CHAPTER V

DISCUSSION

1. Comparison of the Internal Structure of Masticatory Muscles in Dog, Ox, and Man.

The comparison of the internal structures of each masticatory muscles was shown in formulae in Table 2. The formulae of the external and internal tendons of origin were above the horizontal line, and those of the external and internal tendons of insertion were below the line. The left side of the vertical line showed the external tendons and the right side of the line showed the internal tendons. The abbreviations were; A for aponeurosis, P for primary lamina, and S for secondary lamina. The subscript o indicated of origin and i indicated of insertion. The numbers standed for the ordinal numbers of the individual external tendons or internal tendons laminae.

1.1 Temporalis Muscle

The internal structures of the temporalis muscles of dog, ox, and man were simple. They were all composed of one aponeurosis of origin and one primary lamina of insertion. However, in ox, the primary lamina of insertion consisted of one small and two very small secondary laminae of insertion.

1.2 Masseter Muscle

The internal structures of the masseter muscles of dog, ox, and man were different. In dog and man, they consisted of only one aponeurosis of origin and two primary laminae of origin. Defferently, in ox, there were two aponeuroses of origin but three primary laminae of origin. Of the internal structures of insertion, there were more external and internal tendons of insertion in man than in ox, the five primary laminae of insertion, Pi_{1-5}, of man extended slenderly from the aponeuroses of insertion, Ai_1 and Ai_2, and were situated at the same level with each other. On the other hand, in ox, the three primary laminae of insertion of the masseter muscle were situated in different levels. Therefore, the internal structure of the masseter muscle of ox was the most complicated and it was more complicated in man than in dog.

1.3 Medial Pterygoid Muscle

In dog, the internal structure of the medial pterygoid muscle combined so tightly with that of the lateral pterygoid muscle that they cannot be seperated from each other. The pterygoid muscle of dog had no aponeurosis of origin but there were two primary laminae of origin. Of the insertion side, there were three aponeuroses of insertion but only one primary lamina of insertion. Contrastly, the internal structures of the medial pterygoid muscles in ox and man were completely seperated from that of the lateral pterygoid muscle. However, it was more complicated in man than in ox. In ox, the internal structure of the medial pterygoid muscle had two aponeuroses of origin, but one primary lamina of origin, and one secondary lamina of origin. Of the insertion, there were only one aponeurosis of insertion but two primary laminae of insertion. In man, the medial pterygoid muscle was the most complicated of the arrangement of the internal tendons. There was neither aponeurosis of origin nor of insertion. However, it consisted of three primary laminae of origin and four secondary laminae of origin. Of the insertion, they were four primary laminae of insertion but one secondary lamina of insertion. In summary, the internal structure was the most complicated in man, and it was more complicated in ox than in dog.

1.4 Lateral Pterygoid Muscle

The internal structure of the lateral pterygoid muscle of dog cannot be seperated from the medial pterygoid muscle. It was previously described together with the medial pterygoid muscle.

Interestingly, the internal structure of ox was more complicated than that of man. In ox, there were only one aponeurosis of origin and one primary lamina of origin. However, there were two aponeuroses of insertion but only one primary lamina of insertion. In man, there were only two primary laminae of insertion.

