to Mr. Bob Martinez and the staff in the histotechnic lab for their assistance in tissue and slide preparation. I especially want to thank Ms. Sandra Cello for her skillful artistic renderings and Mr. Al Spradlin for his expertise in preparing and mounting the photographic material. I am extremely grateful to Ms. Sally Ford who has been very supportive in preparing the layout and typing of this manuscript. Thank you to all those who in some small, but special way assisted me in the collection and

DEDICATION AND ACKNOWLEDGEMENTS CONTINUED

preparation of the material, methods and thoughts behind this work. May no one go unrecognized.

VITA

The author, Thomas O. Dusek, is the first of four children of Otto William Dusek and Violet Ann (Cierny) Dusek. He was born July 6, 1949 in Chicago, Illinois and became married to Kimberly Ann Cilc on July 1, 1978.

His elementary education was obtained at the Mark Twain elementary, public school of Chicago, Illinois. His secondary education was completed in 1967 at the Harold L. Richards High School in Oak Lawn, Illinois.

In August, 1967, the author entered Western Illinois University in Macomb, Illinois, where he majored in zoology and minored in chemistry. He received the degree of Bachelor of Science in zoology in June of 1971. While attending Western Illinois University, he was inducted into the Tri-Beta Biological Honor Society. In August of 1971, he entered the Loyola University, School of Dentistry in Maywood, Illinois. He graduated with the Doctor of Dental Surgery degree in June 1975.

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Following his active duty Air Force term, Dr. Dusek transferred to the U.S. Public Health Service where he became detailed to the U.S. Coast Guard as a general dental officer. He served six years active duty from July 1978 thru July 1984 attaining the rank of Lieutenant Commander. In August 1984, Dr. Dusek returned to post-graduate studies in Orthodontics at Loyola University in Maywood, Illinois. He received the certificate of specialty in Orthodontics from Loyola University School of Dentistry in May 1986. While attending Loyola for his specialty studies in orthodontics, Dr. Dusek entered the Oral Biology graduate program. He also received an assistantship in the department of Anatomy which enabled him to instruct and do research on the present topic. During the compilation of the data for this research, Dr. Dusek was recalled to active duty by the U.S.Air Force in support of Operation Desert Storm.

Dr. Dusek now maintains a private practice of orthodontics in Chesapeake, Virginia.

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CHAPTER I

INTRODUCTION

There have been numerous studies on the anatomy of the lateral pterygoid muscle. However, an examination of the literature concerning the anatomy of the specific insertional attachments of this muscle, to the components of the temporomandibular joint, demonstrates a considerable difference of opinion.

> "The lateral pterygoid muscle has been mercilessly incriminated as the cause of numerous temporomandibular complaints! This may stem from a lack of understanding of how the muscle is constructed, and what its normal functions are." (Weldon Bell 1979)

Although the lateral pterygoid muscle is actually composed of a superior and inferior head, with antagonistic actions, (McNamara 1973), the divergence of opinion has classically been regarding the insertional attachment of the superior head to the various joint components. Therefore, the exact relationship of the superior head of the lateral pterygoid muscle to the mandibular condyle, the joint capsule, and the articular disc must be specified. Most investigators would agree that although anatomic variation is a normal occurrence, there exists a relative anatomic pattern. A thorough understanding of this functional anatomic pattern is an absolute prerequisite for accurate diagnosis and effective treatment of disc-condylar disorders. It is the basis on which a clinician judges departures from normal. Much has been described and written on the clinical subject of 'anterior disc displacement'. Ishigaki et. al., 1992; Westesson et. al., 1989, 1985, 1984; Juniper, 1984; Leopard, 1984; Liedberg et. al., 1990; Katzberg et. al., 1988; Weinberg, 1979; Hansson, 1979; and Laskin, 1967.

The relationship of the lateral pterygoid muscle to this clinical malady in the so-called 'functional theories' is described as producing a forward, medial and inferior traction on the articular disc. The conflicting opinions and findings concerning the muscle fiber attachments of the superior head to the components of the temporomandibular joint inspired my anatomic investigation. Furthermore, a 'relative anatomic pattern' related to muscle attachment, implies a ratio of muscle fibers attaching to specific structures. Nowhere in the literature is there a scientific method of approach describing this relative anatomic pattern as a ratio of muscle attachment to the specific joint components.

CHAPTER II

PURPOSE

The purpose of this investigation is to describe the specific insertional attachment of the superior head of the lateral pterygoid muscle to the components of the temporomandibular joint in humans. A further purpose is to devise a systematic approach to identify, isolate and quantify as a ratio, in percentage, the portion of the superior head of the muscle which interacts with the disc-capsule complex as compared to the amount that attaches to the pterygoid fovea of the mandibular ramus. Therefore, a scientific approach describing the 'relative anatomic pattern' of superior head attachment to the specific joint components will be offered.

CHAPTER III

REVIEW OF THE RELATED LITERATURE

Most anatomical studies of the lateral pterygoid muscle have consisted of gross dissections. The consensus is that there are indeed two heads; an inferior and superior head, each with independent functions. (McNamara, 1973)

The literature can be summarized into three popular beliefs concerning the insertion of the lateral pterygoid muscle. 1) The Dual Insertion Theory says that the superior head of the lateral pterygoid muscle inserts primarily into the pterygoid fovea of the mandibular ramus while only a very small portion inserts into the disc. No one describes the 'portion' in terms of an actual quantity! 2) A separate insertion theory says that the superior head of the muscle is inserted into the disc and capsule exclusively while the inferior head of the lateral pterygoid muscle inserts into the pterygoid fovea. 3) The Non-discal insertion theory says that the superior head of the muscle does not insert into the disc but rather the muscle is separated from the disc by loose fibrous connective tissue.

Dual Insertion Theory

According to Gray (1964), "the greater part of the fibers of the superior head are attached to the fovea pterygoidea of the articular process of the mandible and only a small portion are attached to the central part of the articular capsule and disc". There is no quantification or percentage of fibrous attachment given in the description. Sichers' text (1965) states that the superior and inferior heads of the muscle are fused posteriorly. Schumacher (1961) supports this contention. Both investigators dissected human and rhesus macaque specimens and they found the fibers of the superior head to be attached partly to the medial aspect of the anterior border of the head of the mandible, partly to the anteriomedial aspect of the articular capsule and partly to the articular disc directly. Grant (1973) also carefully described the two heads as being joined midway in their length by a central tendon flattened mediolaterally. He describes each head as inserting primarily into one side of this tendon which in turn inserts into the base of the condyle at the pterygoid fovea. However, he describes that the "remaining fibers insert into the condyle itself". The superior head runs from 'its origin, inferiorly, laterally, and posteriorly and sends a few fibers to the articular capsule and interarticular disc. He refers to this head as the 'sphenomeniscus' head. He indicates that the inferior head runs from its origin superiorly, laterally and posteriorly to insert to the underside of the central tendon. The orientation of the inferior head was described as mediolateral. Its 'insertion into the condyle' extends more medially and inferiorly than that of the superior head. He claimed that the total physiologic cross section of the inferior head is 1.5 times that of the superior head. Grants' study was primarily focused on the biomechanical advantage of each of the heads in opening and closing moments related to an instantaneous center of rotation about a hinge axis.

He carefully described his findings in six adult macques but only stated that 'personal dissection' in humans was made. It must be clear in the interpretation of the literature that we are distinctly looking to define the exact insertional attachment of the superior head of the lateral pterygoid to the joint components of humans. Choukas and Sicher (1960) describe the relationship of the superior head to the base of the cranium from its origin to insertion as coursing downward, laterally and posteriorly. The entire lateral part of the superior head and a variable number of fibers of its medial part are attached to the mandibular neck and not the disc. They describe the medial and superior bundles of the superior head of the lateral pterygoid muscle as being attached to the medial anterior 'corner' of the fused capsule and disc. They state that the disc and capsule are fused anteriorly which allows insertion of muscle fibers into the disc indirectly. Troiano (1967) describes three heads of insertional attachment. He essentially states that the most cranial attachment of the superior head is to the anterio-medial portion of the articular disc by a separate tendon while the middle 'tendon' inserts to the joint capsule and the medial subcondylar area of the articular process. The inferior head then inserts into the remaining portion of the subcondylar portion of the articular process. We often refer to this area as simply the pterygoid fovea. This investigation seems to have conveniently categorized the superior head into two distinct heads based on where the fibers insert. This is similar to the description of a sphenomandibular and sphenomeniscus head as described by Schumacher. As a side note, it is interesting that as one reviews the literature, one can easily be influenced by personal descriptions, opinions and categorizations. Sometimes it is helpful, but certainly it can detract from the range of true anatomic variation, which in its almost artistically natural state becomes the norm.

Vaughn (1966) and Thilander (1964) both state that a part of the fibers of the superior head are attached to the articular disc. Thilander supports the opinion of Sicher, in that the attachment is limited to the articular capsule and therefore the insertion is indirect. McNamara (1973) described the independent functions of the two heads of the lateral pterygoid muscle in 33 Macaca mulatta by conducting electromyographic studies. He dissected the joints to confirm the anatomic similarity to the human lateral pterygoid attachments. He stated that in both man and rhesus monkey, fibers of the superior head are attached to the articular disc, capsule and to the condylar head. This is the second literature citation in which monkeys were used with a description of the condylar attachment referring to insertion to the 'condylar head'. This differs from the subcondylar fovea on the superior aspect of the ramus, known as the pterygoid fovea, described in most human specimen studies.

Isacsson and Isberg (1985) studied eight adult Macaca fascicularis monkeys to determine disc attachments and related vascularization. They found that in all of their animal subjects that the superior head merged with the capsule and the capsule merged with the disc anteriorly. They stated that some fibers of the superior head followed the inferior head closely to insert at the condylar neck via the periostium. Meyenberg et. al., (1986) studied the relationship of the masticatory muscles to the articular disc of the temporomandibular joint. This study describes the anterior part of the disc as compared to a 'foot', the "heel" of which is attached, posteriorly, to the condyle and caudally to the upper head of the lateral pterygoid muscle. They studied twenty five TM joints from twenty two individuals with an average specimen age of seventy-one years. Preparations were preserved in 4% formaldehyde. In order to study the insertion of the muscles, they dissected in the direction of the fibers, strips 3 mm in width, and traced them back to the insertion. The insertion of the lateral pterygoid was also histologically studied. They found that "in 60% of the specimens examined, (15 out of 25), fibers of the superior head of the lateral pterygoid were attached medially to the disc and the rest of the muscle inserted into the pterygoid fovea". They further describe that "fibers inserting into the disc were distributed around the middle of the medial half, mostly underneath it". By pulling these fibers, the muscle exerts a 'forward' pull on the disc in only 60% of the specimens. In 40% of the specimens there was no direct muscle insertion at all! Meyenberg also indicated that 12% (3 out of 25), of the specimens showed very loose attachment of the disc to the condyle. This may likely be an 'aging factor' since the mean specimen age was seventy-one. The ligaments holding these discs could have been stretched and altered in some way. Wilkinson and Maryniuk (1983) dissected eight human cadaver joints. They showed that both the inferior and superior heads insert into the pterygoid fovea. They described the disc like a 'slipper', the sole of which is securely attached to the superior head and into which only a few fibers of muscle insert. They called the inferior aspect of the anterior band of the disc, 'the anchor point'. This anchor point attaches to the superior aspect of the superior head of the lateral pterygoid. They did sequential dissections which allowed them to grip the anterior part of the superior head after each cut in order to demonstrate the traction the muscle imparts to the disc-condyle complex. They conclude that it is anatomically impossible for the superior head of the lateral pterygoid to

pull the disc forward independently of the condyle, as in anterior displacement, unless the muscles' insertion to the pterygoid fovea was ruptured. Mahan et. al. (1983) described fibers of the superior head inserting into the neck of the condyle at the pterygoid fovea and a smaller portion of these fibers inserting into the anterior margin of the disc. Their work with human cadavers revealed that the anterior margin of the disc blends with the fascia that covers the superior surface of the superior head of the lateral pterygoid. The inferior head blends with the superior head and together they insert into the neck of the condyle. Isacsson and Isberg (1985) studied disc attachments and related vascularity in the right TM joints of eight Macaca fascicularis monkeys. They found that the muscle fibers of the superior head continued into the joint capsule but not into the disc attachment. The superior head also coursed with the inferior head to insert at the condylar neck closely connected to the periosteum. They related these findings to those of Mahan et. al., who two years prior studied humans and stated that the anterior margin of the disc blended into the fascia that covered the superior surface of the superior head of the lateral pterygoid muscle and that the inferior and superior head blend to insert into the neck of the condyle. They concluded that these two aspects of superior head insertion are "alike in man and monkey". However, they observed that in the eight monkey joints studied, there were no muscle fiber insertions into the anterior margin of the disc. Again, they referred to Mahan et. al., stating that "in man", Mahan's group found "a small portion of the superior belly fibers inserting into the anterior margin of the TM joint disc". Isacsson and Isberg therefore conclude this to be a difference between man and monkey. Mahan made no indication as to the percentage of fibers inserting or the number of discs where insertions were found. He did not publish the number of dissections. As previously stated, Meyenberg found muscle attachment directly to the disc in only 60% of his specimens (15 out of 25) and these were at the medial aspect of the disc. Comparisons cannot be made between findings in the literature with small sample sizes.

Flatau and Klineberg (1985) made progressive dissections of the infratemporal fossa from lateral and superior approaches on ten human adult cadavers. They found using this sagittal sectioning technique that the superior head of the lateral pterygoid was in all cases inserted into the pterygoid fovea of the mandibular articular process. The junction of the anterior discal band and the superior head increased in thickness medially, with fibers of the lateral pterygoid inserting into the medial half of the disc and the anterior medial surface of the articular capsule. The degree of "fusion" between the superior and inferior heads anterior to the condyle varied. This so stated "fusion" would be contradictory to the well accepted EMG studies of both heads which show them to be antagonistic in function. Widmalm, Lillie and Ash, (1987), also studied anatomical and electromyographic relationships of the lateral pterygoid muscle. They used a total of ten specimens. Their findings showed that fibers of the superior head not only insert into the disc but also into the pterygoid fovea at the neck of the ramus.

Wilkinson and Chan (1989) again studied five human cadaver joints under a dissecting microscope. They found that the 'major' insertion of the superior lateral pterygoid muscle was to the neck of the ramus at the pterygoid fovea. They described this insertion either by way of a 'central tendon', or by direct insertion at the fovea. Another type of insertion was by blending with the anterior joint capsule to gain indirect attachment to the condyle by way of the capsule. They described the uppermost fibers of the superior head as "often appearing to terminate under the disc". In one of the five joints, fibers of the superior head appeared to insert into the 'foot' of the disc. Traction of these fibers failed to pull the disc independently. Rather the condyle and disc moved together. In none of the joints did they see fibers passing through the anterior joint capsule. They highlighted an illustration by stating that "less than 20 per cent of the superior head of the muscle blend with the capsular fibers under the foot of the disc". No description was provided as to how the percentage of fiber attachment was calculated.

Carpentier, et. al. (1988) used ten cadavers with sufficient teeth to derive an 'intercuspal position'. They block embedded in acrylic and made serial sections in three planes. They found fibers of the upper and lower heads to be fused in front of the joint with a strong muscular wall medially. Laterally, the anterior band of the disc, showed no evidence of muscle insertion. The middle third of the anterior band showed fibers that coursed under the anterior band of the disc and attached in the upper part of the pterygoid fovea. Only in the medial third could they demonstrate fibers inserting into the disc and into the bone.

Separate Insertion Theory

Rees (1954) studied twelve specimens just after death. At this time, there was a contention that the disc did not move with the condyle. Rees described the "lateral pterygoid" with "tendinous fibers merging with the disc to form a true insertion". He was one of the earliest investigators to describe the disc as moving with the condyle over the temporal bone (fossa). He contended that "the forward movement of the 'meniscus' when the mouth is opened is evidently due to the pull of the lateral pterygoid muscle and the attachment of the meniscus to the condyle on either side". Christensen (1969) described two heads of the lateral pterygoid muscle as distinct anatomical entities in man. He reported that the origins are separate, the fibers of each head run in entirely different directions, and that there is no fusion of the fibers of either entity. From these observations, he reasoned that the two heads have separate functions! Honee (1972) studied ten muscles from five human heads. The muscles were removed with the condyle, joint capsule and articular disc and fixed in 10% formalin. By gross dissection, he determined that the proximal section of the lateral pterygoid muscle is clearly separated into two parts! Distally, this division is less apparent, but both superior and inferior heads are separated by a fascia as far as the attachment to the mandible, joint capsule and disc. He found that the superior head only attaches to the anterior border of the joint capsule and to the disc, but not to the condyle. The inferior head attaches to the pterygoid fovea of the neck of the ramus. Honee's primary purpose was to determine the average length of fibers of the superior and inferior heads, the average dry and moist weights and average physiologic cross section of both heads. He was then able to describe an average force value for both heads from these data. Before Honee, Porter (1970), dissected forty-two adult human cadavers from a superior approach. He concluded that the superior head is attached to the anterior portion of the disc as well as along the medial and medio-inferior surface of the disc. The inferior head of the lateral pterygoid muscle is attached to the pterygoid fovea. Juniper (1981) produced an EMG study based upon the anatomic findings of these separate insertion theories and combined the independent functional theories of McNamaras' EMG study on monkeys. He used surface electrodes and from this study coined the term 'Superior Pterygoid Muscle'.

Non-Discal Insertion Theory

Arstad (1954) dissected eighteen human TM joints. He concluded that the lateral pterygoid muscle has no attachment to the disc either directly or indirectly. Pinkert (1984) more recently demonstrated on human cadavers that the lateral pterygoid muscle does not insert at the disc at all.

Of interest in the literature is the observation as to how easily the "pendulum can swing" and how quickly the published information can be interpreted as the 'truth'.

CHAPTER IV

METHODS AND MATERIALS

Anatomic Description; Gross Dissection

Anatomic examination was accomplished by carefully dissecting the contents of the infratemporal fossa from a lateral approach using a layered technique on thirty six adult human cadavers, ranging in age from 45 to 93 years with an average age of 75 years. Bilateral dissections were made in sixteen whole specimens and twenty half specimens for a total of fifty-two joints studied. The entire lateral pterygoid muscle with the disc-condyle-capsule assembly attached were removed in the following manner. Using a stryker surgical saw, whole heads were bisected sagittally at the midline. (Plates 1-3) The pinna of the ear was then removed with a scalpel. (Plate 4) To preserve the insertional attachments of the lateral pterygoid muscle, the entire joint complex was removed from the lateral base of the skull. (Plate 5) A rectangular incision was made using the superior orbital ridge as the superior limit, the canthus of the eye as the anterior limit, the posterior border of the external auditory meatus as the posterior limit and the level of the occlusal plane as the inferior limit of the cut. (Plate 4) All cutaneous fat, the masseter and superficial temporalis muscles were dissected away so the bone could be visualized. A stryker saw was then used to cut through the base of the skull so the entire middle cranial fossa with the joint intact could be removed in toto. (Plate 6) Similarly, the mandibular ramus was transected and the coronoid process was carefully removed. Posteriorly, an osseous cut was made through the mastoid process and continued inferiorly to the foramen magnum. The zygomatic arch was removed by resecting it just anterior to the eminence and just posterior to the frontal process of the zygomatic bone. This gave access to the pterygoid plates of the sphenoid bone. An osseous cut was then made through the posterior maxilla so the pterygoid plates could be removed in toto. These gross blocks were removed with the entire lateral pterygoid intact from origin to insertion. (Plate 6) The entire temporomandibular joint was also intact within the capsule.

Blunt Dissection of Lateral Pterygoid Muscle and Joint Components

Utilizing an American Optical model 569 dissecting scope at 3-30 times magnification, the origin of the lateral pterygoid was stripped away, with periosteum intact, from the infratemporal crest and lateral pterygoid plate. In each specimen the superior head was identified at its origin and tied off with color coded thread. The inferior head, also identified at the origin, was tied off with color coded thread. The condyle-disc assembly was then dissected away from the temporal fossa using a series of Molt surgical currettes. The entire synovial lining of the superior joint space and the fibrous periosteum of the temporal fossa was stripped away. An intact disc-capsule-condyle with both heads of the lateral pterygoid intact was thus obtained. (Plates 8 and 9) While obtaining these specimens, each joint was surveyed for abnormal component relationships (i.e. disc displacement, perforation of retrodiscal tissue and altered disc form.)

Decalcification/Fixation Process

These muscle-disc-condyle preparations were then decalcified in a solution of 45% Formic Acid and 20% Sodium Citrate in agitating beakers. The decalcification process was accomplished over a period of twenty one days. Sample radiographs were taken to verify complete condylar decalcification. The specimens were washed and stored in 10% formalin. In order to determine the anatomic insertion and to determine the ratio of superior head fibers which interact with the joint components (i.e. disc-capsule-condyle), the muscle fibers were teased apart into 2-3 millimeter strips. Fiber direction was used as orientation and the strips were followed to their insertion. As the insertion of superior head fibers became apparent, the color coded thread was used to identify and bundle the muscle fibers into groups. These fiber groups were then tied both proximal and distal to a cut which was perpendicular to the direction of fiber orientation. (Plates 8 and 9) A new #15 Bard Parker scalpel blade was used to make each cut. On fifty specimens the cuts were made to separate the major portion of the muscle fiber groups which inserted onto the joint components approximately 10 to 20 millimeters distal to the point of insertion. In this way, the major muscle mass was embedded for a cross sectional microtome technic to do a fiber count/ratio evaluation of muscle insertion. The distal portion (i.e. tendinous insertion to the disc-capsule and condyle) were embedded for a histologic description of insertion.

Fine Muscle Dissection

The superior and inferior heads were separated by blunt dissection until a 'central tendon' was encountered. (Plate 15) The 'coalescing tendons' of the superior head to the tendons on top of the inferior head were cut with a scalpel blade to facilitate isolation of superior head to its insertion at the joint components.

The superior head was dissected back to the joint components. Fibers going directly to insert on the bony fovea pterygoideous as well as fibers which went to tendons which 'reinforced' the anterior medial capsule, but ultimately had primary functional insertion on the fovea were isolated as a single group. This fiber group was manually manipulated with a hemostat and were seen to have direct and indirect functional action on the fovea. These fibers were tied and cut as previously described. (Plates 10 and 18)

Some fibers of the superior head could be traced to the disc. These fibers ended in tendons which coalesced with the disc directly, or in tendons which adhered to the anterior inferior portion of disc. but traversed on to the anterior capsule. These were manually manipulated and were seen to have primary functional influence on the disc itself. These fibers were isolated, tied and cut, as previously described. (Plates 10 and 18)

Embedding Technique

All specimens were passed through a series of ethanol washes ranging from 75% to 100% within a commercial technicon unit. The first wash was 75% EtOH for 24 hours. The second wash was also 75% for 3-4 hours with no agitation. The third wash was 80% for 24 hours with no agitation. There were then two consecutive agitating rinses with 95% EtOH for 2 hours per rinse. There were then four consecutive rinses in 100% EtOH, each for 2 hours. All but the last rinse was agitated. The next rinse was 50% EtOH and 50% Xylene and then 100% Xylene which graduated to a paraffin slush. The final rinses were in 100% paraffin under vacuum for 3.5 hours and then into oscillating paraffin for 45 minutes.

The specimens for cross sectional fiber count were carefully oriented in a vacuum embedding machine so fibers were perpendicular to the face of the block. These specimens were then embedded under vacuum. Similarly, the specimens for histologic description of fiber insertion were oriented in the block so the tissues could carefully be cut parallel to the orientation of fiber direction.

Microtome Technique

The specimens for histologic analysis of insertion to joint components were placed in the microtome and cuts were accomplished at 10 micron thicknesses. As the cuts approached the medial portion of the specimen, every fifth section was saved. Two slices were mounted per slide. These sagittal cuts were then stained with Milligans trichrome stain to clearly discern collagen from muscle myofibrils.

The specimens for cross sectional muscle fiber counts were also cut at 10 micron thicknesses. Twelve sections per specimen were obtained by saving every tenth cut. These twelve sections per specimen were mounted and stained with sirius red with hematoxylin for nuclei after Van Gieson.

The slides of the sagittal cuts parallel to the long axis of insertion were examined under light microscope under a 100x to 400x objective. A histologic description of superior head insertion was made.

Method of Muscle Fiber Counting

The specimens mounted for quantification of muscle fibers interacting with the disc-capsule and pterygoid fovea joint components, were processed in the following manner. Using the Bioquant System for Apple Computer, digitizing morphometry was accomplished on all specimens under 40x magnification. (Plates 32-36) Four random sections from each of the twelve sections obtained were digitized to arrive at the total area of muscle interacting with disc-capsule and pterygoid fovea. The average total muscle cross sectional area for each of the fifty specimens was computed by averaging the four figures obtained from digitizing each section pair (i.e. disc-capsule area and pterygoid fovea area). Using a microscope stage and grid, calibrated in square millimeters, the muscle fibers were counted on each of the four section pairs per specimen. Ten fields per section pair were counted for a total of 40 fields per disc-capsule area and 40 fields per pterygoid fovea area. These 40 fields were averaged to obtain the average number of muscle fibers per square millimeter of muscle. (Table II) By multiplying the number of muscle fibers per square millimeter, by the total area of muscle and calculating the average, the percentage of fibers associated with the disc-capsule group and with the pterygoid fovea group, was computed. The percentage per group was based upon the total number of fibers in the superior head of the lateral pterygoid. (Tables I and III)

CHAPTER V

RESULTS

General Anatomic Features

A superior and inferior lateral pterygoid muscle was seen in all joint specimens. The insertion of these muscles to the neck of the condyle was always by tendons to the medial half of the neck at the pterygoid fovea.

The disc and capsule could not be functionally separated and must be considered as a disc-capsule complex. (Plate 10) The disc itself normally lies between the condyle and mandibular fossa of the temporal bone. The posterior thicker zone is centered on the condyle. The intermediate thinner zone rests against the articular eminence and the anterior or foot-like zone feathers out anteriorly and rests atop the superior head of the lateral pterygoid. Posteriorly, the disc is attached to the condyle below and to the anterior margin of the petrotympanic fissure above by way of bilaminar connective tissue to the joint capsule. Together with the capsule the disc is attached at the inferior margin of the articular surface of the condyle, the articular eminence and at the anterior margin of the petrotympanic and squamotympanic fissures. There is firm attachment of the disc at the lateral and especially the medial poles of the condyle. There is also attachment to the posterior and inferior margin of the articular condylar surface and to the articular eminence by way of the capsule. There is a more elastic attachment at the anterior margin of the petrotympanic fissure posteriorly and to the anterior margin of the articular surface of the condyle anteriorly. The disc is very densely bound at the medial pole. There is a heavy confluence of tendons which coalesce with the medial pole. (Plate 16) In 13 out of 52 specimens (25%) muscle fibers of the inferior head could be followed directly to tendons which inserted at the medial pole of the disc.

The general orientation of the two heads is as follows: The inferior head of the lateral pterygoid follows an upward, lateral and posterior course from its origin at the lateral pterygoid plate to its insertion at the fovea. It tends to run parallel to the posterior slope of the articular eminence in sagittal view. The inferior head is approximately two thirds larger in cross section than the superior head.

The superior head of the lateral pterygoid runs inferiorly, laterally and posteriorly from its origin at the infratemporal crest of the greater wing of the sphenoid to its insertion.

In 39% of a sample of thirty-six total cadavers used in this study, a variation at the origin of the two heads occurred as a vertical musculotendinous band called the pterygoideous proprius muscle. (Plates 41 and 42) This muscle slip was first described by Henle in 1858 and reported by Wagstaffe in 1871. Of the 16 specimens where both sides were available for dissection, 3 had bilateral presence (18.75%). (Plate 43)

This muscle is a vertical musculotendinous band about 8-10 mm. wide which passes between two fixed points; namely the anterior pterygoid ridge of the sphenoid bone above, to the lateral inferior surface of the lateral pterygoid plate below. (Plates 39, 40, 46 and 47) Some fibers occasionally continue downward to blend with lateral fibers of the medial pterygoid muscle. (Plate 44) In all cases, the superior head of the lateral pterygoid was seen to take origin on its lateral aspect from the medial surface of this vertical band! (Plate 52) At the inferior limit of this muscle, the horizontal fibers of the inferior head of the lateral pterygoid blend with fibers of this vertical band. (Plates 48 and 49) The lateral superior surface of the pterygoideous proprius is closely intertwined with the deep fibers of the anterior temporalis muscle. (Plate 45)

Superior Head Insertions To The Pterygoid Fovea

There is variation among subjects as to how the fibers of the superior head actually reach, insert onto and ultimately interact with the joint. None of the specimens showed a complete insertion of the superior head to just one joint component. In all specimens the fibers of the superior head interacted with the superior surface of the inferior head. Lateral and central fibers of the superior head blend with fibers and tendons of the inferior head to insert into the fovea; (Group A insertion). Approximately two-thirds the distance distal to its origin some fiber bundles of the superior head inserted on to a 'central tendon' which lies on top of the central superior fibers of the inferior head. (Plate 15) This central tendon inserts at the fovea; (Group B insertion). Medially, the superior fiber bundles of the superior head interacted by tendinous attachment with the anterior inferior joint capsule in a way that seems to 'reinforce' this portion of the capsule. (Plates 10 and 14) This anterior inferior joint capsule attaches at the anterior inferior condylar rim or superior aspect of the fovea; (Group C insertion). (Plate 10)

Superior Head Insertions To The Disc-Capsule

The base of the anterior discal band is suspended in a 'hammock like' fashion upon the superior aspect of the superior head. (Plates 8 and 9) The anterior inferior joint capsule is closely bound to the anterior inferior portion of the disc. (Plate 14) The medio-superior fibers of the superior head which blend with this part of the capsule have an indirect interaction with the disc. (Plates 11-14, 19 and 20) These muscle fiber bundles end in tendinous attachments which blend with the capsule and are bound to the anterior inferior portion of the disc by a dense collagenous connective tissue. (Plates 26-28) Many of these tendons increase in number and therefore thicken the medio-anterior portion of the anterior inferior capsule. These tendons form an 'arc' as they curve down the anterior inferior capsule to insert at the superior rim of the fovea with the capsule. (Plate 7) Traction on these muscle fibers had a lift effect on the foot of the disc, both as a result of the foot being suspended on these fiber bundles and because traction tightened the anterior inferior capsule to which the foot of the disc is bound. Ultimately the anterior inferior capsule becomes stretched forward and the traction pulls on the condyle. (Plates 17-20)

In 15% (8 out of 52) of the joints there was a direct muscle insertion into the disc. This was always at the most medial and superior aspect of the disc, and was of the most superficial fibers of the superior head. At the medial pole, fibers of the superior head end in tendons which insert onto this portion of the capsule which overlies the medial collateral discal ligament. (Plate 16) Fascia which overlies the superior head blends with the anterior superior aspect of the disc. (Plate 17)

All joint specimens except 5 (1%) displayed group A, B, and C fiber attachment configurationsto the fovea. The five exceptions had only group A and B configurations with no C configuration and no other direct or indirect disc-capsule insertion. These same five specimens had anterior-medial disc displacement, disc distortion and perforation of the posterior attachment.

Histologic Findings of Superior Head Insertion

Histologically, the anterior inferior joint capsule is closely bound to the anterior inferior portion of the disc by dense collagenous connective tissue. (Plates 26 and 27) Therefore, the disc and capsule, in function, must be considered to be an integral disc-capsule complex. The fascia which overlies the superior head blends with the anterior superior aspect of the disc. (Plates 30 and 31) The tendons of the superior head that blend with the anterior inferior portion of the disc and anterior inferior capsule show an interface of organized dense collagenous tissue of the disc with a wavy unorganized dense collagenous tissue of the tendon. (Plates 28 and 29) Where the muscle fibers of the superior head insert into the disc as described previously for 15% of the specimens, there was continuation of the perimysium which continued on into the dense collagen of the disc. (Plates 30 and 31)

The capsule-condyle interface is one of a dense unorganized confluence of collagenous fibers which become more compacted as these fibers blend with the periosteum of the condyle. (Plates 24 and 25) The superior head and the region between the superior and inferior head is infiltrated with blood vessels, fat tissue and neural fibers. (Plate 25) The amount of fat varied from individual to individual. Also where there was little to no direct or indirect attachment of superior head to disc-capsule complex, there was a large amount of fat within the superior head.

Fiber Count Distribution

A ratio of muscle fibers interacting with the disc-capsule complex and pterygoid fovea was computed from the muscle fiber count. (Table I) The quantity of superior head with primary direct and indirect insertion on the disc-capsule complex ranged from 12.63% to 77.08% with 38.59% as a mean (S.D. = + 15.37%). The amount of superior head which primarily inserted on the pterygoid fovea directly and indirectly ranged from 22.92% to 87.37% with 61.41% as a mean (S.D. = + 15.37%). (Tables II and III; Plates 37 and 38)

TABLE I

EQUATIONS

I. Area/square Millimeters x Number of Muscle Cells Per Square Millimeter = Number of cells per Muscle Area

This calculation was accomplished on four samples per specimen for the disc-capsule group and for the pterygoid fovea group. The four PRODUCTS were added and divided by four to arrive at the average.

EXAMPLE:

Muscle Area of Disc-Capsule Insertion Group	x	#Muscle Cells Per Square MM.	=	#Muscle Cells Within Area
13.38 mm^2	x	1582.5	=	21173.9
15.70 mm^2	x	1645	=	25826.5
14.70 mm^2	x	1592	=	23402.4
15.77 mm^2	x	1550	=	24443.5
				94846.3

94846.3/4 = 23711.6 = Average # Muscle Cells within Muscle Area of Disc-Capsule Insertion Group

Muscle Area of Pterygoid Fovea Insertion Group	x	#Muscle Cells Per Square MM.	=	#Muscle Cells Within Area
18.64 mm^2	x	1610	=	30010.4
20.95 mm^2	x	1695	=	35510.3
20.32 mm^2	x	1787.5	=	36322
19.53 mm^2	x	1797.5	=	35105.2
				136947.9

13947.9/4 = 34237 = Average # Muscle Cells within Muscle Area of Pterygoid Fovea Insertion Group.

TABLE I CONTINUED

EQUATIONS

II. Average # Muscle Cells within Muscle Area of Disc-Capsule Insertion Group (Group I)

PLUS

Average # Muscle Cells Within Muscle Area of Pterygoid Fovea Insertion Group (Group II)

EQUALS

Average # Muscle Cells in Total Area of Superior Head of Lateral Pterygoid (Total)

III. Percent of Fibers to Disc-Capsule $= \frac{\text{Group I}}{\text{Total}}$

Percent of Fibers to Pterygoid Fovea $= \frac{\text{Group II}}{\text{Total}}$

TABLE II

AVERAGE NUMBER OF MUSCLE CELLS PER TOTAL MUSCLE AREA

Specimen Number	Disc-Capsule Insertion Group (1)	Pterygoid Fovea Insertion Group (2)	Total = Groups (1) Plus (2)
1	3916.6	15287.5	19204.1
2	23711.6	34237.0	57948.6
3	21015.9	21903.0	42918.9
4	36916.1	39167.2	76083.3
5	22880.6	22690.2	45570.8
6	20220.5	23796.2	44016.7
7	20282.5	27973.1	48255.6
8	22269.8	13500.3	35770.1
9	19889.3	36896.0	56785.3
10	26947.4	26761.6	53709.0
11	11661.9	60798.6	42460.5
12	14093.7	33656.0	47749.7
13	12875.3	37552.9	50428.2
14	19927.4	29102.2	49029.6
15	14844.7	63031.8	77876.5
16	19446.3	17530.0	36979.3
17	14221.7	30480.8	44702.5
18	16070.9	51943.2	68014.1
19	19622.7	75798.0	95420.7
20	20402.0	42350.5	62752.5
21	17062.7	60207.7	77270.4
22	12781.5	17600.5	30382.0
23	11789.6	25929.2	37718.8
24	27613.2	14374.4	41987.6
25	10802.4	34475.3	45277.7
26	13315.1	54331.2	67646.3

TABLE II

AVERAGE NUMBER OF MUSCLE CELLS PER TOTAL MUSCLE AREA

Specimen Number	Disc-Capsule Insertion Group (1)	Pterygoid Fovea Insertion Group (2)	Total = Groups (1) Plus (2)
27	18453.7	34594.5	53048.2
28	32539.7	32063.4	64603.1
29	5815.2	28529.3	34344.5
30	19589.3	15409.0	34998.3
31	45430.9	14681.8	60112.7
32	23176.1	6889.8	30065.9
33	16278.9	56835.1	73114.0
34	26348.0	47735.6	74083.6
35	30802.5	18601.4	49403.9
36	19416.8	27491.7	46908.5
37	15328.0	53319.6	68647.6
38	17983.3	24306.0	42289.3
39	9387.9	25841.5	35229.4
40	18019.4	19494.6	37514.0
41	14098.3	97489.0	111587.3
42	23771.3	41070.0	64841.3
43	14118.7	31553.1	45671.8
44	11063.6	.8972.5	50036.1
45	22642.1	50144.5	72786.6
46	45096.1	66741.6	111837.7
47	9140.3	10479.1	19619.4
48	12042.5	14465.7	26508.2
49	17213.3	35159.0	52372.3
50	33428.6	16874.9	50303.5

These figures were used to determine the percentage of muscle attachement to the disc-capsule and pterygoid fovea. 'Percentage' is expressed as that of the total number of muscle cells per area of superior head (Total = Group I plus Group 2.)

TABLE III

PERCENTAGES

Specimen Number	Disc-Capsule Insertion Group (1) Percent	Pterygoid Fovea Insertion Group (2) Percent
1	20.39	79.61
2	40.92	59.08
3	48.96	51.04
4	48.52	51.48
5	50.21	49.79
6	45.94	54.06
7	42.03	57.97
8	62.26	37.74
9	35.03	64.97
10	50.17	49.83
11	27.46	72.54
12	29.52	70.48
13	25.53	74.47
14	40.64	59.36
15	19.06	80.94
16	52.59	47.41
17	31.81	68.19
18	23.63	76.37
19	20.56	79.44
20	32.51	67.49
21	22.08	77.92
22	42.07	57.93
23	31.26	68.74
24	65.77	34.23
25	23.86	76.14
26	19.68	80.32
27	34.79	65.21

TABLE III

PERCENTAGES

Specimen Number	Disc-Capsule Insertion Group (1) Percent	Pterygoid Fovea Insertion Group (2) Percent
28	50.37	49.63
29	16.93	83.07
30	55.97	44.03
31	75.58	24.42
32	77.08	22.92
33	22.27	77.73
34	35.57	64.43
35	62.35	37.65
36	41.39	58.61
37	22.33	77.67
38	42.52	57.48
39	26.65	73.35
40	48.03	51.97
41	12.63	87.37
42	36.66	63.34
43	30.91	69.09
44	22.11	77.89
45	31.11	68.89
46	40.32	59.68
47	46.59	53.41
48	45.43	54.57
49	32.87	67.13
50	66.45	33.55
	Range = 12.63 to 77.08%	Range = 22.92 to 87.37%
	Total = 1929.37 : 50 = Average = 38.59% (SD = 15.37%)	Total = 3070.63 : 50 = Average = 61.41% (SD = 15.37%)

CHAPTER VI

DISCUSSION

General Discussion

An examination of the literature on the anatomy of the lateral pterygoid muscle and its insertional attachments to the temporomandibular joint components, demonstrates a considerable difference of opinion. From the present study, it seems that these differences arise primarily from a poor understanding of the muscle architecture. Knowledge of structure can greatly assist in the understanding of function and create an awareness that function can change with altered morphology. At first glance, differences of opinion in the literature seem to be due to differences in the methods employed. However, after dissecting fifty two specimens, the presence of anatomic variation from specimen to specimen became readily apparent. Although the lateral pterygoid muscle is actually composed of a superior and inferior head, with antagonistic actions, the controversy deals with the relationship of the superior head with the joint components. These components are the condyle, the joint capsule and the articular disc. It was felt that an anatomic study on the insertion of the superior head to these components should encompass both a microdissection technique, followed by a histologic observation at the interface of these structures. This study used a sizeable sample to more realistically consider anatomic variation and to determine the relative anatomic relationship of the superior head to the joint components. This 'relationship' also implies that there is a ratio of muscle fiber interaction with the various components. By utilizing microdissection, a three dimensional functional understanding becomes possible. Histologic observation of these tissues allows detailed examination of their interrelationships. Isolation of muscle fiber groups with microdissection, allows the calculation of the proportion of fiber bundles which interact sequentially on the joint components during function.

A wide range of variation was found in the musculature between specimens. The average specimen age was 75 years and this may partly account for the variation since age and associated functional changes can alter structure. (Lexall, 1983)

The results of this study would seem to support previous studies which describe a 'dual insertion' of the superior head, to the disc-capsule and to the condyle by way of the pterygoid fovea. The results of this study closely agree with the findings of Wilkinson and Chan, (1989). They indicated that the major insertion of the superior lateral pterygoid muscle was to the condyle and that the uppermost fibers of this muscle head also inserted into the 'disc-capsule complex'. The present study extends this observation by quantifying the muscle fibers that interact both directly and indirectly with these components. It seems that the term " disc-capsule complex", should be changed to the "disc-capsule-condyle complex". Although it is possible to separate these structures anatomically, they are all functionally interrelated. While the capsule completely envelopes the joint, the foot of the disc becomes an integral part of the capsule anterio-medially. In this region the tendinous attachment of disc-capsule muscle fibers 'reinforces' the anterior inferior capsule and actually gains an indirect insertion onto the condyle by way of the anterior inferior capsule. These tendinous attachments do not 'penetrate' the capsule to become intracapsular, but rather 'blend' with the anterior inferior capsule and 'sole' of the foot of the disc to reinforce and thicken it. (Plates 13 and 14)

The muscle components do not actually penetrate the capsule to insert into the disc. In those specimens where tendons of fibers can be seen penetrating the most medial superior aspect of the disc, the question is whether the capsule in this region is actually void. If so, in this region the disc would act to fill this space! Since this observation was made in just 15% of the sample, it could be considered a remnant of a developmental vestige. Consider the divergent opinions concerning morphogenesis, with respect to the tendon of the lateral pterygoid, assisting in development of the disc in fetuses. Harpman and Woollard, (1938) Moffett, (1957) and Symons, (1952) have proposed that the 'tendon of the lateral pterygoid' contributes to the formation of the medial part of the disc. The lateral portion of the disc is thought to be derived from a condensation of mesenchyme. Coleman, (1970) proposed that the fetal diskomalleolar ligament, observed in his sample of fetuses less than 140 mm C-R, was a continuation of the fetal lateral pterygoid tendon. Indeed, Moffet was able to provide histologic evidence of the lateral pterygoid tendon extending into the malleus! Whether the capsule develops later as a 'specialization' of mesenchymal tissues is a topic yet to be considered. Generally, in the adult specimen, the tendons of the lateral pterygoid do not actually penetrate the capsular structures. Rather there is a blending of tendon and capsular-discal collagen. (Plates 26-31)

Superior Head in Joint Dynamics (Hypothesis)

The inferior head functions primarily on opening and protrusion. (Mahan, et. al., 1983) The superior head functions primarily on final closing and clenching of the teeth, (Mahan, et. al., 1983) in a manner that supports and stabilizes the disc-capsule-condyle complex upward, into, and against the medio-anterior glenoid fossa surfaces. This occurs as the entire complex returns to a close-packed position. As the superior head contracts, traction appears to be placed on the anterior inferior disc surface to push the disc upward into the eminence while the entire disc-capsule-condyle complex slides back and upward into the fossa under the guidance of the superior head. It would appear that the superior head acts like "reins of a harness", gradually calling functional motor units into action to first place tension on the most medio-superior muscle bundles to draw the disc-capsule-condyle complex medially toward the pyramid of the fossa and to suspend the anterior inferior position of the disc on top of the superior head in a "hammock-sling" fashion in order to pack the disc against the eminence. This has been referred to as a tethering of the foot of the disc to the roof of the muscle by Wilkinson and Maryniuk (1983). As more motor units come into play, there is more tethering tension upward on the foot of the disc, tension on the anterior inferior capsule, and ultimately the condyle. This wave of activity continues to pass into motor units inferiorly and laterally, ultimately passing to the motor units that insert onto the pterygoid fovea. Traction would then be placed in such a manner as to stabilize the entire disc-capsule-condyle complex as the unit rotates and slides upward, backward and into the confines of the fossa. This entire maneuver probably occurs rapidly and with harmony in a synchronized fashion with other masticatory muscle units. Thus, the superior head appears to play the important role of stabilizing the disc-capsule-condyle complex during specific mandibular movements. Since the quantity of muscle fibers inserting on these joint components varies over a wide range between individuals, it is possible that a decrease or imbalance in the amount of muscle interaction with the disc-capsule-condylar complex, coupled with certain clinical factors, could allow for instability during function of the complex. I consider this lack of stabilization during closing and clenching to be more of a predisposing factor for anterior medial disc displacement. Because of the complex inter-relationship of the joint components and the superior head, it is totally inconceivable to think that traction of the superior head causes anterior disc displacement. Consider also the possibility that variation in collagen structure may occur between individuals. The loss of retrodiscal elasticity, stretch of the retrodiscal and/or collateral ligaments and capsular fibers would allow more laxity within a joint complex. Laxity will eventually lead to alteration in disc surface shape, possibly due to alteration in hemodynamics and synovial lubrication. (Heffez and Jordan, 1992) As the disc changes in shape, so does the superior and inferior joint space, and so the joint fluid lubricating system is again altered. This change may be adaptive (physiologic) or non-adaptive (pathologic) for the individual. It must then be decided whether a clinical treatment problem exists. There have been studies on the number of muscle spindles within the lateral pterygoid. (Gill, 1971). These spindles are few and tend to be located within the inferior head. It makes sense that the superior head would have no muscle spindles because of its contraction in an almost isometric manner.

Whether the mean amount of superior head fibers (38%), interacting with disc-capsule and the mean amount of superior head fibers (62%), interacting with condyle is significant in terms of joint stabilization is another area for further study. Is there a proportional imbalance point that needs to be reached before joint dynamics are disrupted? Is it only coincidence that those joints in this study which had little to no tendon attachment at the disc-capsule complex also demonstrated anterior-medial disc displacements and perforation of the retrodiscal lamina? These are horizons that warrant further investigation.