TABLE 2

COMPARISON OF THE INTERNAL STRUCTURE OF MASTICATORY MUSCLES IN DOG, OX, AND MAN

MUSCLE	DOG	OX	MAN
TEMPORALIS	$\begin{array}{l\|l} Ao & - \\ \hline & Pi \end{array}$	$\begin{array}{l\|l} Ao & - \\ \hline & Pi, Si_1, Si_2, Si_3 \end{array}$	$\begin{array}{l\|l} Ao & - \\ \hline - & Pi \end{array}$
MASSETER	$\begin{array}{l\|l} Ao & Po_1, Po_2 \\ \hline - & Pi_1, Pi_2 \end{array}$	$\begin{array}{l\|l} Ao_1, Ao_2 & Po_1, Po_2, Po_3 \\ \hline Ai & Pi_1, Pi_2, Pi'_1 \end{array}$	$\begin{array}{l\|l} Ao & Po_1, Po_2 \\ \hline Ai_1, Ai_2 & Pi_1, Pi_2, Pi_3, Pi_4, Pi_5 \end{array}$
MEDIAL PTERYGOID	$\begin{array}{l\|l} - & Po_1, Po_2 \\ \hline Ai_1, Ai'_1, Ai_2 & Pi \end{array}$	$\begin{array}{l\|l} Ao_1, Ao_2 & Po, So \\ \hline Ai & Pi_1, Pi_2 \end{array}$	$\begin{array}{l\|l} - & Po_1, Po_2, Po_3, So_1, So_2, So_3, So_4 \\ \hline - & Pi_1, Pi_2, Pi_3, Pi'_3, Si \end{array}$
LATERAL PTERYGOID		$\begin{array}{l\|l} Ao & Po \\ \hline Ai_1, Ai_2 & Pi \end{array}$	$\begin{array}{l\|l} - & - \\ \hline - & Pi_1, Pi_2 \end{array}$

2. Significance of the Internal Tendons of the Masticatory Muscles to the Action of the Jaw Movement.

Considering the actions of the masticatory muscles, the temporalis, masseter, and medial pterygoid muscle acted mainly in a vertical direction to close the jaw while the lateral pterygoid muscle acted mainly in horizontal direction to grind food (Lindblöm, 1951; Gardner & et al., 1963; Gray & Goss, 1966). From the formulae in Table 2, the temporalis muscles of the dog, ox, and man had a single primary internal tendon. Furthermore, the internal tendon of ox had, in addition, three secondary laminae. In the general rule of thumb, the increasing the number of the internal tendon was tended to increase the area of attachment of muscle fibers in the limited space provided, and thus the more muscle fibers the more ability to contract (Gans & Bock, 1965). If this is true, the temporalis muscle of ox had more ability than that of man and dog. As described above in section 1, the internal structure of the masseter muscle of ox was more complicated than that of man, which inturn, more complicated than that of dog. Again, the masseter muscle of ox was more powerful than that of man which inturn more powerful than that of dog. On the contrary, the medial pterygoid muscle of man was the most powerful, and that of ox was more powerful than that of dog. Therefore, the ability to close the jaw in ox and man was more than that of dog.

Concerning the lateral pterygoid muscle, the internal structure of ox was more complicated than that of man. Again, the lateral pterygoid muscle of ox was more powerful than that of man.

In addition, the internal structure of the lateral pterygoid muscle of dog was not seperated from that of the medial pterygoid muscle. Therefore, the ox had more ability to move the jaw in horizontal direction than man, while the dog did not have. In summary, the internal tendon was significant to the action of the jaw movement.

3. Difference in Mode of Mastication in Dog, Ox, and Man.

As discussed in section 2, the ox had more ability to move the jaw in horizontal direction than the man, while the dog had very little. Since, the horizontal movement of the jaw produced a grinding action by the lateral pterygoid muscle , ox could grind the food better than man, which inturn, man was better than dog in this aspect.

Concerning the cheek teeth of those three kinds of animals, the cheek teeth of ox were of a selenodont type, which had wide flat surfaces; and those of man were of the bunodont type which had low cusps for grinding; while those of dog were of the sectorial type which was not designed for grinding but for cutting (Adam, 1949; Romer, 1971). Thus, ox and man can chew hard food between the grinding surfaces of the cheek teeth (O'Rourke, 1951), while that of the sectorial teeth prevent grinding action in dog. Therefore, the internal structure of the lateral pterygoid muscle was less developed.

Judging from the ability to close the jaw, food cutting action should be best in ox, and better in man than in dog by the temporalis and masseter muscles. But, there was no shearing edge for cutting action in ox or man. Therefore, they can only press for crushing. On the other hand, dog with shearing teeth of the premolar and molar were designed for cutting action.