In anterior disc displacement, Wilkinson and Maryniuk indicate that the foot of the disc is 'tethered' to the roof of the tendon of the superior lateral pterygoid. During translation, the capsule anterior inferior to the disc is shortened and thickened while the capsule posterior to the disc is elongated with an increase in the anterior fornix of the inferior joint space. Meyenberg, et. al., suggest it is unlikely that contraction of the superior lateral pterygoid muscle could actually stretch the disc forward independently of the condyle. The present study is in full agreement with that proposal. However, superior lateral pterygoid activity does occur with the mandible in a protrusive position during anterior clenching according to Mahan et. al., (1983). This could lead to elongation of the retrodiscal bilaminar zone and lateral collateral discal ligaments if the activity of this head prevented normal rotation of the disc back over the condyle during protrusion. This could eventually cause an elongation of the retrodiscal tissue and lateral collateral ligaments. Should this scenario occur, the hemodynamics of the joint would be altered which would also alter the synovial dynamics of the joint which would accentuate the collagen changes. Also, as the condition becomes chronic, changes in fluid dynamics could also set the stage for intra-articular adhesions which is also a constant finding with anterior medial disc displacement. (Scapino, 1983; Westesson, 1985; deBont, et. al., 1985) Therefore, superior lateral pterygoid activity may lead to disc displacement, not by 'pulling' the disc forward independently of the condyle but by preventing the disc from rotating back during protrusion. Another way of looking at this however would be the 'lack of stability' proposal offered earlier. Without this 'tethering' effect of the disc-capsule arcuate tendons, elevating the foot of the disc into the posterior slope of the eminence and packing it into the medial vertex of the fossa, the disc would be subject to excessive rotational motion especially during retrusive condylar movements. Excessive motion in a joint adapted for close packed loaded mechanics certainly would alter the synovial hemodynamics and hasten disc surface change!

Pterygoid Proprius Muscle

The finding of a high incidence of pterygoid proprius muscles in this study (38.89%) may indicate that there is an effective function. Because published reports are scarce, the incidence of this anatomical variation is not known. While being unusual and variable, these so called anatomic anomalies may be the result of specific genetic influences and rarely interfere with the normal function of surrounding structures. In the case of the pterygoid proprius muscle, its relationship with the deep temporalis, superior lateral pterygoid and medial pterygoid muscles and its frequency of occurrence (38.89%), creates questions as to the nature of its innovation, function during jaw movements and its role if any, in temporomandibular dysfunction. Nerve fibers were seen passing between the deep temporalis muscle and this vertical musculotendinous band. The muscular component of this band may contract simultaneously with mandibular elevation and retrusion. If it is indeed innervated by fibers which innervate the deep temporalis, then this pterygoid proprius muscle would contract as the temporalis contracted during elevation. This would tense the tendinous component where the lateral fibers of the superior head of the lateral pterygoid originate. (Plate 52) As this vertical musculotendinous band draws tight, it would provide the lateral fibers of origin of the superior head with a semi-rigid; semi-fixed point on which to draw. As these horizontal lateral pterygoid muscle fibers tense, a semi-fixed origin is provided against which to pull. This structure may also be a vestige of an embryogenic muscle which in lower vertebral forms functioned to hold or draw the palatoquadrate to the base of the skull. It may now have an indirect function in assisting the stabilization of the superior head, while the superior head acts to stabilize the joint.

CHAPTER VII

SUMMARY & CONCLUSIONS

The anatomical relationship between the superior head of the lateral pterygoid muscle and its insertional interaction with the disc-capsule-condylar complex of the human temporomandibular joint was studied in thirty-six adult human cadavers for a total of fifty-two separate joints using the dissecting microscope and histologic technique.

A method was employed in which the portion of the superior head attaching to the disc-capsule complex was isolated from the portion that inserted into the pterygoid fovea of the condyle. These muscle bundles were then resected in cross-section and prepared histologically in order to quantify the number of muscle fibers associated with each of these components.

The following conclusions were drawn from this anatomic investigation:

1. The number of muscle fibers of the superior head which inserted into the various components of the joint complex varied greatly between specimens.

2. The amount of superior head which inserted into and influenced the disc-capsule complex ranged from 12.63% to 77.08% with 38.59% as a mean. (S.D. = + 15.37%).

3. The quantity of superior head which directly or indirectly inserted into and influenced the pterygoid fovea ranged from 22.92% to 87.37% with 61.41% as a mean. (S.D. = + 15.37%).

4. Rather than a separate discal insertion, the tendon of the superior head, becomes integrally related with the anterior inferior disc-capsule complex, and the pterygoid fovea of the mandibular ramus.

5. Histologically, the anterior inferior joint capsule is closely bound to the anterior inferior portion of the disc by dense collagenous connective tissue.

6. Medio-superior fibers of the superior head, end in tendons which blend with the medio-anterior inferior aspect of the capsule, in such a way as to reinforce this part of the capsule, and thus have an indirect attachment to the disc.

7. Extending anteriorly in a 'slipper like' configuration, the anterior discal band is suspended in a 'Hammock-Like' fashion upon the superior aspect of the superior head.

8. Fascia which overlies the superior head blends with the anterior superior aspect of the disc.

9. At the medial pole of the disc-condyle complex, the tendons of the superior head blend with this portion of the capsule which overlies the medial collateral ligament.

10. Approximately two-thirds the distance distal to its origin, some fiber bundles of the superior head insert onto a central tendon which lies on top of the central superior fibers of the inferior head.

11. Very few of the most superficial fibers of the superior head of the lateral pterygoid actually terminate in the anterior portion of the foot of the disc. When this occurred it was always at the most medial and superior aspect of the disc. It was found in 15% (8 out of 52 joints) of this sample.

12. The pterygoideus proprius muscle is a vertical musculotendinous band about 8-10 mm. wide.

13. It inserts into two fixed points; the anterior pterygoid ridge of the sphenoid bone above, and the inferior lateral aspect of the lateral pterygoid plate below.

14. It occurred in fourteen out of thirty-six (36) specimens (38.89%).

15. Of the sixteen specimens where both sides were available for dissection, three had bilateral presence (18.75%).

16. In all cases, lateral fibers of the superior head of the lateral pterygoid took origin on the medial superior surface of this musculotendinous band.

17. The lateral superior surface of pterygoideus proprius is closely intertwined with the deep fibers of the anterior temporalis muscle.

18. Some fibers of the pterygoideus proprius muscle continue downward to blend with lateral fibers of the medial pterygoid muscle.

19. It is suggested that the pterygoideus proprius muscle be given serious consideration as a distinct anatomic entity by

anatomists, physiologists and clinicians.

20. Understanding these normal structural configurations of both heads of the lateral pterygoid muscle and their interaction with the disc-capsule-condylar complex, makes it anatomically impossible for the lateral pterygoid muscle alone to cause an anteriorly displaced articular disc. It is perceived that the independent function of the superior head of the lateral pterygoid muscle on the joint components is one of stabilization and guidance during functional movements. The concept of decreased or imbalanced muscle interaction on the various joint components as a predisposing factor leading to internal dysfunction, may be a topic which warrants future investigation.

CHAPTER VIII

APPENDIX A

PLATES OF GROSS DISSECTION TECHNIQUE

PLATE 1 - BILATERAL DISSECTIONS WERE MADE IN SIXTEEN WHOLE SPECIMENS (32 JOINTS) AND TWENTY HALF SPECIMENS (20 JOINTS) FOR A TOTAL OF 52 JOINTS STUDIED.

USING A STRYKER SURGICAL SAW, WHOLE HEADS WERE BISECTED SAGITALLY AT THE MIDLINE.

PLATE 2 - EXTERNAL VIEW OF SAGITALLY BISECTED SPECIMEN. SIXTEEN WHOLE SPECIMENS WERE BISECTED TO PROVIDE 32 OF THE 52 TOTAL JOINTS STUDIED.

PLATE 3 - INTERNAL VIEW OF SAGITALLY BISECTED SPECIMEN. TWENTY HALF HEAD SPECIMENS WERE ALSO A PART OF THE TOTAL 52 JOINTS STUDIED.

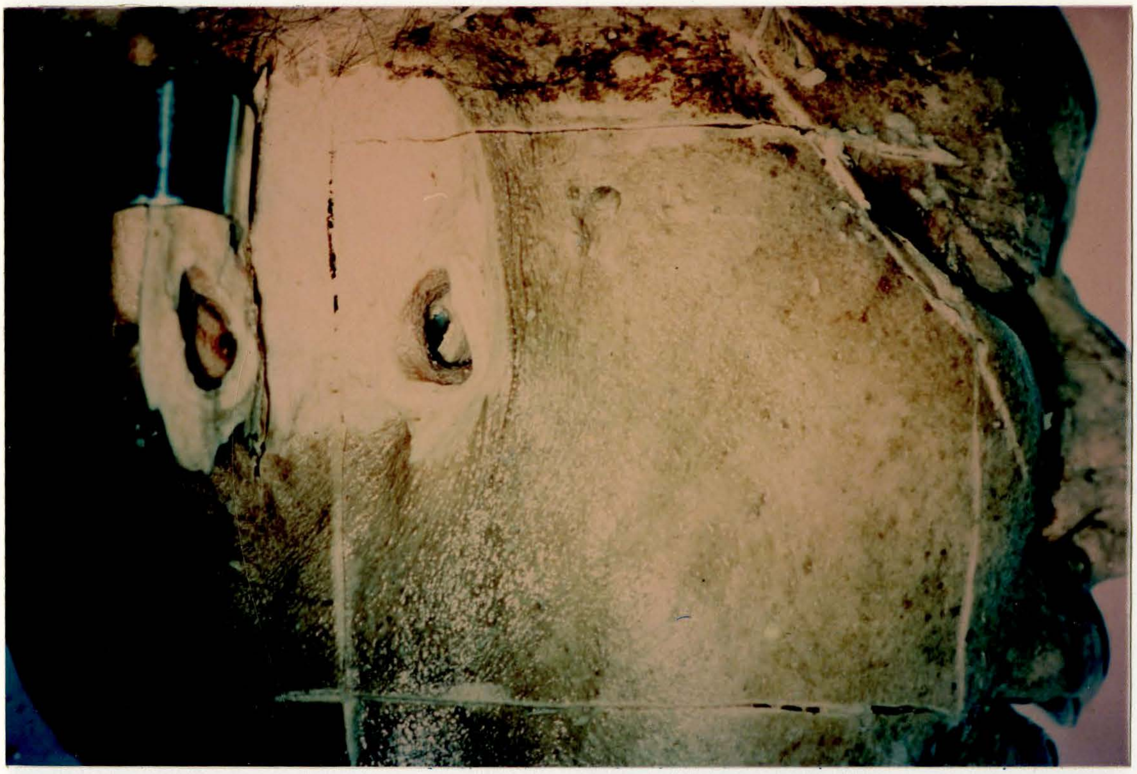


PLATE 4 - THE PINNA OF THE EAR WAS REMOVED WITH A SCALPEL. A RECTANGULAR 'BLOCK' INCISION WAS MADE WITH EXTENSIVE BORDERS TO INCLUDE THE ENTIRE JOINT COMPLEX AND COMPLETE LATERAL PTERYGOID MUSCLE.

PLATE 5 - GROSS BLOCK WITH ENTIRE JOINT COMPLEX AND LATERAL PTERYGOID MUSCLE AND ORIGINS INTACT IS OUTLINED.

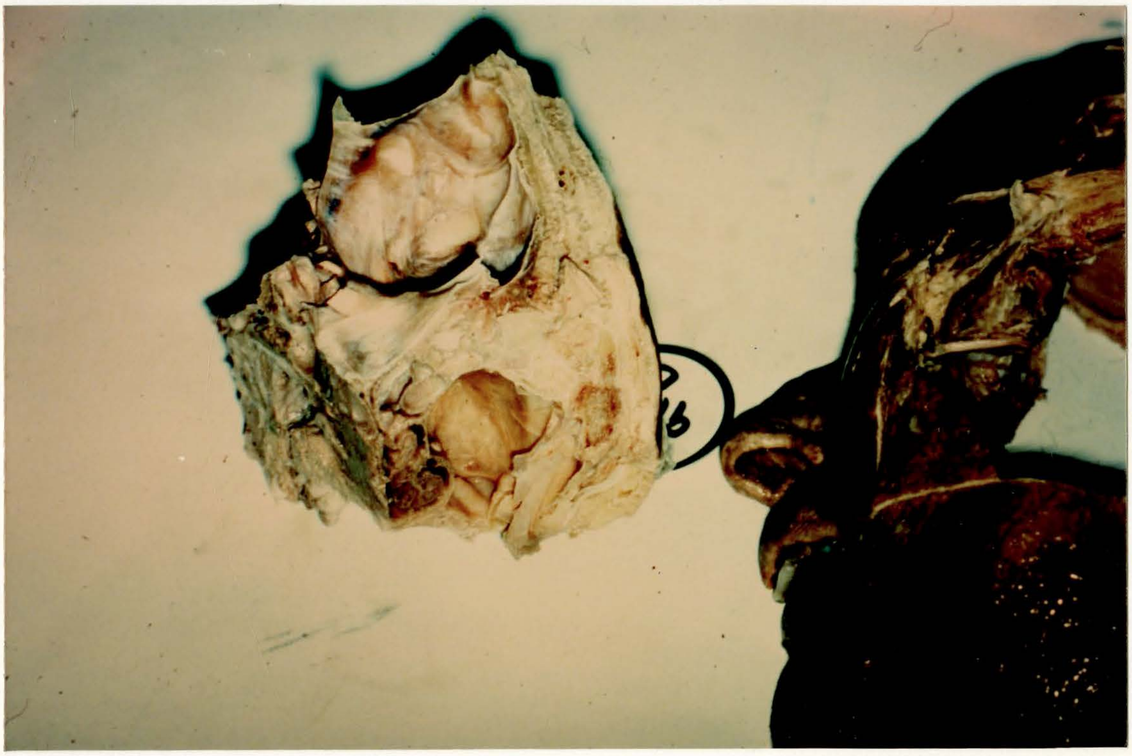


PLATE 6 - THESE GROSS BLOCKS WERE REMOVED WITH THE ENTIRE LATERAL PTERYGOID INTACT FROM ORIGIN TO INSERTION. THE ENTIRE JOINT WAS INTACT WITHIN THE CAPSULE.

PLATES OF MICRODISSECTION RESULTS

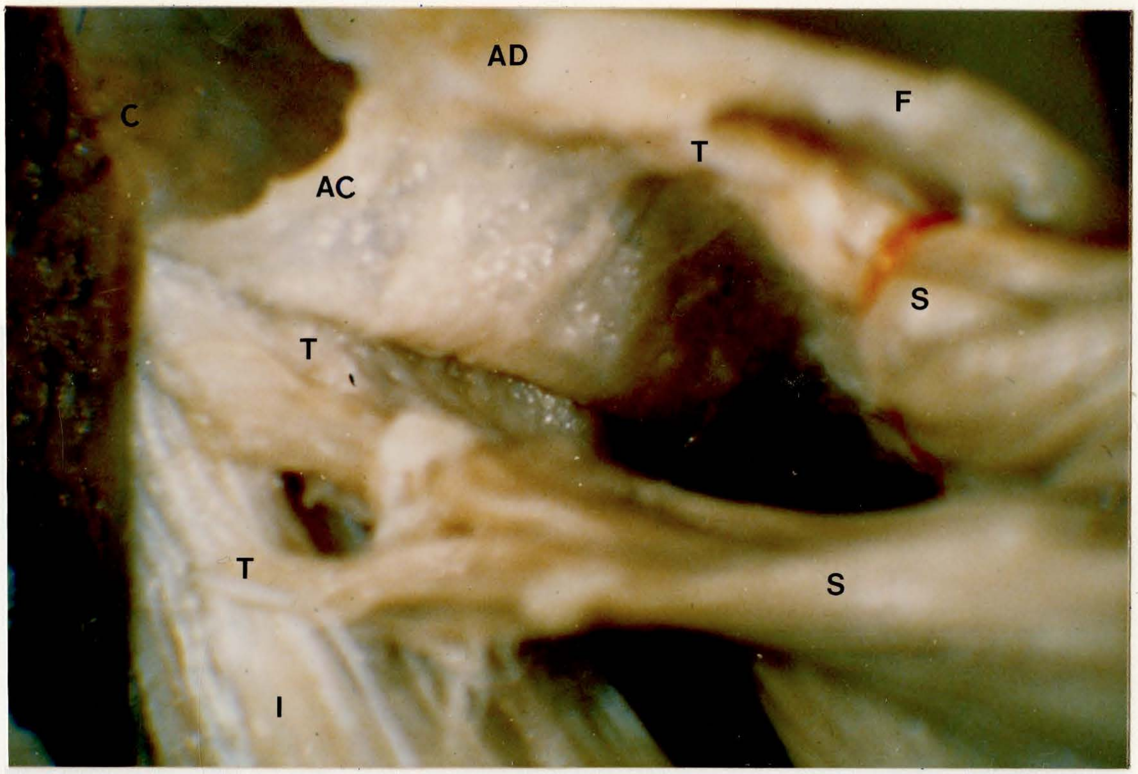


PLATE 7 - ANTERIOR INFERIOR CAPSULE - VIEW IS LATERAL TO MEDIAL - (20X).

TENDONS OF THE SUPERIOR HEAD FORM AN 'ARC' AS THEY CURVE DOWN THE ANTERIOR INFERIOR CAPSULE TO INSERT AT THE SUPERIOR RIM OF THE FOVEA WITH THE JOINT CAPSULE.

KEY FOR PLATES 7-17

C = CONDYLE
D = DISC
AD = ANTERIOR DISCAL BAND (FOOT OF DISC)
S = SUPERIOR HEAD
I = INFERIOR HEAD
AC = ANTERIOR INFERIOR CAPSULE
F = FASCIA
CT = DENSE COLLAGENOUS CONNECTIVE TISSUE
T = TENDONS OF SUPERIOR HEAD

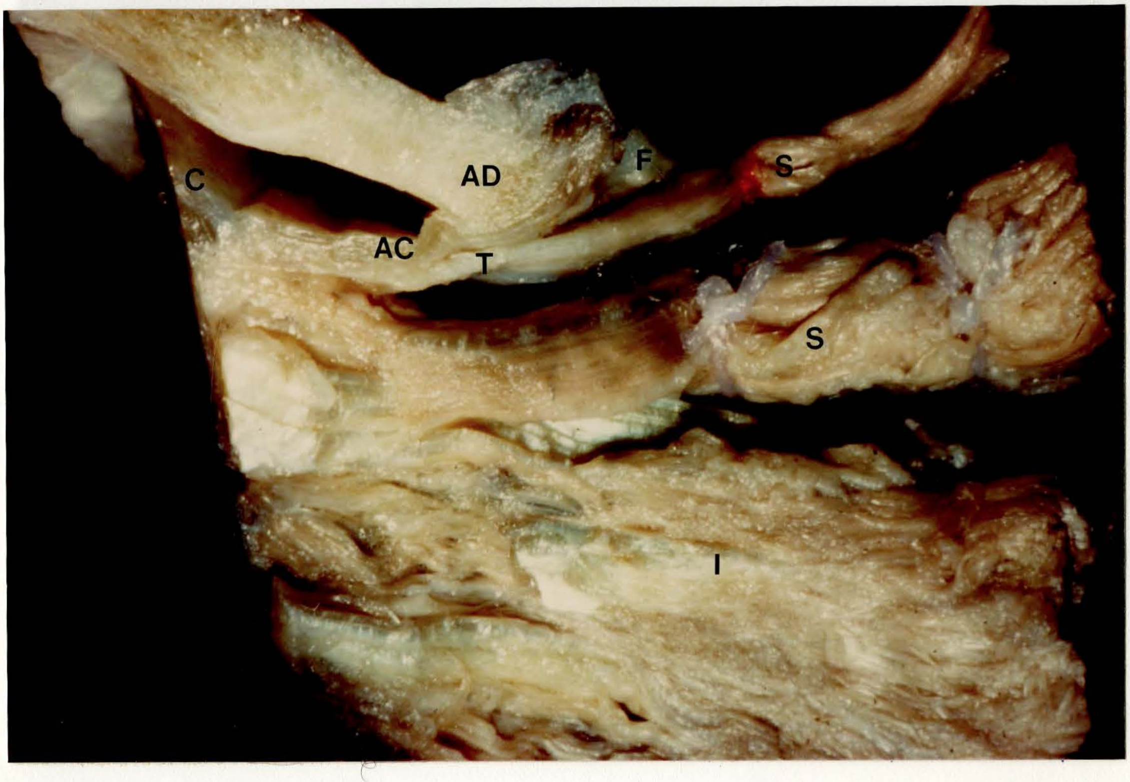


PLATE 8 - SAGITTAL CUT THRU MEDIAL ONE THIRD OF JOINT - DISC ON TOP OF SUPERIOR HEAD - (10X).

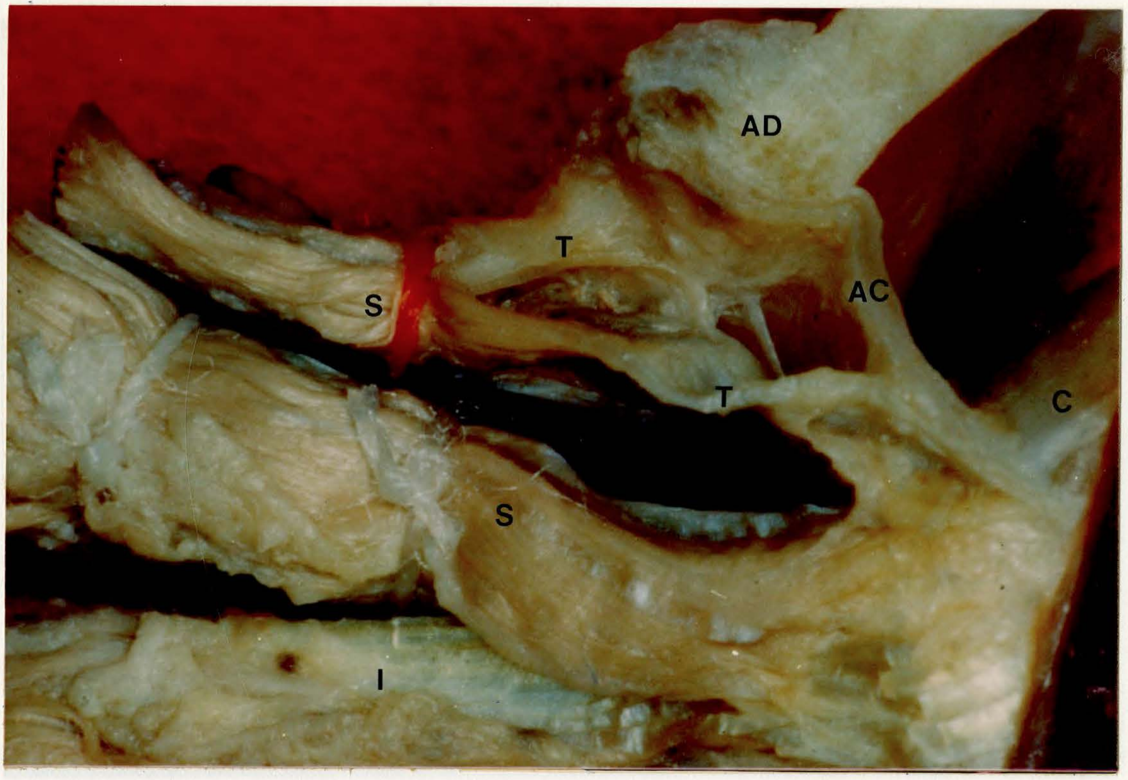


PLATE 9 - SAGITTAL CUT THRU MEDIAL ONE THIRD OF JOINT. DISC LIFTED TO OBSERVE TENDON INTERACTION. - (10X).

EXTENDING ANTERIORLY IN A 'SLIPPER LIKE' CONFIGURATION, THE ANTERIOR DISCAL BAND (AD) IS SUSPENDED IN A 'HAMMOCK LIKE' FASHION UPON THE SUPERIOR ASPECT OF THE SUPERIOR HEAD (S). (PLATES 8 AND 9).

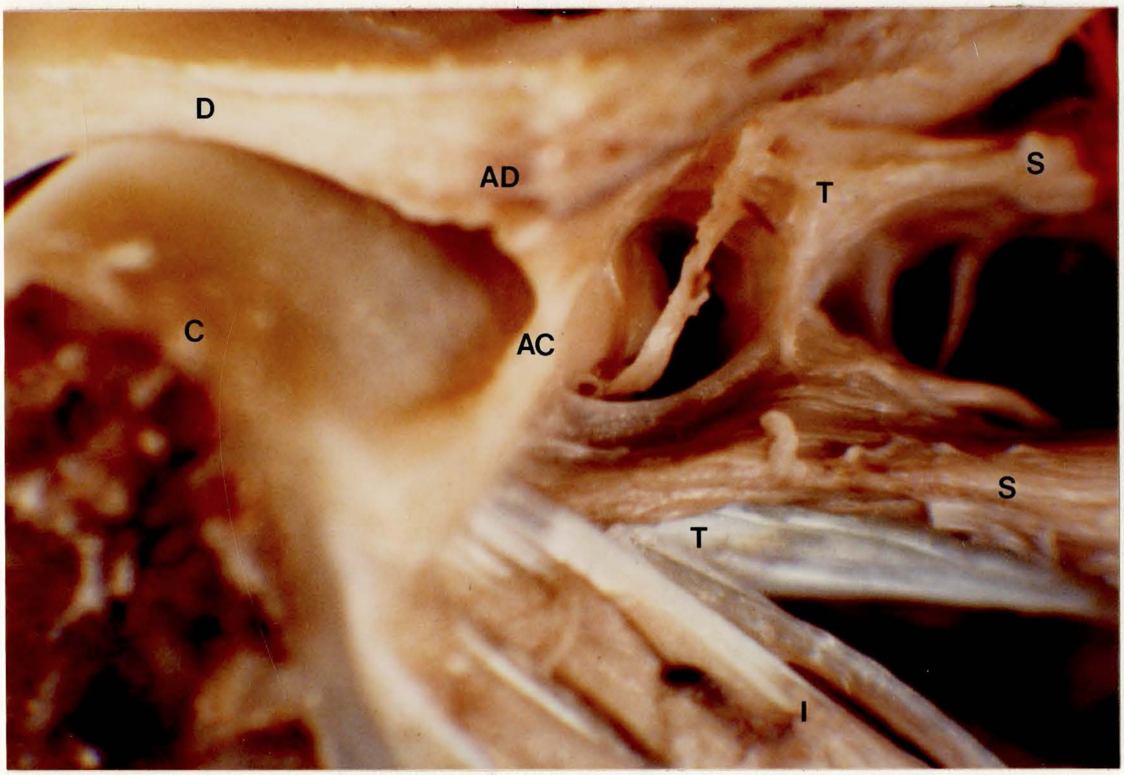


PLATE 10 - LATERAL VIEW OF MEDIAL ONE THIRD - TENDON OF SUPERIOR HEAD 'TEASED' AWAY FROM ANTERIOR INFERIOR CAPSULE. (30X).

RATHER THAN A SEPARATE DISCAL INSERTION, THE TENDON OF THE SUPERIOR HEAD BECOMES INTEGRALLY RELATED WITH THE ANTERIOR INFERIOR DISC-CAPSULE COMPLEX AND THE PTERYGOID FOVEA OF THE MANDIBULAR RAMUS.

PLATE 11 - LATERAL VIEW OF DISC-CAPSULE-CONDYLE COMPLEX. TENDONS OF SUPERIOR HEAD 'THICKEN' THE CAPSULE AT THE MEDIAL ONE THIRD. (20X)

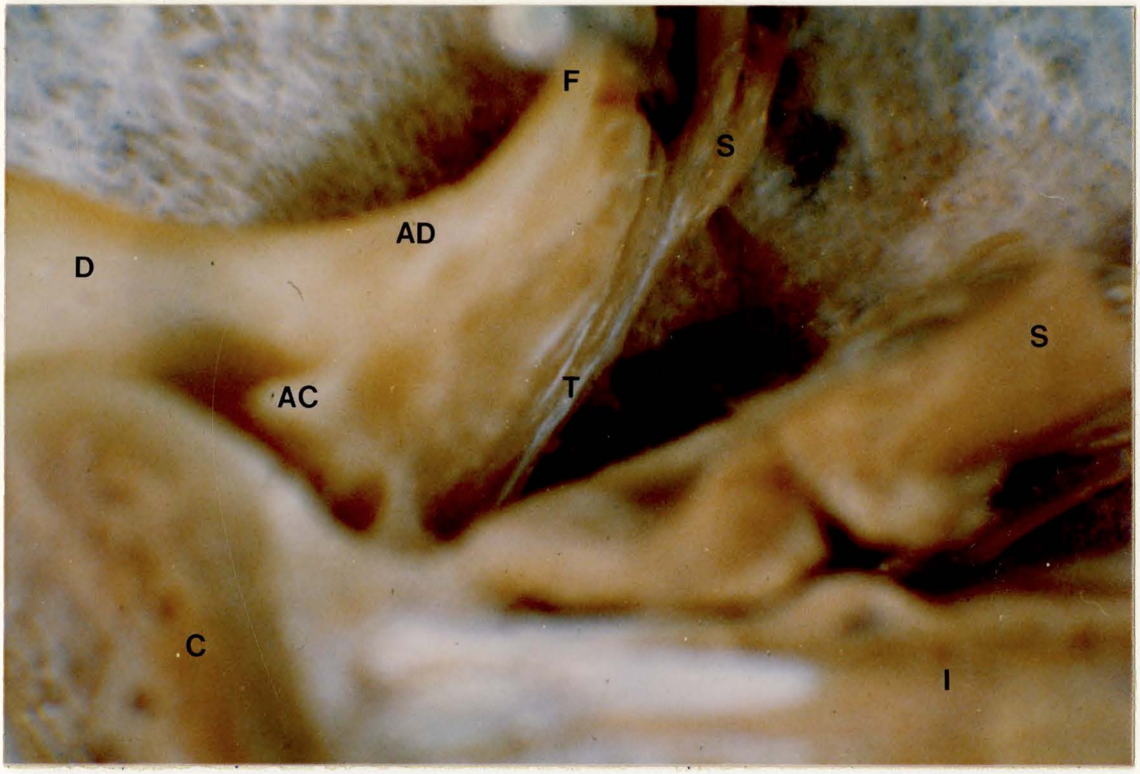


PLATE 12 - ANTERIOR INFERIOR VIEW OF DISC; LATERAL TO MEDIAL. (30X)

MEDIO-SUPERIOR FIBERS OF THE SUPERIOR HEAD, END IN TENDONS WHICH BLEND WITH THE ANTERIOR INFERIOR JOINT CAPSULE IN A WAY WHICH REINFORCES THIS PART OF THE CAPSULE AND THUS HAS AN INDIRECT ATTACHMENT TO THE DISC. (PLATES 11 AND 12)

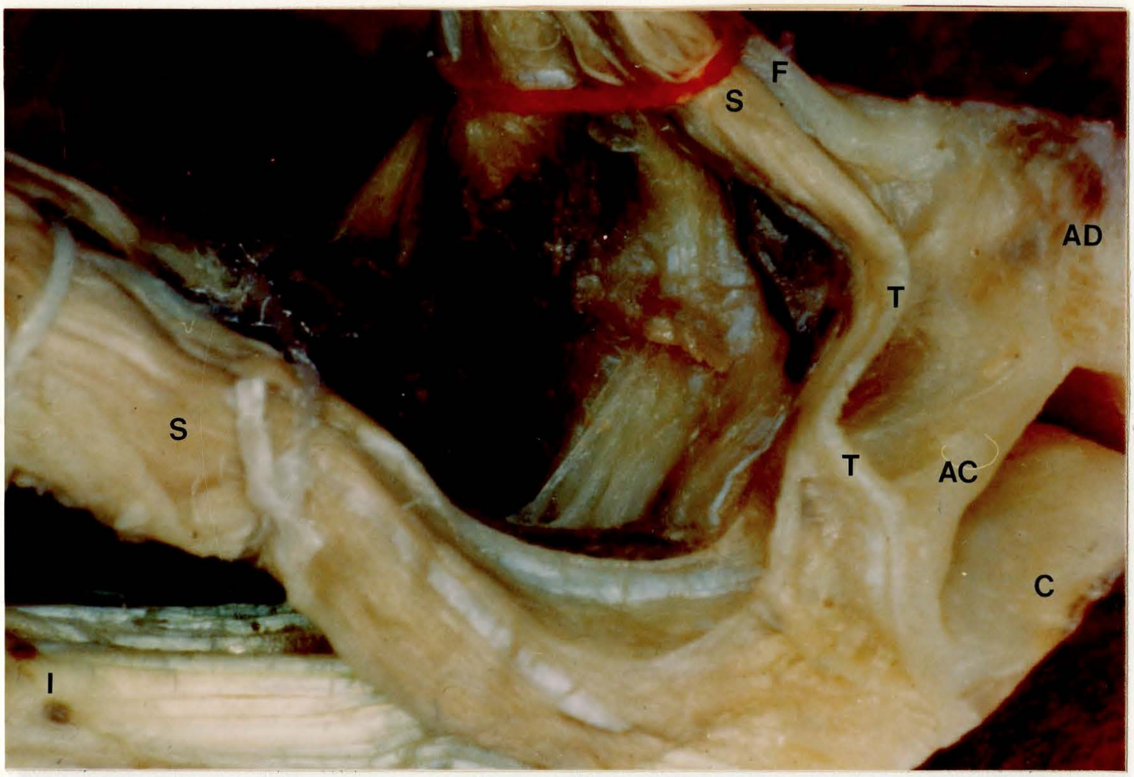


PLATE 13 - SUPERIOR HEAD FIBERS; DISC-CAPSULE GROUP = ORANGE THREAD; PTERYGOID FOVEA GROUP = WHITE THREAD. (10X)

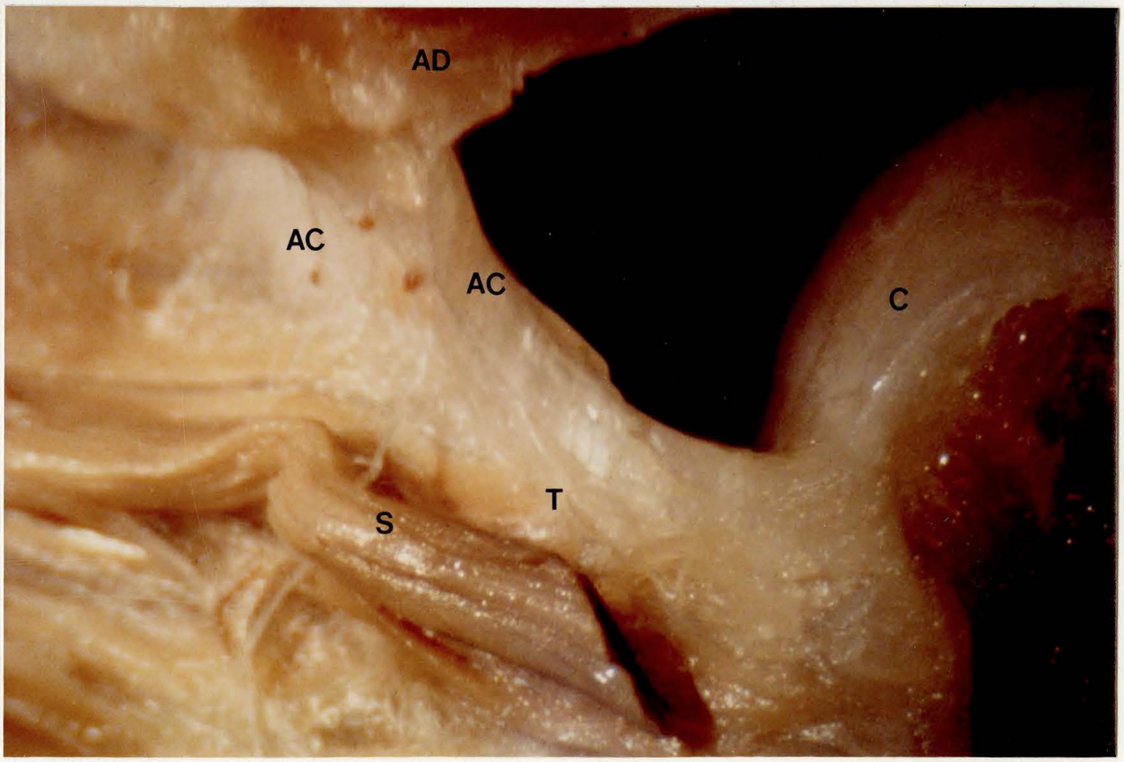


PLATE 14 - DISC LIFTED TO VIEW ANTERIOR INFERIOR CAPSULE. (20X)

MEDIO-SUPERIOR FIBERS OF THE SUPERIOR HEAD, END IN TENDONS WHICH BLEND WITH THE MEDIO-ANTERIOR INFERIOR ASPECT OF THE CAPSULE, IN SUCH A WAY AS TO REINFORCE THIS PART OF THE CAPSULE, AND THUS HAVE AN INDIRECT ATTACHMENT TO THE DISC. (PLATES 13 AND 14)

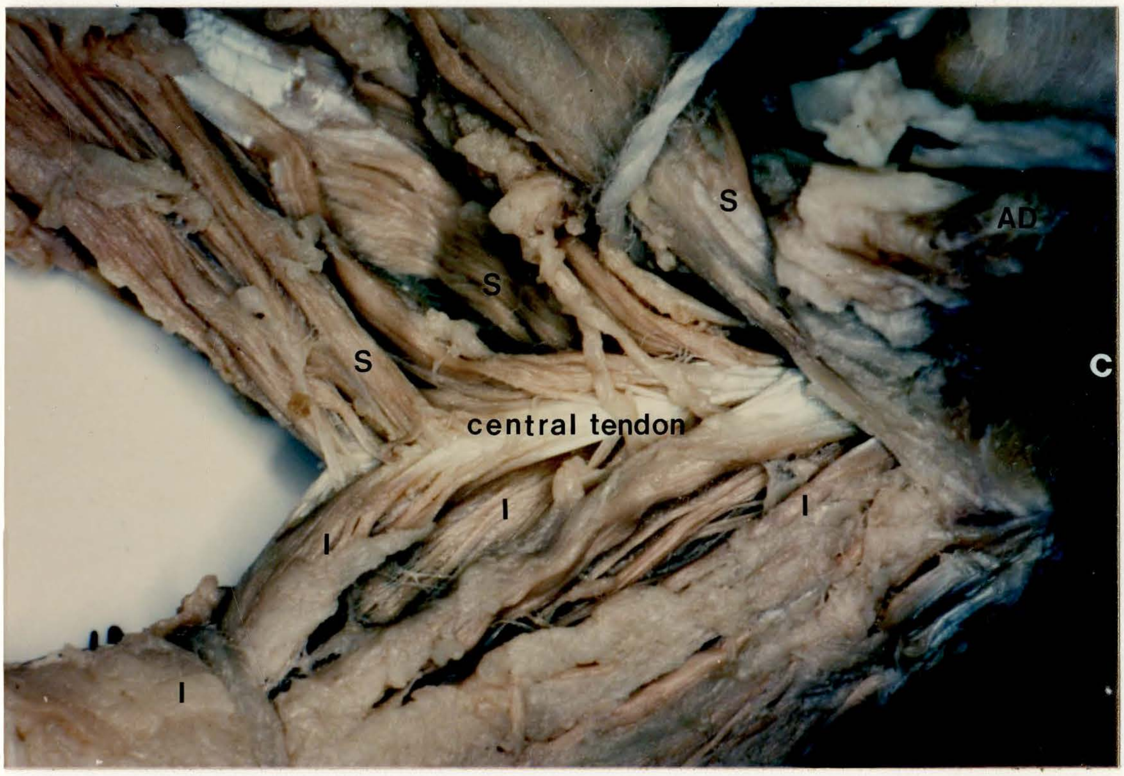


PLATE 15 - CENTRAL TENDON OF INFERIOR HEAD. (10X)

ABOUT TWO-THIRDS THE DISTANCE DISTAL TO ITS ORIGIN, SOME FIBER BUNDLES OF THE SUPERIOR HEAD INSERT ONTO A CENTRAL TENDON WHICH LIES ON TOP OF THE CENTRAL SUPERIOR FIBERS OF THE INFERIOR HEAD.

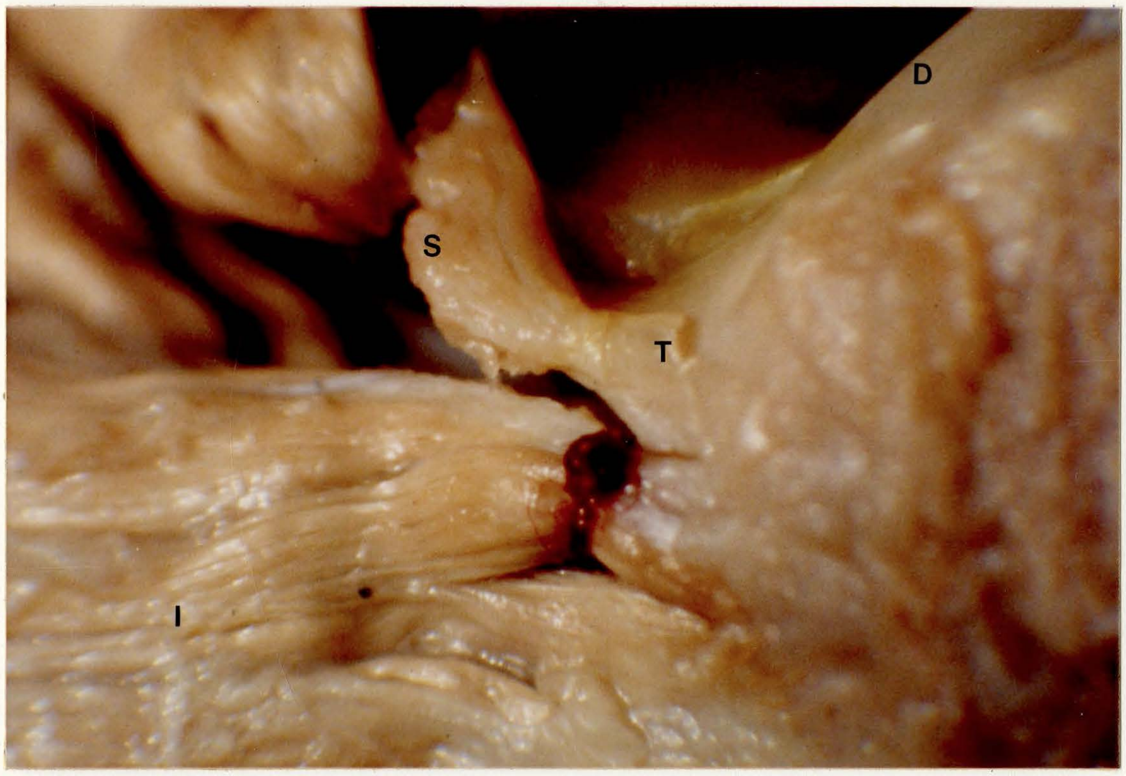


PLATE 16 - MEDIAL POLE OF DISC-CAPSULE-CONDYLE COMPLEX. (10X)

AT THE MEDIAL POLE OF THE DISC-CONDYLE COMPLEX, THE TENDONS OF THE SUPERIOR HEAD BLEND WITH THIS PORTION OF THE CAPSULE WHICH OVERLIES THE MEDIAL COLLATERAL LIGAMENT.

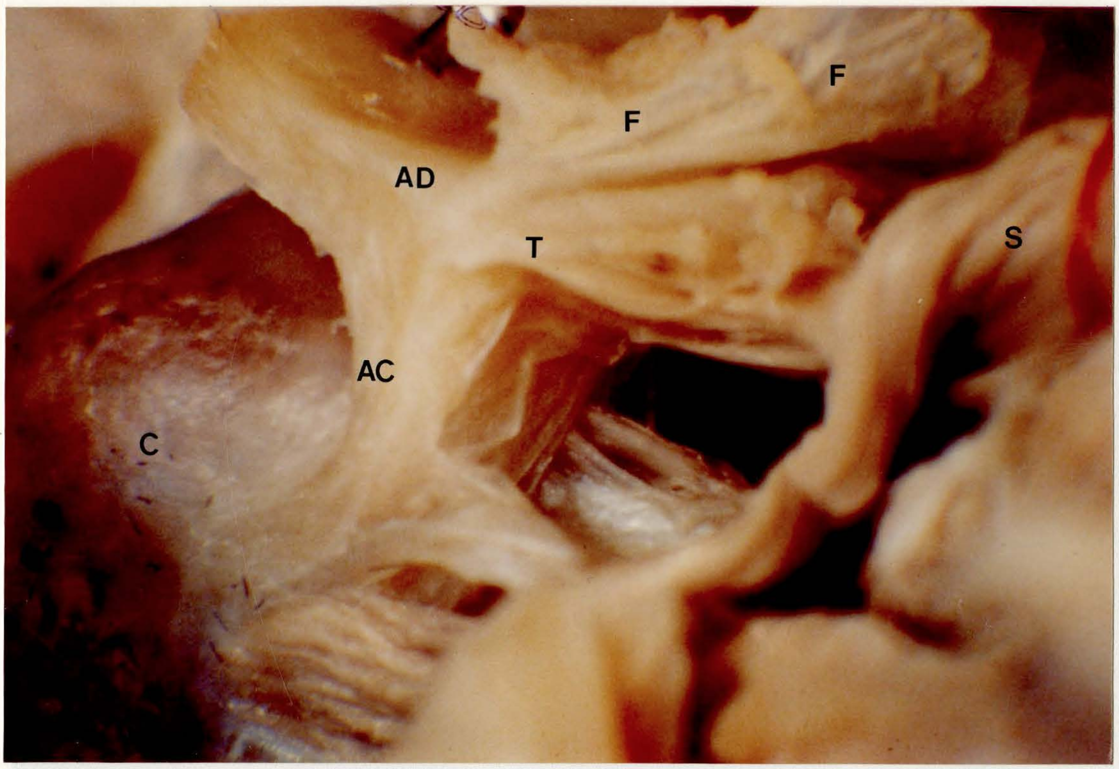


PLATE 17 - FASCIA WHICH OVERLIES THE SUPERIOR HEAD BLENDS WITH THE ANTERIOR SUPERIOR ASPECT OF THE DISC. (20X)

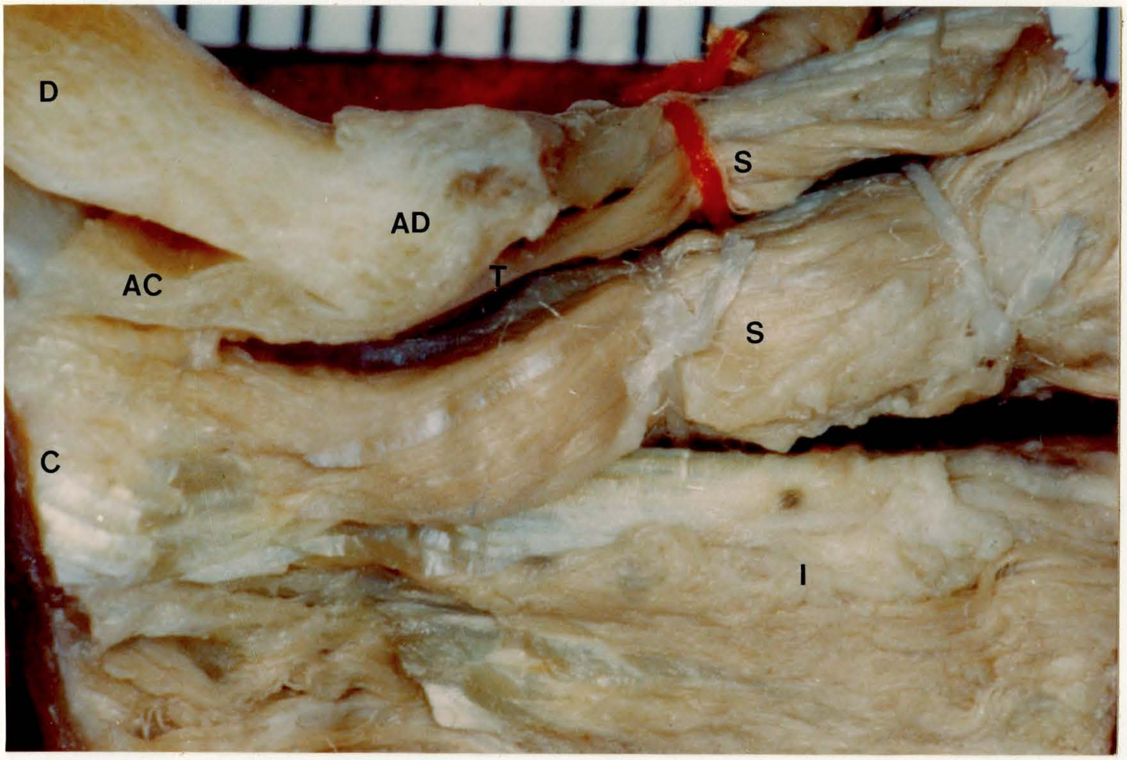


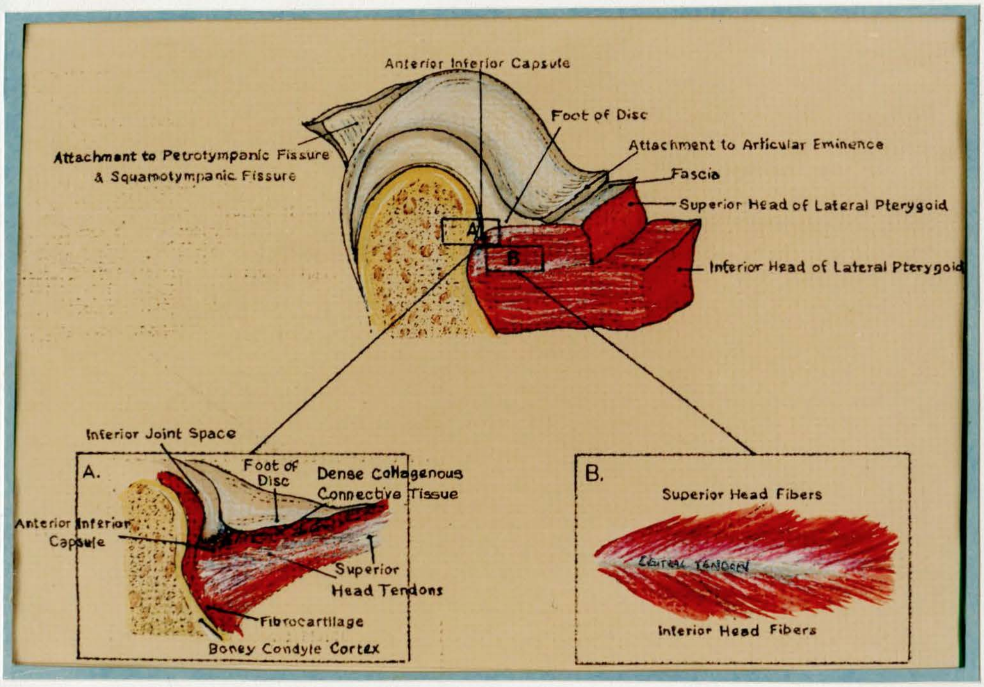
PLATE 18 - AS THE INSERTION OF SUPERIOR HEAD FIBERS BECAME APPARENT, COLOR CODED THREAD WAS USED TO IDENTIFY AND BUNDLE THE MUSCLE FIBERS INTO GROUPS OF DISC-CAPSULE AND CONDYLAR FOVEA INSERTION. (10X)

DIAGRAMS OF FINE DISSECTION

PLATE 19

DIAGRAM 1

SAGITTAL SECTION THROUGH MIDDLE OF
CONDYLE-DISC-CAPSULE COMPLEX



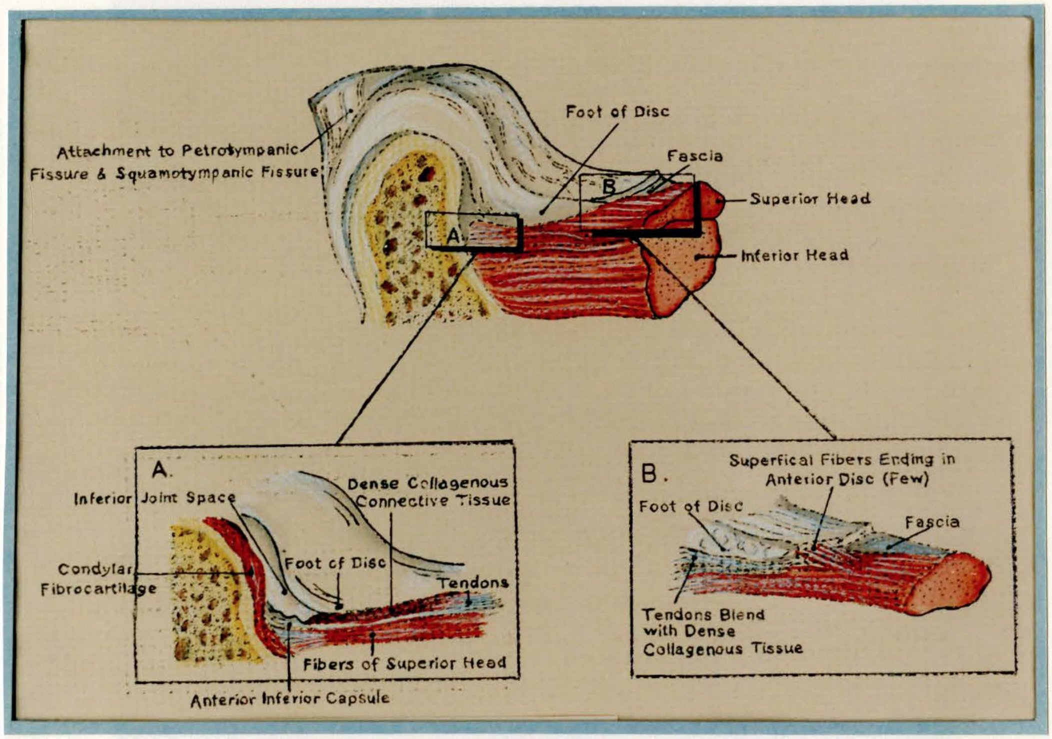
DETAIL (INSERT A) = DIAGRAM OF SUPERIOR HEAD TENDONS INSERTING INTO PTERYGOID FOVEA WITH DENSE COLLAGENOUS CONNECTIVE TISSUE ATTACHMENT TO INFERIOR OF FOOT OF DISC.

DETAIL (INSERT B) = INTERACTION OF SUPERIOR HEAD FIBERS INSERTING ON A "CENTRAL TENDON" ON TOP OF THE INFERIOR HEAD OF THE LATERAL PTERYGOID MUSCLE.

PLATE 20

DIAGRAM 2

SAGITTAL SECTION THROUGH MEDIAL ONE-THIRD OF CONDYLE-DISC-CAPSULE COMPLEX



DETAIL (INSERT A) = INTERACTION OF SUPERIOR HEAD OF LATERAL PTERYGOID MUSCLE WITH ANTERIOR-INFERIOR DISC-CAPSULE COMPLEX.

DETAIL (INSERT B) = DIAGRAMATIC EXPRESSION OF INTERACTION OF SUPERIOR HEAD WITH "FOOT" OF THE DISC. ONLY A SMALL AMOUNT OF MUSCLE FIBERS BLEND WITH THE ANTERIOR-INFERIOR DISC. MOST SUPERFICIAL FIBERS END IN SMALL TENDONS WHICH BLEND WITH DENSE COLLAGENOUS CONNECTIVE TISSUE WHICH IS CONNECTED WITH THE INFERIOR SURFACE OF THE FOOT OF THE DISC AND ANTERIOR INFERIOR CAPSULE.

DIAGRAM 3

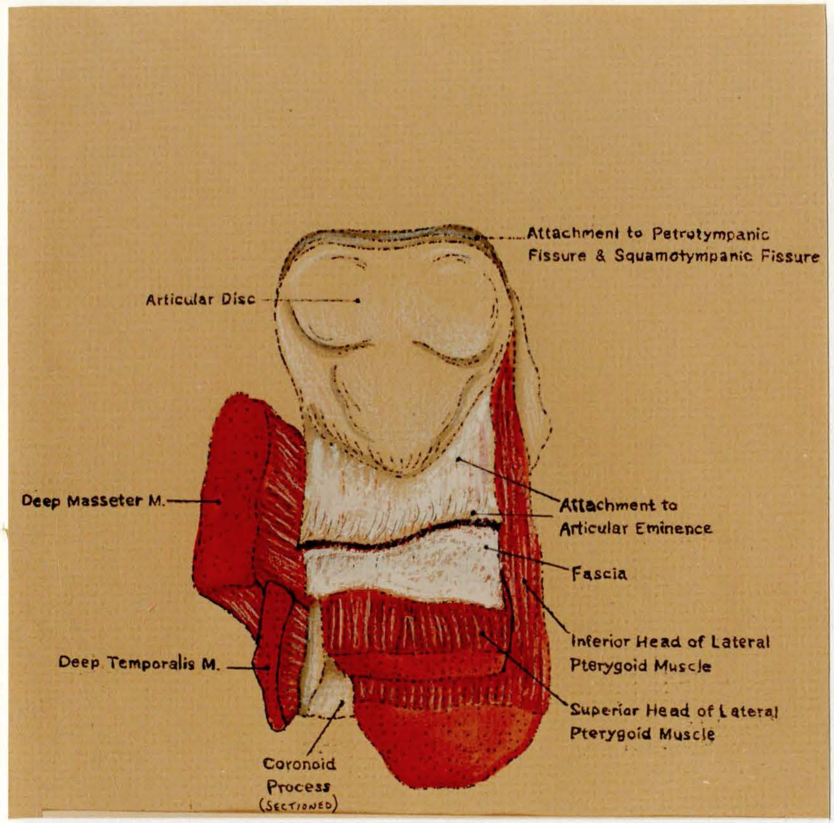


PLATE 21 - ANTERIOR CRANIAL VIEW OF DISC-CONDYLE COMPLEX WITH MUSCLE AND ASSOCIATED FASCIA.

DIAGRAM 4

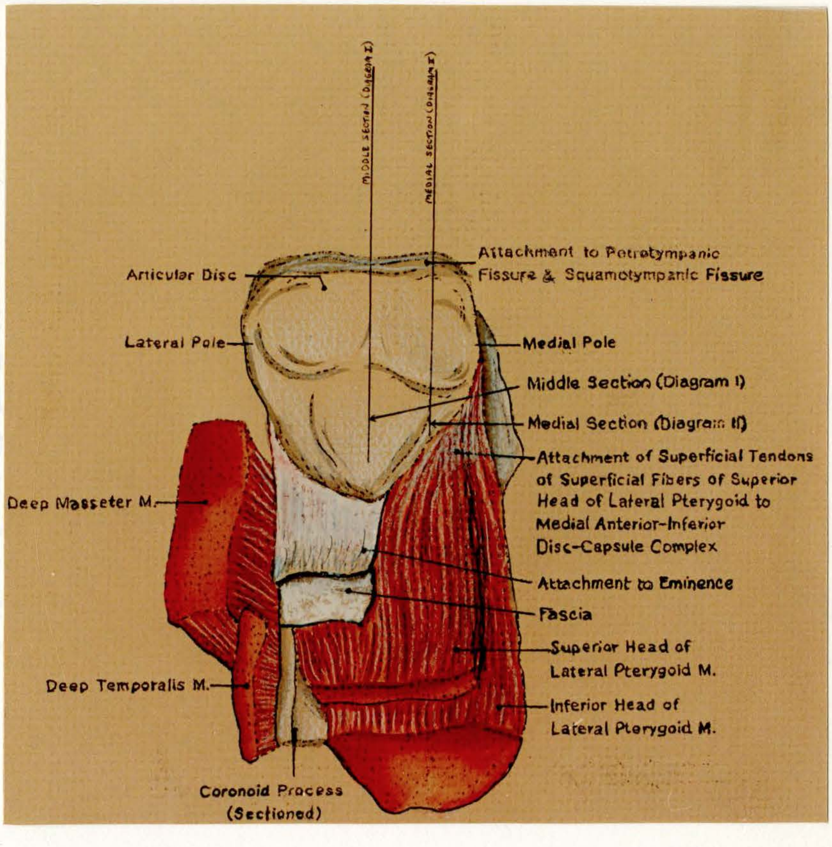


PLATE 22 - ANTERIOR CRANIAL VIEW OF DISC-CONDYLE COMPLEX WITH MUSCLES AND FASCIA. FASCIA HAS BEEN STRIPPED AWAY ON THE MEDIAL SUPERIOR ASPECT.

PLATE 23 - KEY FOR PLATES 24-29

C	=	CONDYLE
D	=	DISC
AD	=	ANTERIOR DISCAL BAND (FOOT OF DISC)
S	=	SUPERIOR HEAD
I	=	INFERIOR HEAD
AC	=	ANTERIOR INFERIOR CAPSULE
F	=	FASCIA
CT	=	DENSE COLLAGENOUS CONNECTIVE TISSUE
T	=	TENDONS OF SUPERIOR HEAD

PLATES OF HISTOLOGIC RESULTS

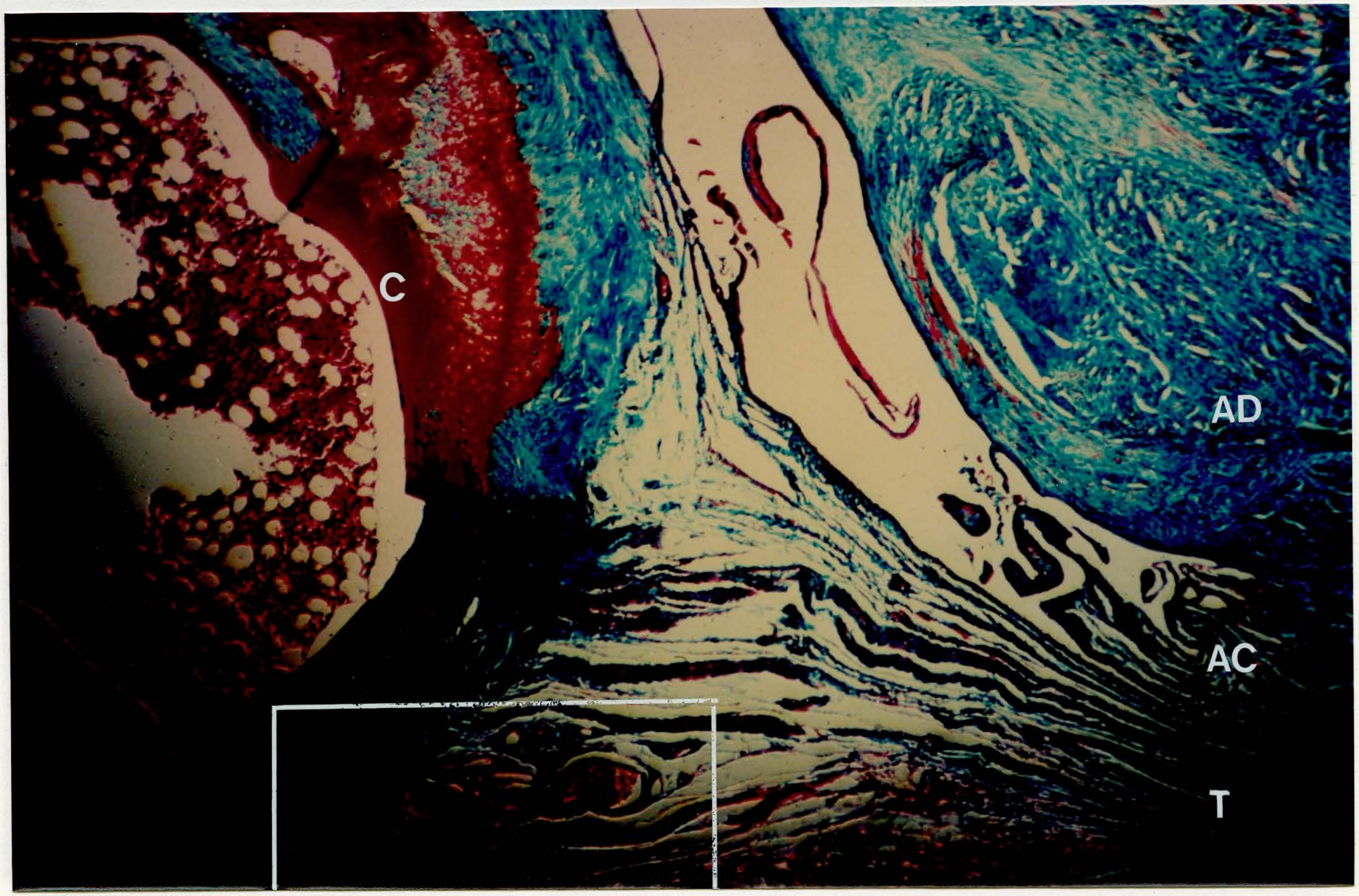


PLATE 24 - ANTERIOR INFERIOR CAPSULE AS IT ATTACHES TO BONE. (40X) MILLIGANS TRICHROME

THE CAPSULE-CONDYLE INTERFACE IS ONE OF A DENSE UNORGANIZED CONFLUENCE OF COLLAGENOUS FIBERS WHICH BECOME MORE COMPACTED AS THESE FIBERS BLEND WITH PERIOSTEUM OF THE FOVEA.

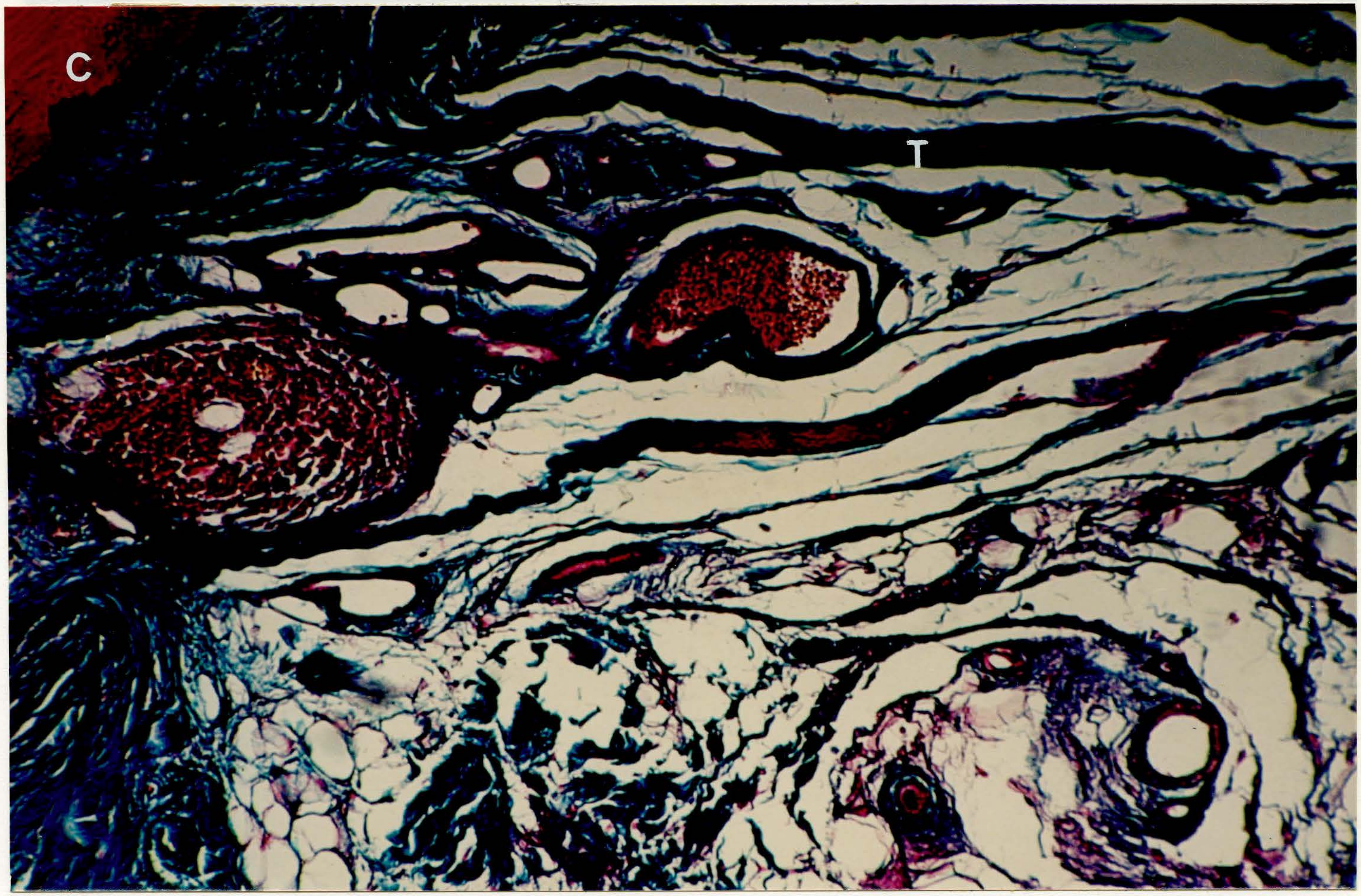


PLATE 25 - ANTERIOR INFERIOR CAPSULE BONE JUNCTION. SEE BLOOD VESSELS. (100X)

(ENLARGEMENT OF AREA OUTLINED ON PLATE #24) MILLIGANS TRICHROME

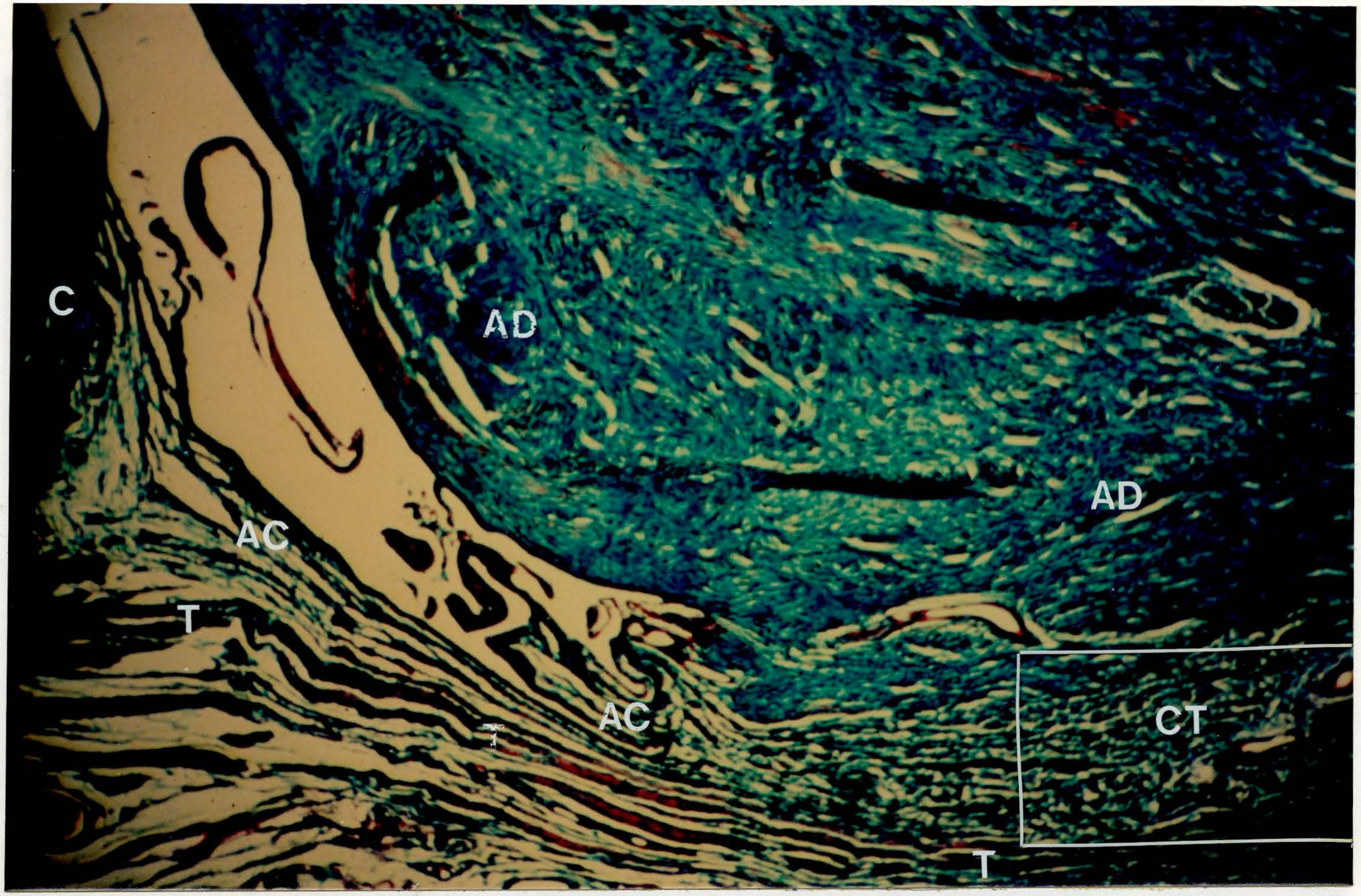


PLATE 26 - FOOT OF DISC. SOME FIBERS ATTACH TO CONDYLE WHILE OTHERS ATTACH TO ANTERIOR INFERIOR CAPSULE. (45X) MILLIGANS TRICHROME

HISTOLOGICALLY, THE ANTERIOR INFERIOR JOINT CAPSULE IS CLOSELY BOUND TO THE ANTERIOR INFERIOR PORTION OF THE DISC BY DENSE COLLAGENOUS CONNECTIVE TISSUE.

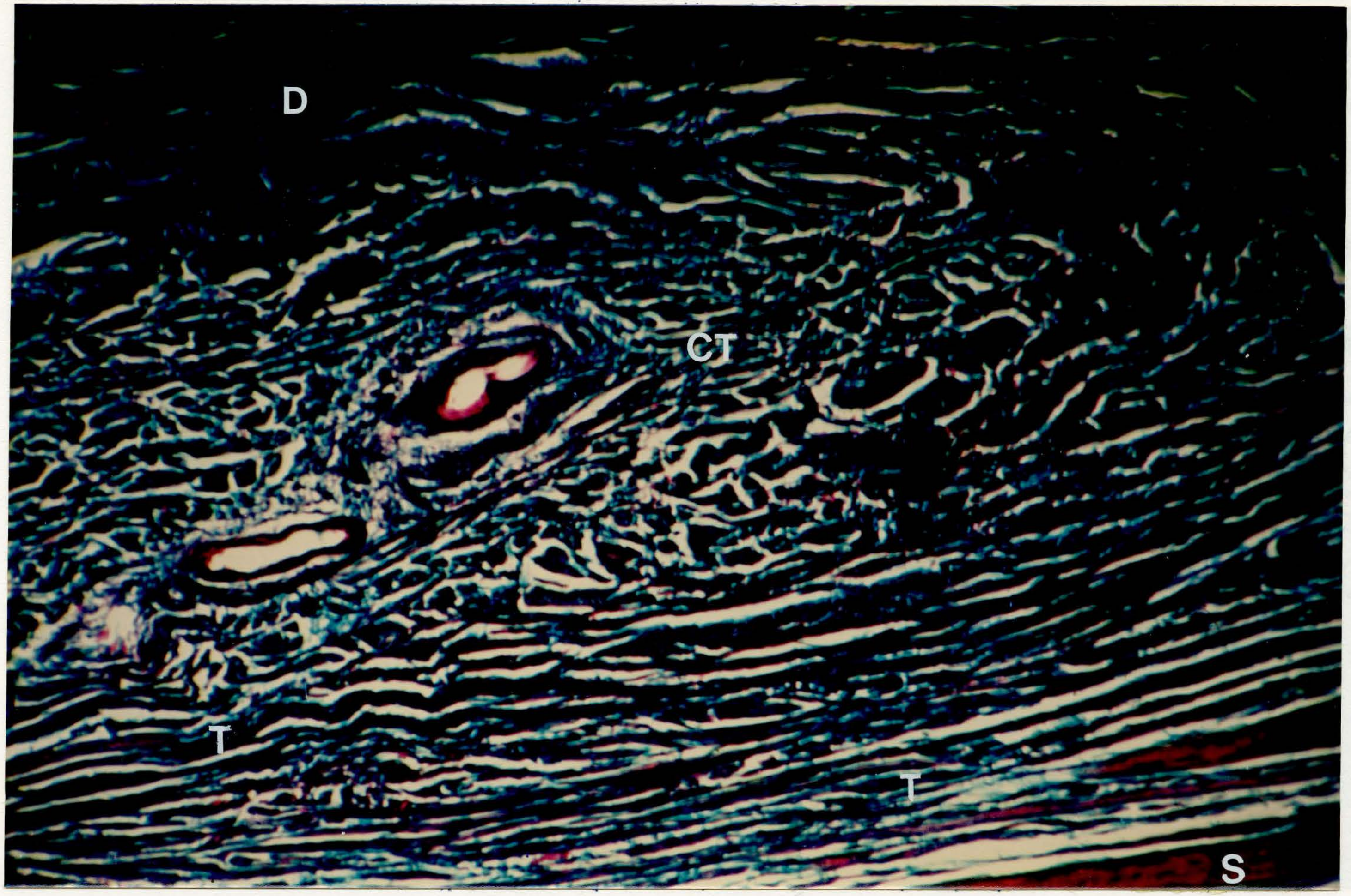


PLATE 27 - FOOT OF DISC WITH TENDONS OF SUPERIOR HEAD ALONG THE BASE. (100X) (ENLARGEMENT OF AREA MARKED 'CT' ON PLATE 26). MILLIGANS TRICHROME.

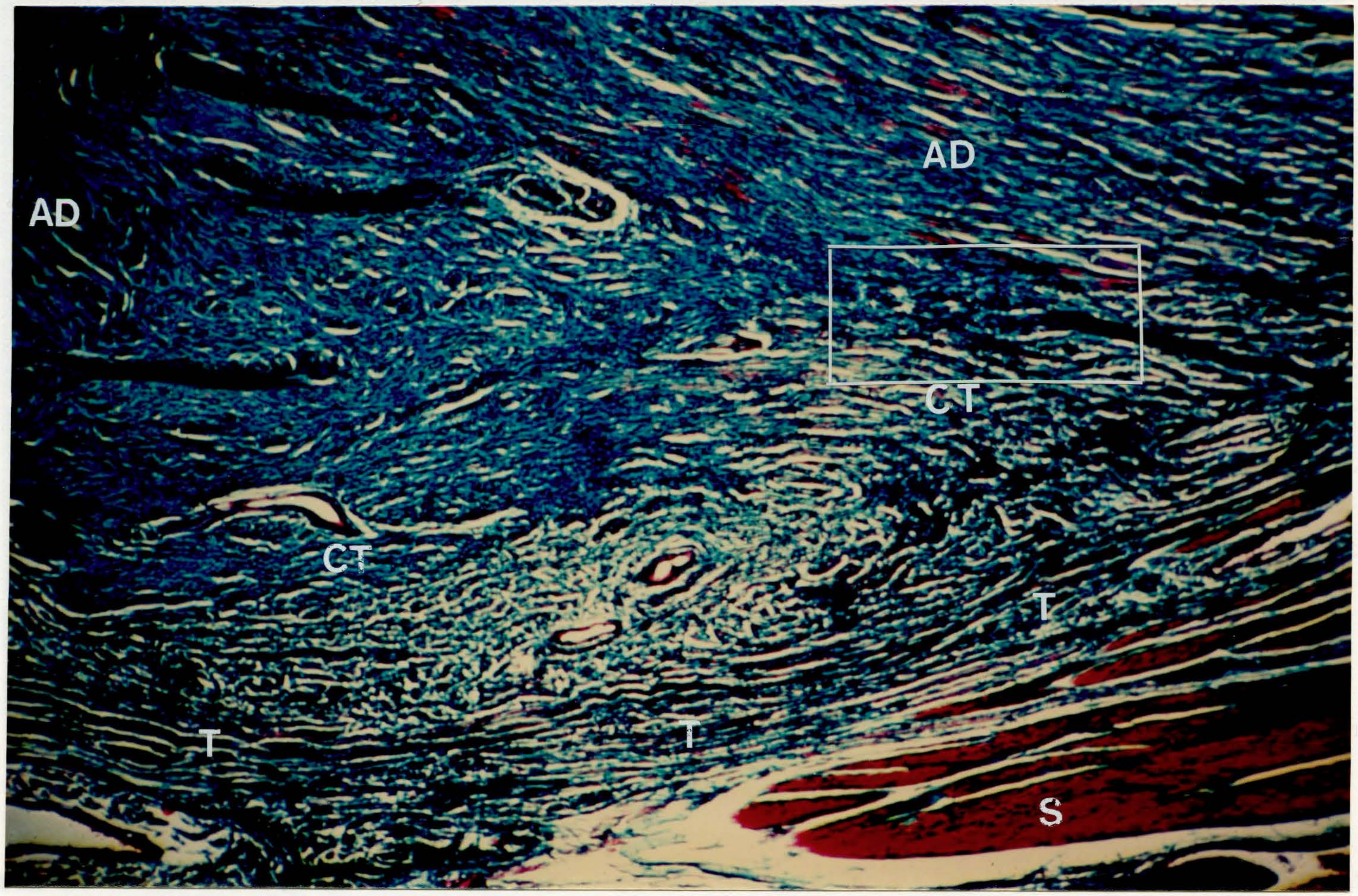


PLATE 28 - FOOT AREA OF THE DISC (ANTERIOR BAND) WITH TENDONS COURSING ALONG THE BASE OF THE FOOT OF THE DISC. (40X) (AREA OUTLINED IS DEPICTED IN PLATE 29).

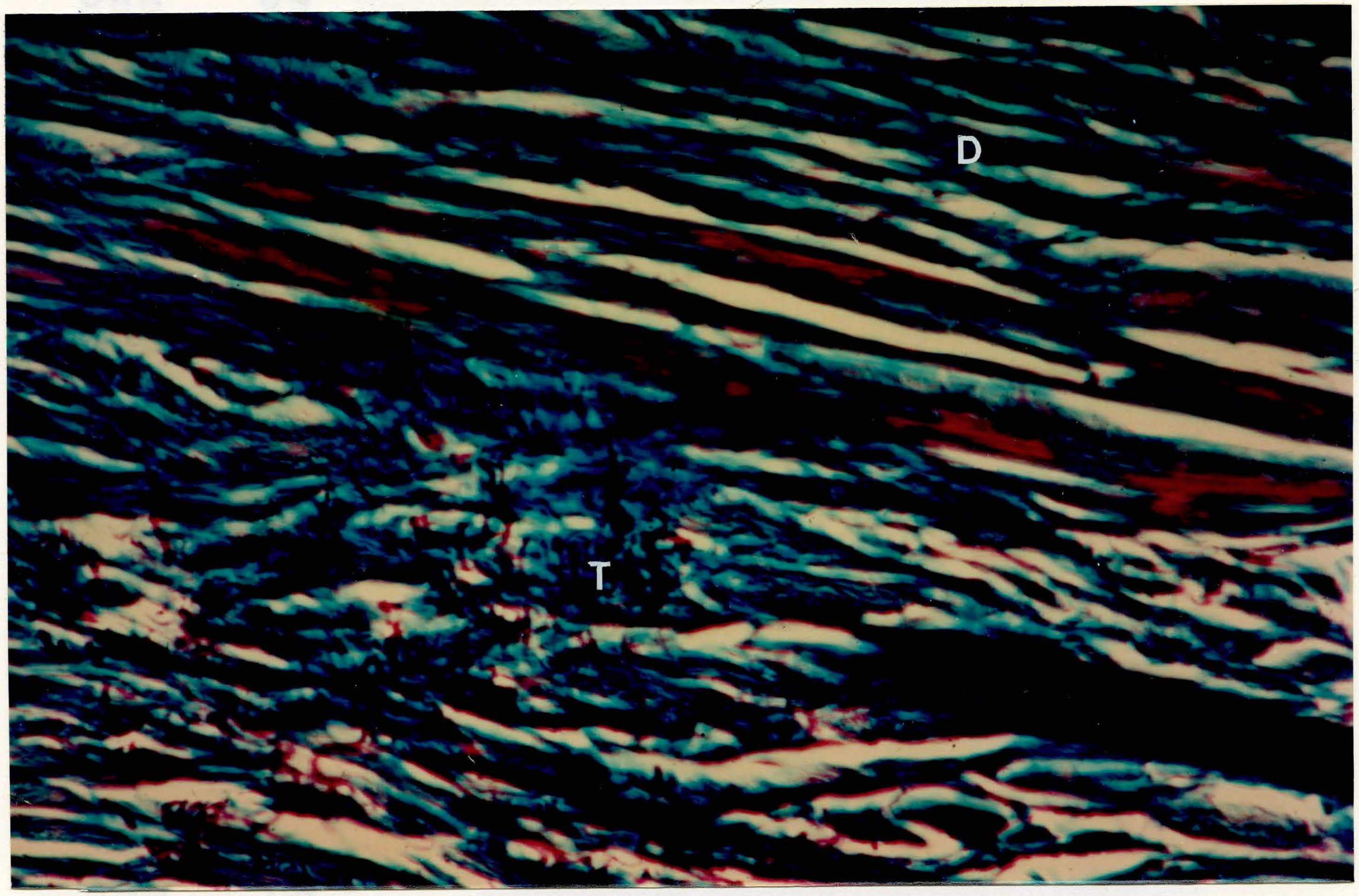


PLATE 29 - INTERFACE OF DISC/TENDON. DISC IS DENSE REGULAR COLLAGEN. TENDON IS WAVY WITH RED THREADS OF FIBERS. (200X) THE TENDONS OF THE SUPERIOR HEAD THAT BLEND WITH THE ANTERIOR INFERIOR PORTION OF THE DISC AND ANTERIOR INFERIOR CAPSULE SHOWN AN INTERFACE OR ORGANIZED DENSE COLLAGEN OF THE DISC WITH A WAVY UNORGANIZED DENSE COLLAGEN OF THE TENDON.

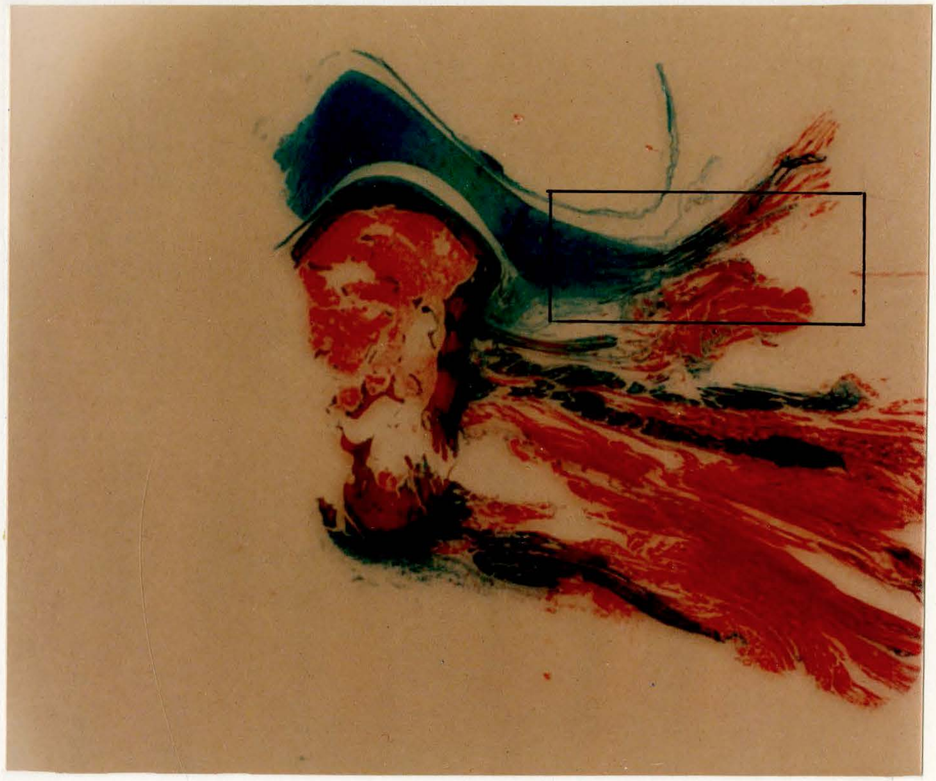


PLATE 30 - SAGITTAL CUT THRU THE MEDIAL ONE-THIRD OF THE CONDYLE-DISC-CAPSULE COMPLEX. MILLIGANS TRICHROME. (40X)

IN 15% (8 OUT OF 52) JOINTS THERE WAS A DIRECT MUSCLE INSERTION INTO THE DISC. THIS WAS ALWAYS MEDIOSUPERIOR, AND OF THE MOST SUPERFICIAL FIBERS OF THE SUPERIOR HEAD.

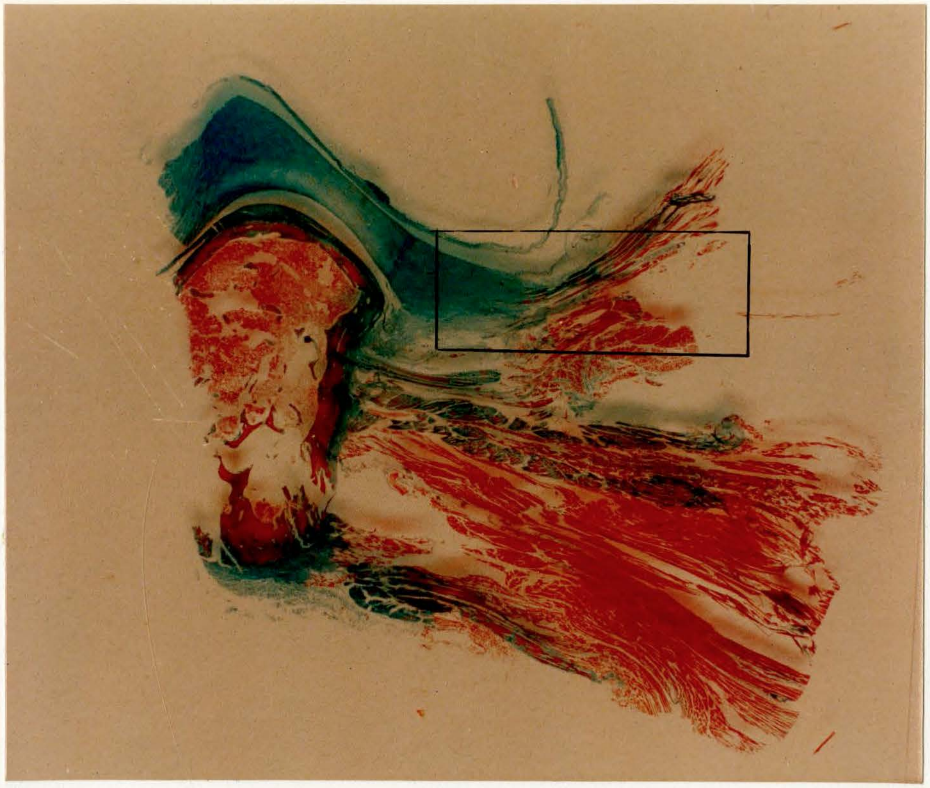


PLATE 31 - SAGITTAL SECTION THRU MEDIAL ONE-THIRD OF CONDYLE-DISC-CAPSULE COMPLEX. MILLIGANS TRICHROME. (40X)

WHERE THE MUSCLE FIBERS OF THE SUPERIOR HEAD INSERT INTO THE DISC, THERE WAS A CONTINUATION OF THE PERIMYSIUM WHICH CONTINUED ON INTO THE DENSE COLLAGEN OF THE DISC.

PLATES OF MORPHOMETRIC ANALYSIS TECHNIQUE

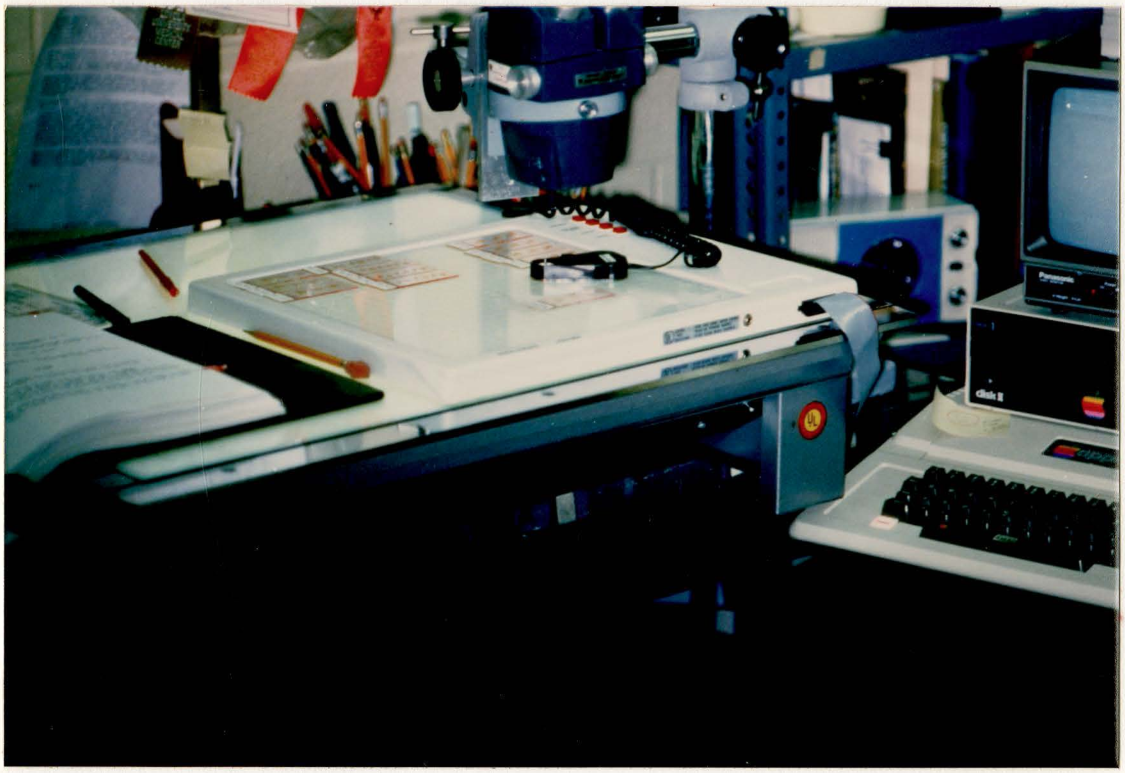


PLATE 32 - DIGITIZER WITH BIOQUANT SYSTEM FOR APPLE COMPUTER.

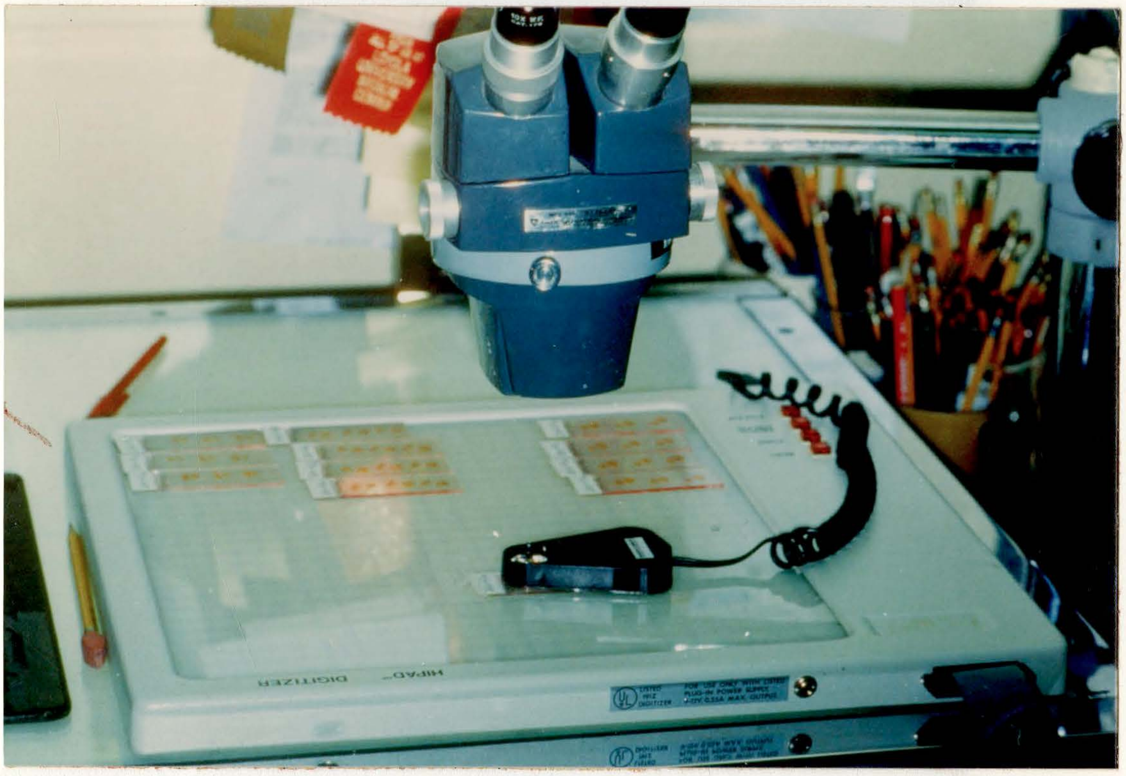


PLATE 33 - DIGITIZING MORPHOMETRY WAS ACCOMPLISHED UNDER MAGNIFICATION ON FOUR RANDOM SECTIONS FROM EACH OF THE TWELVE SECTIONS TO OBTAIN THE AVERAGE MUSCLE CROSS SECTIONAL AREA FOR EACH OF FIFTY SPECIMENS.

PLATE 34 - DIGITIZER HANDPIECE AGAINST THE HIPAD DIGITIZER BOARD WITH SLIDE OF TISSUE SECTION SECURED TO DIGITIZER BOARD.

PLATE 35 - HANDPIECE CROSS-HAIRS UNDER MAGNIFICATION OUTLINING THE AREA OF SUPERIOR HEAD MUSCLE TISSUE WHICH INTERACTED WITH THE DISC-CAPSULE.

USING DIGITIZING MORPHOMETRY UNDER MAGNIFICATION ON FOUR RANDOM SETS OF THE 12 CUT FOR EACH OF THE 50 SPECIMENS, THE AVERAGE MUSCLE CROSS-SECTIONAL AREA WAS OBTAINED FOR THE DISC-CAPSULE MUSCLE GROUP AND THE PTERYGOID FOVEA MUSCLE GROUP.

PLATE 36 - MUSCLE FIBER (CROSS SECTION) AS IT APPEARED UNDER THE CALIBRATED STAGE. (40X)

USING A CALIBRATED MICROSCOPE STAGE AND GRID, THE MUSCLE CELLS WERE COUNTED ON EACH OF THE FOUR RANDOM SECTIONS PER SPECIMEN. THE AVERAGE NUMBER OF MUSCLE FIBERS PER SQUARE MILLIMETER OF MUSCLE WAS OBTAINED ON ALL FIFTY SPECIMENS FOR THE DISC-CAPSULE MUSCLE GROUP AND PTERYGOID FOVEA MUSCLE GROUP.

PLATES OF FIBER COUNT RESULTS

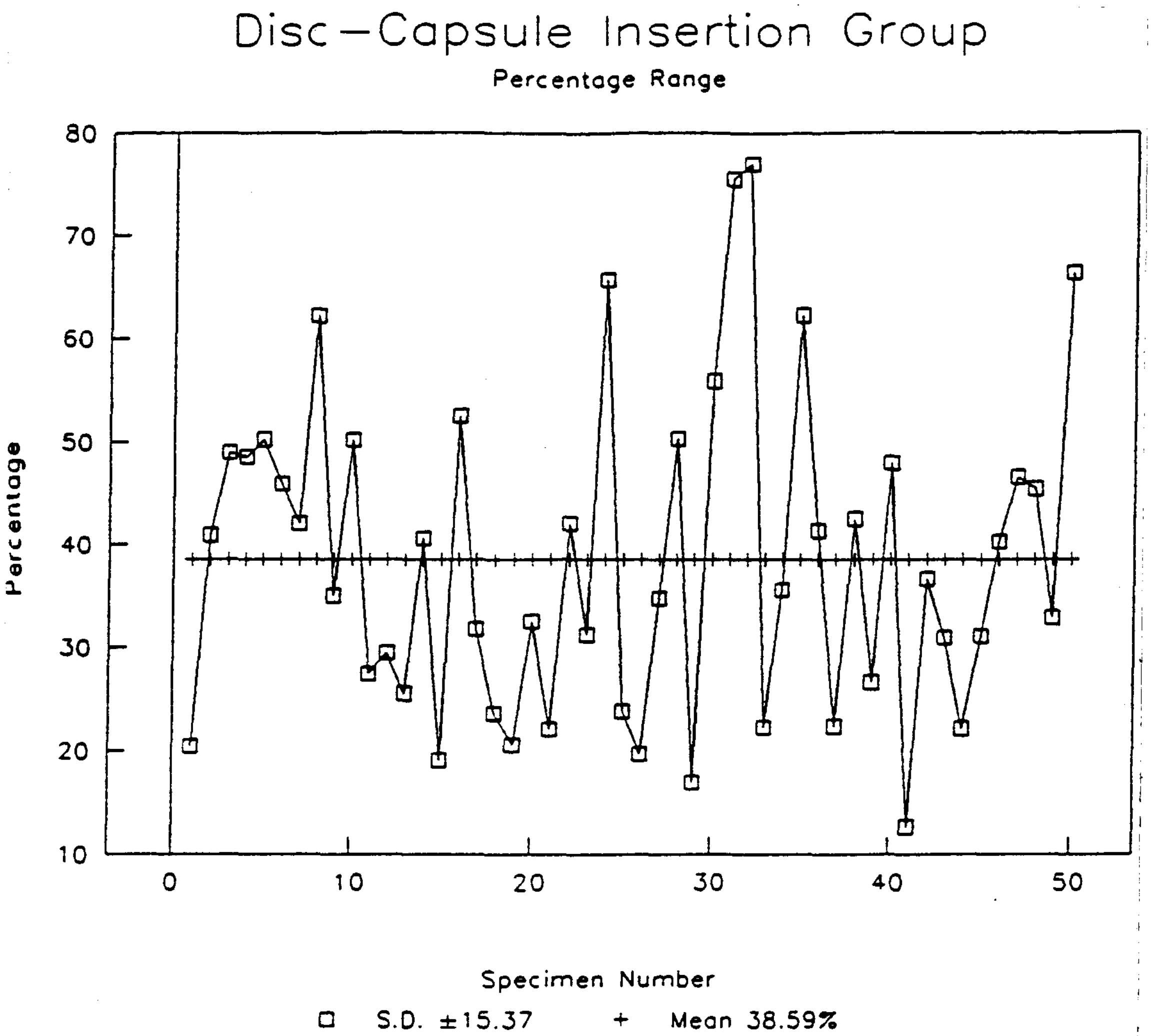


PLATE 37 - THE QUANTITY OF SUPERIOR HEAD INSERTION ON THE DISC-CAPSULE COMPLEX RANGED FROM 12.63% TO 77.08% WITH 38.59% AS A MEAN. (S.D. =±15.37)

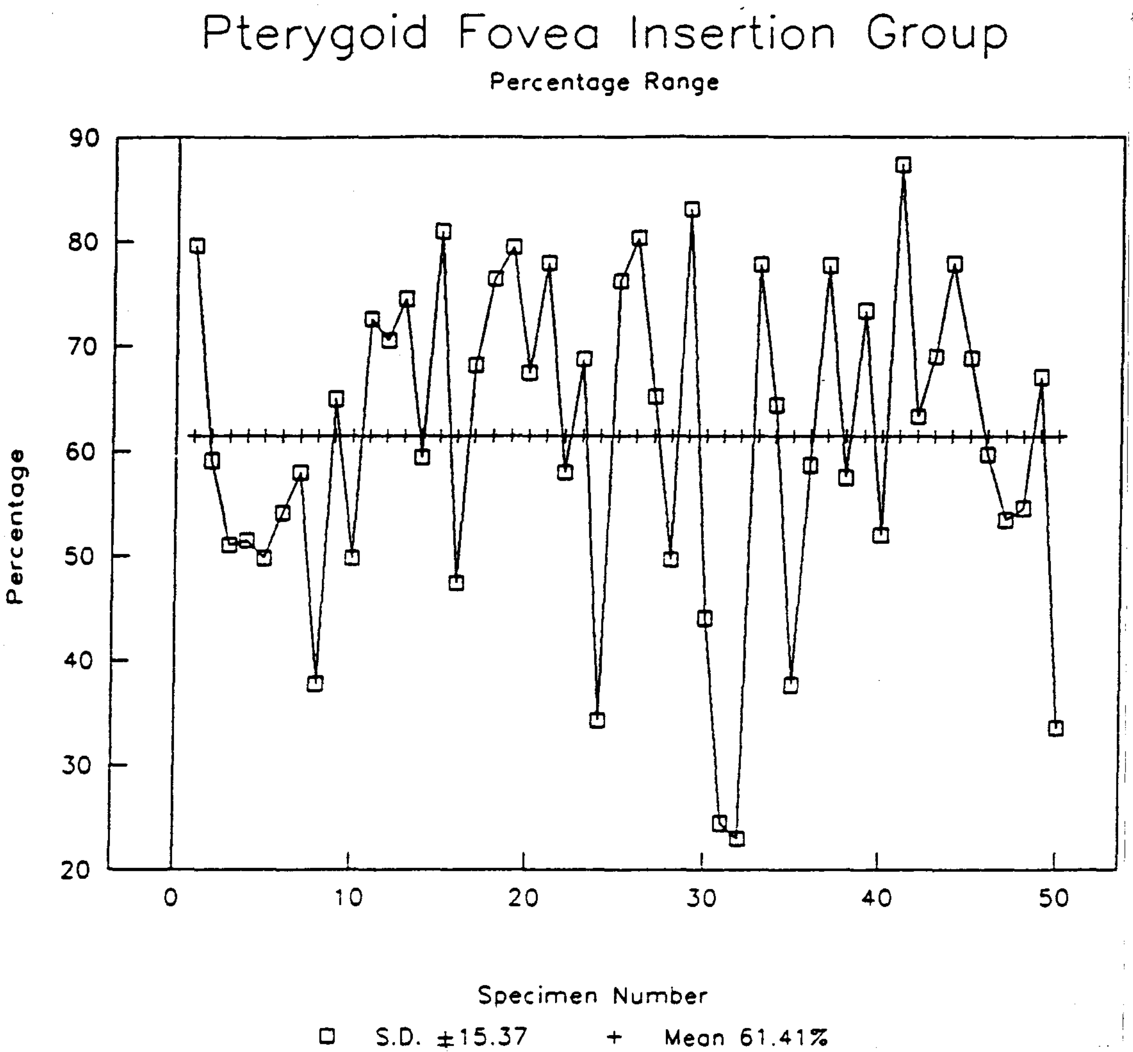


PLATE 38 - THE AMOUNT OF SUPERIOR HEAD WHICH INSERTED ON THE PTERYGOID FOVEA RANGED FROM 22.92% TO 87.37% WITH 61.41% AS A MEAN. (S.D. =±15.37)

PLATES OF PTERYGOIDEUS PROPRIUS MUSCLE

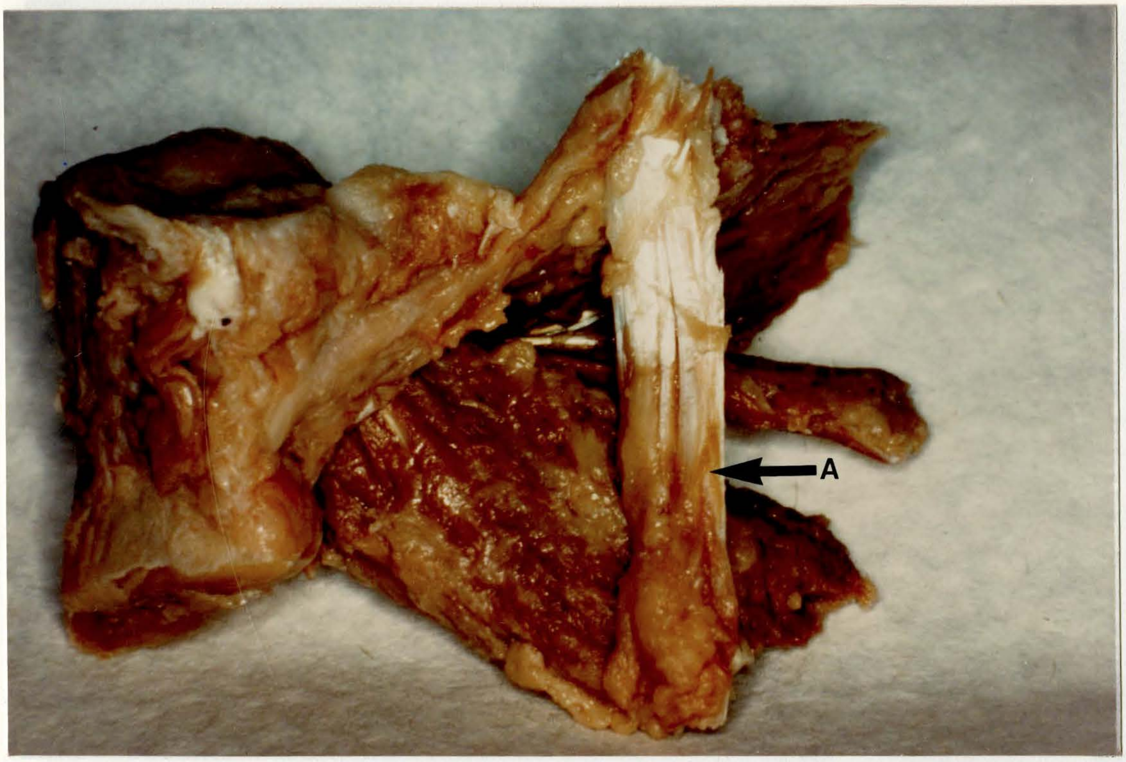
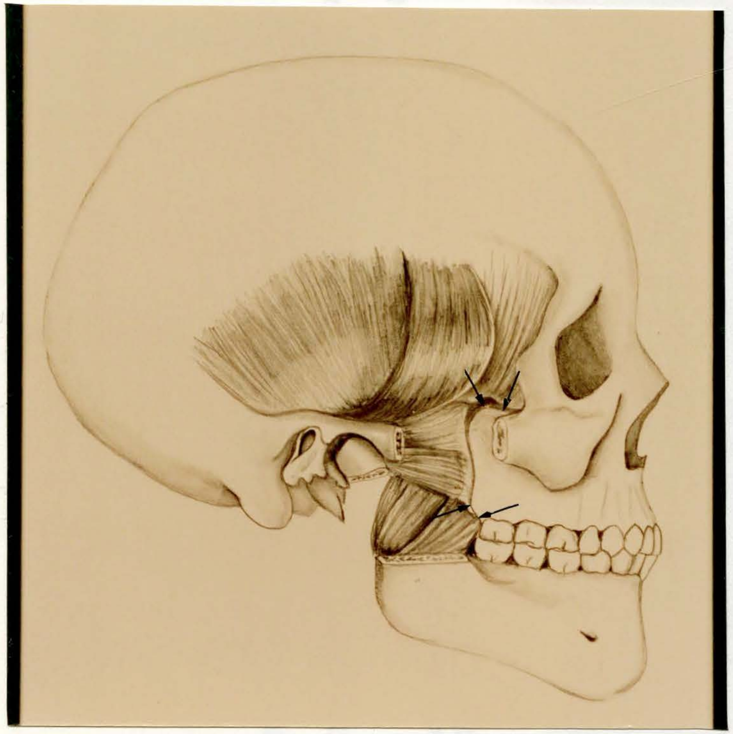


PLATE 39 - PTERYGOID PROPRIUS MUSCLE (POINTER A) ATTACHED TO BOTH HEADS OF THE LATERAL PTERYGOID MUSCLE. (3X)

PLATE 40 - THE PTERYGOIDEUS PROPRIUS MUSCLE IS A VERTICAL MUSCULOTENDINOUS BAND ABOUT 8-10 MM. WIDE. (POINTER A) (10X)



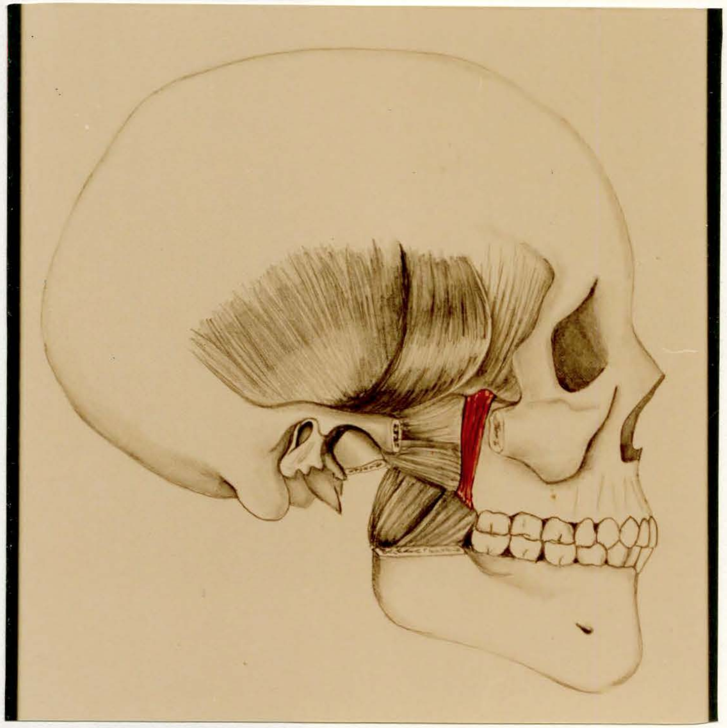


PLATE 41 - SKELETAL LANDMARKS FOR ORIGIN AND INSERTION OF PTERYGOID PROPRIUS MUSCLE

PLATE 42 - PTERYGOID PROPRIUS MUSCLE SUPERIMPOSED.

IN 39% OF A SAMPLE OF 36 TOTAL CADAVERS USED IN THIS INVESTIGATION, A VARIATION AT THE ORIGIN OF THE TWO HEADS OF THE LATERAL PTERYGOID OCCURRED AS A VERTICAL MUSCULOTENDINOUS BAND. (PTERYGOID PROPRIUS MUSCLE)

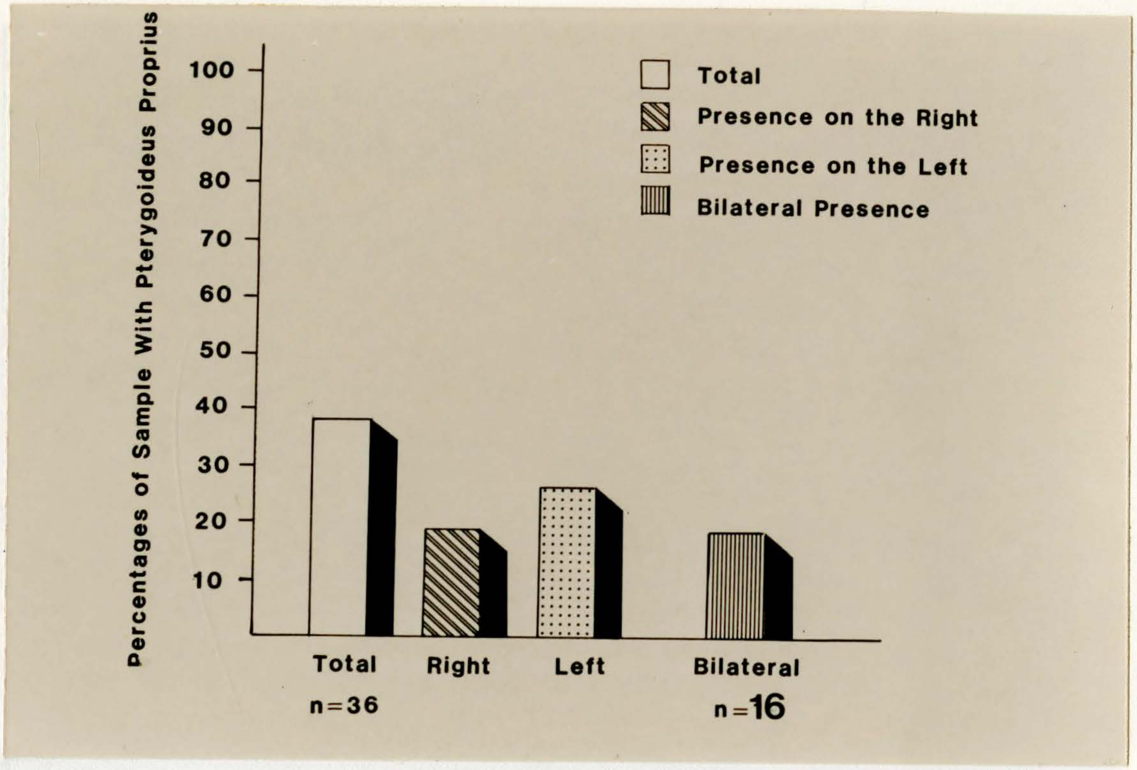


PLATE 43 - GRAPHIC REPRESENTATION OF OCCURRENCE OF PTERYGOID PROPRIUS MUSCLE IN PERCENT. TOTAL NUMBER OF SPECIMENS = 36. TOTAL NUMBER OF WHOLE HEAD SPECIMENS = 16.

OF THE 36 TOTAL SPECIMENS, 39% DISPLAYED THE MUSCLE

OF THE 16 WHOLE HEAD SPECIMENS, 19% DISPLAYED BILATERAL PRESENCE.

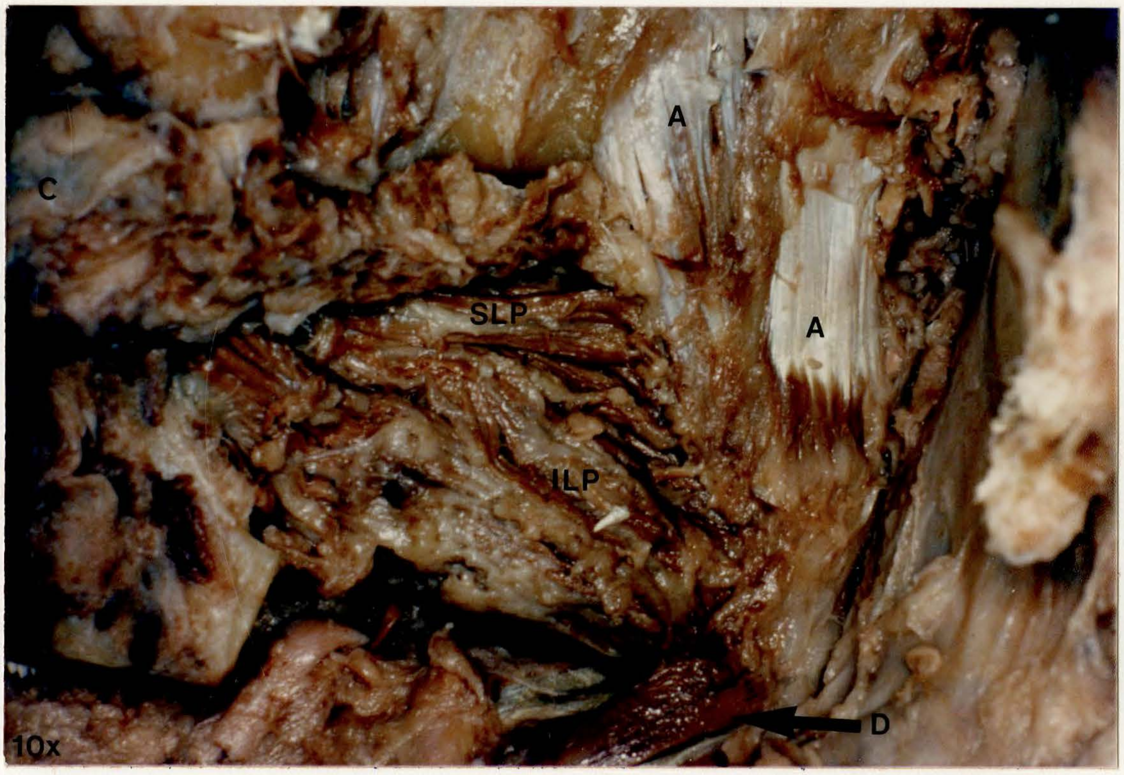


PLATE 44 - FIBERS OF PTERYGOID PROPRIUS M. BLENDING WITH MEDIAL PTERYGOID MUSCLE (POINTER D). (10X)

S.L.P. = SUPERIOR LATERAL PTERYGOID M.

I.L.P. = INFERIOR LATERAL PTERYGOID M.

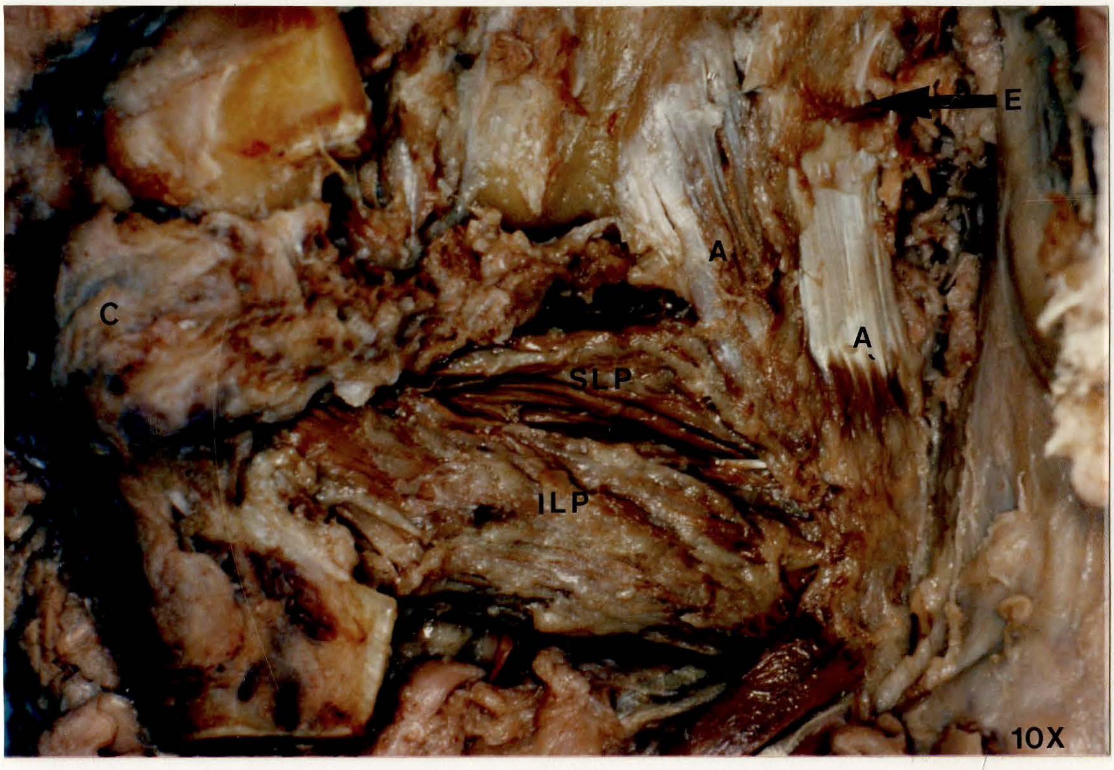


PLATE 45 - THE LATERAL SUPERIOR SURFACE OF THE PTERYGOIDEUS PROPRIUS IS CLOSELY INTERTWINED WITH DEEP FIBERS OF THE ANTERIOR TEMPORALIS TENDON; (POINTER E) (10X)

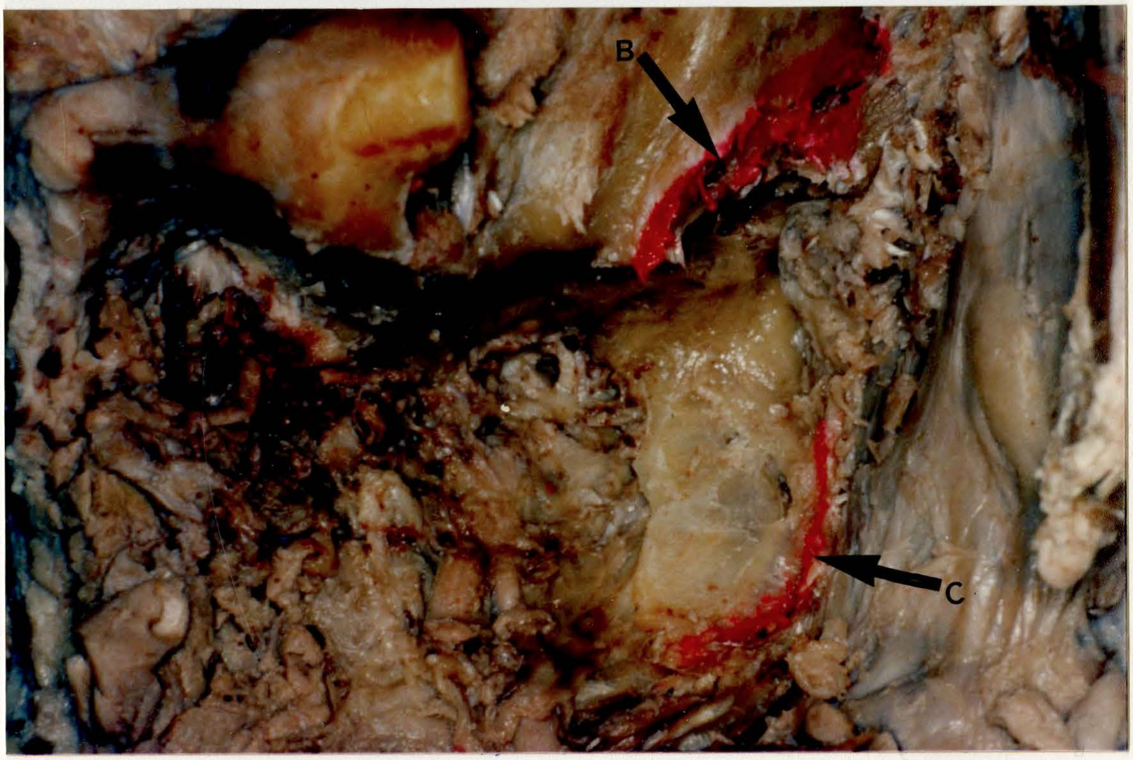


PLATE 46 - THE PTERYGOID PROPRIUS MUSCLE PASSES AND IS INSERTED INTO TWO FIXED POINTS; THE ANTERIOR PTERYGOID RIDGE OF THE SPHENOID BONE ABOVE; (POINTER B) AND GENERALLY THE INFERIOR LATERAL SURFACE OF THE LATERAL PTERYGOID PLATE BELOW; (POINTER C) (10X)

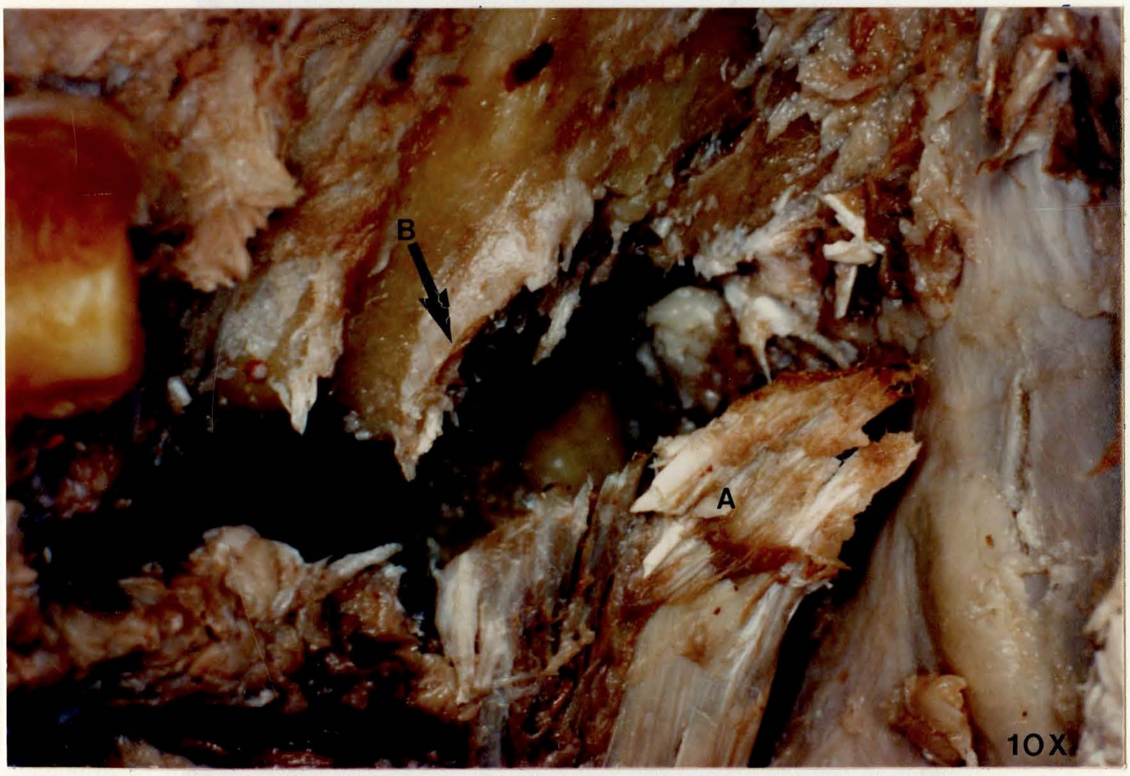


PLATE 47 - ANTERIOR PTERYGOID RIDGE OF SPHENOID BONE (POINTER B) WITH PTERYGOID PROPRIUS MUSCLE (A) DISSECTED AWAY FROM ATTACHMENT.

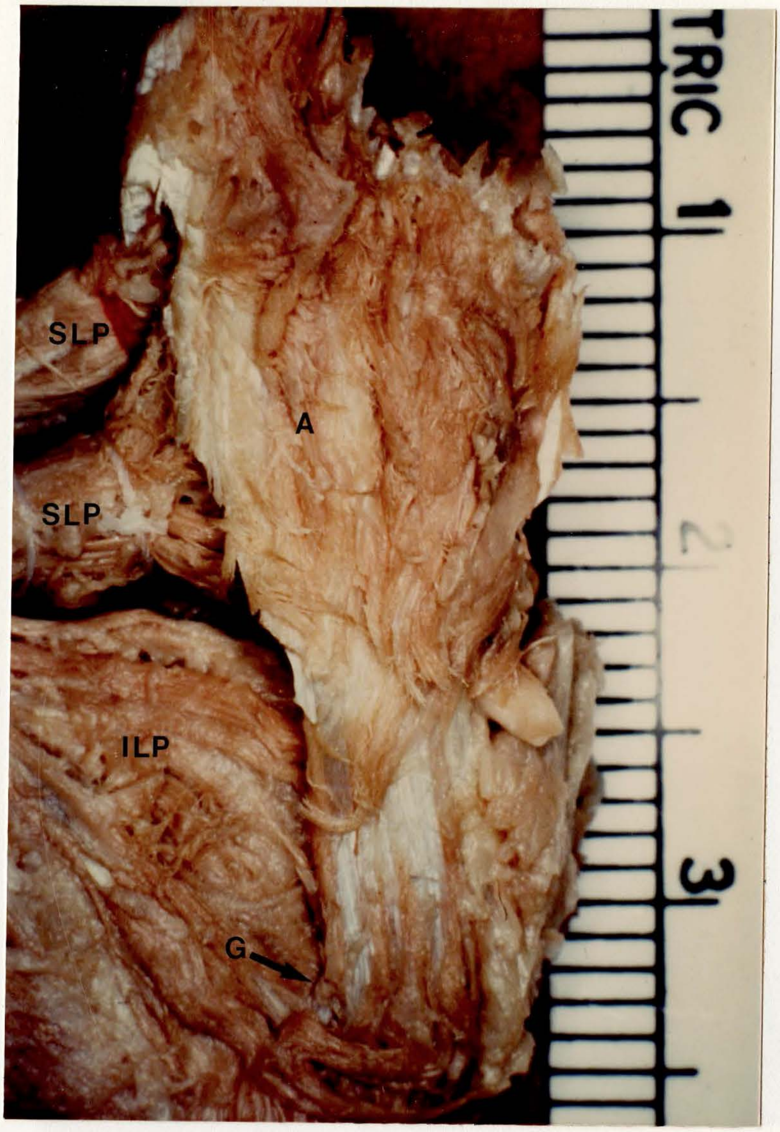


PLATE 48 - THE INFERIOR HEAD OF THE LATERAL PTERYGOID, (POINTER G) INTERMINGLES AT THE MEDIAL INFERIOR SURFACE OF THE PTERYGOIDEUS PROPRIUS MUSCLE. (10X) (LATERAL VIEW)

S.L.P. = SUPERIOR LATERAL PTERYGOID M.

I.L.P. = INFERIOR LATERAL PTERYGOID M.

PLATE 49 - POSTERIOR TO ANTERIOR VIEW OF ORIGIN OF FIBERS OF THE LATERAL PTERYGOID ON THE PTERYGOID PROPRIUS. (10X)

THE INFERIOR HEAD OF THE LATERAL PTERYGOID, (POINTER G) INTERMINGLES AT THE MEDIAL INFERIOR SURFACE OF THE PTERYGOIDEUS PROPRIUS MUSCLE.

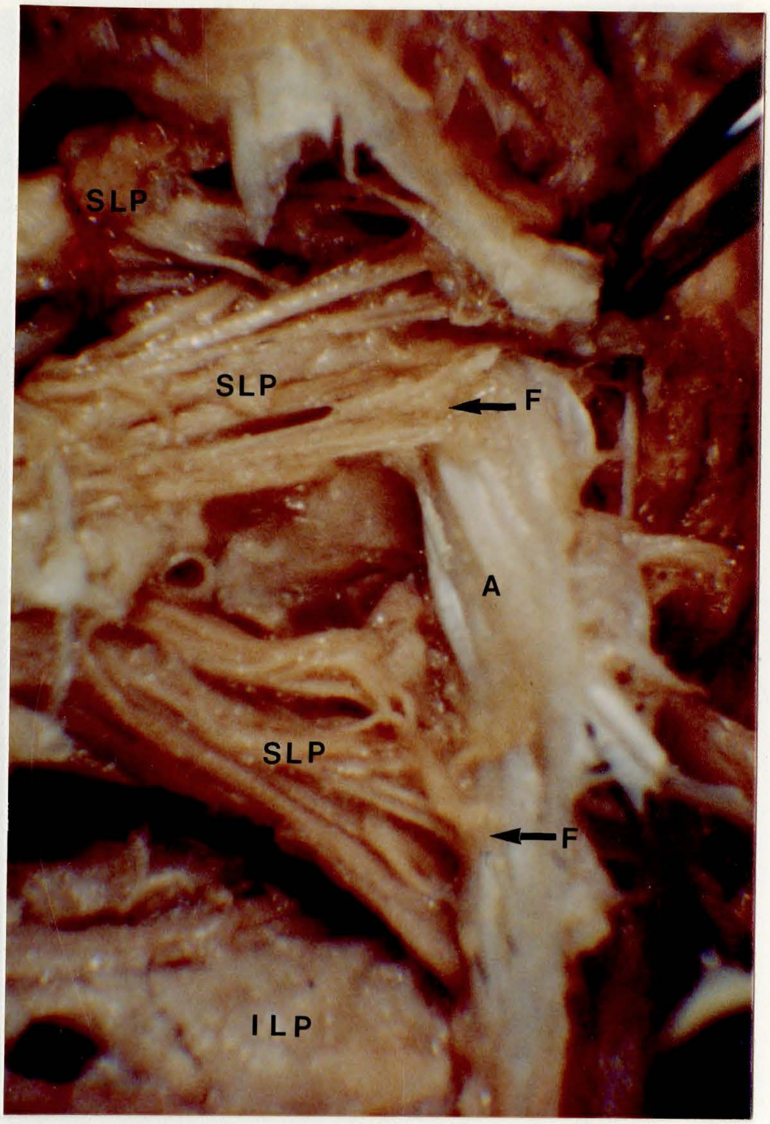


PLATE 50 - ORIGIN OF SUPERIOR LATERAL PTERYGOID MUSCLE (S.L.P.) ON MEDIAL SURFACE OF PTERYGOID PROPRIUS MUSCLE. (25X)

LATERAL FIBERS OF THE SUPERIOR HEAD OF THE LATERAL PTERYGOID, (POINTER F), TAKE ORIGIN ON THE MEDIAL SUPERIOR SURFACE OF THIS MUSCULOTENDINOUS BAND.

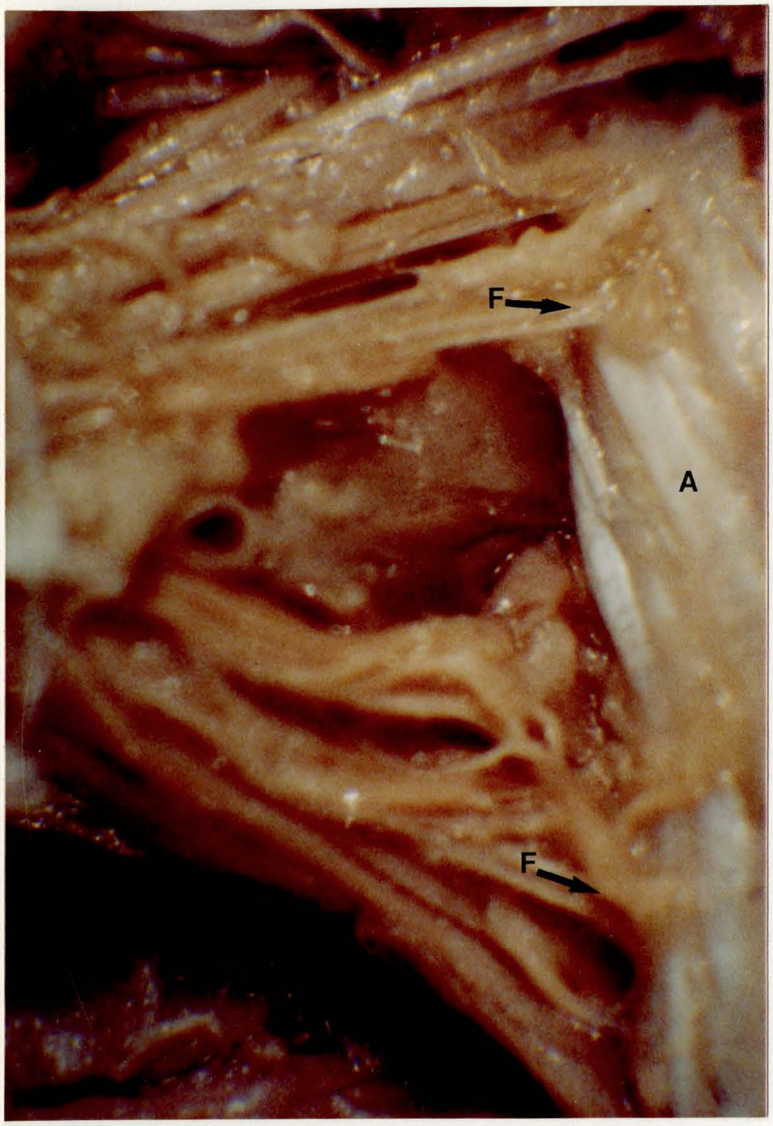


PLATE 51 - ORIGIN OF LATERAL FIBERS OF THE SUPERIOR HEAD OF LATERAL PTERYGOID MUSCLE (POINTER F) ON THE PTERYGOID PROPRIUS MUSCLE. (40X)

PLATE 52 - LATERAL FIBERS OF THE SUPERIOR HEAD OF THE LATERAL PTERYGOID, (POINTER F), TAKE ORIGIN ON THE MEDIAL SUPERIOR SURFACE OF THIS MUSCULOTENDINOUS BAND. (40X)

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

June 28, 1993
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