4. Significance of the Internal Tendons of the Masticatory Muscles to the Area of Attachment.

Heinze (1969) stated that the internal structure of each muscle consisted of the internal tendons and the muscle fibers. The internal tendon of origin gave rise to the attachment of the muscle fibers at one end, and the other end of the muscle fibers attached to the internal tendon of insertion. The arrrangements of the muscle fibers, therefore, arose from either the internal or external tendon of origin which inturn arose from the area of origin on the bone. These fibers passed obliquely one over each other to insert on either the internal or external tendon of insertion which again inserted on the insertion area on the bone. Logically, the number of the muscle fibers of origin and of insertion should be equal. Thus, the area of attachment of the muscle fibers of origin would equal to that of insertion. Concerning the temporalis muscle, the area of origin on the temporal bone was large while that of insertion on the coronoid process of the mandible was limited and small. According to the logical theory of Heinze (i.e. the areas of attachment of origin and of insertion must be equal), the temporalis muscle of ox increased the area of insertion by increasing the area on a primary lamina and three secondary laminae of insertion. Contrastly, in man and dog, the number of the internal tendon of origin and of insertion were the same. Thus, the primary lamina of insertion of the temporalis muscle of man and dog must be large in order to equalize the area of attachment of insertion to that of origin.

In the masseter of dog and ox, the area of origin was narrower and smaller than that of insertion. Thus, from Table 2, the number of the external and internal tendons of origin were larger than that of insertion. Nevertheless, in man, the area of origin of the masseter muscle was rather equal to that of insertion. But the number of the internal tendon of insertion was greater than that of origin. However, it can be explained that the primary laminae of insertion, Pi_{1-4}, were the part of the aponeurosis of insertion, Ai_2. Thus, there were only three tendons of insertion (aponeuroses of insertion, Ai_1 and Ai_2, and the primary lamina of insertion, Pi_5). Therefore, the number of internal tendon of origin was presumptively equal to that of insertion.

In the medial pterygoid muscle of man and ox, the area of origin was limited and small, while that of insertion on the medial surface of the mandible was larger. Therefore, the increasing the area of attachment of origin by increasing the number of the external and internal tendon of origin was needed. From Table 2, the number of the external and internal tendon of origin was greater than that of insertion. Contrastly to the medial pterygoid muscle, the number of the internal tendon of insertion of the lateral pterygoid muscle of ox and man were greater than that of origin in order to equalize the area of attachments of insertion and of origin.

Interestingly, the pterygoid muscle of the dog cannot be seperated. However, the area of origin on the pterygopalatine fossa was wide and large but that of insertion on the mandible was narrow and small. Thus, the number of the external and internal tendon of insertion was greater than that of origin in order to increase the area of attachment of insertion to be equalized.

In summary, the internal tendon acted in equalizing the area of origin to that of insertion as suggested by Heinze.

5. Comparison of the Observation of the Internal Structure of the Masticatory Muscles with those of the Previous Investigators.

Table 3 displayed a comparison of the present observation of the external and internal tendons of the masticatory muscles with those reported earlier (Heinze, 1964; Sicker & Dubrul, 1975). The letter " O " represented the external and internal tendon of origin, while the " I " represented the external and internal tendon of insertion. The number under of " O " or " I " indicated the number of the external and internal tendon which presented in that muscle. The symbol " - " displayed that there were no evidence of the external and internal tendons.

The number of the external and internal tendons of the three masticatory muscles of dog in this study equaled to those of Heinze but a dissimilarity was evident in ox; nevertheless, the basic pattern was the same. This may be due to the species differences of the Bos sundiacus, used in this study and Bos tuarus of Heinze.

In man, Sicker & Dubral (1975) studied the masseter and medial pterygoid muscles. Their observations were different from those observed in this study. The number of the external and internal tendons of both muscles in this study was greater than those of

TABLE 3

COMPARISON OF THE NUMBER OF THE EXTERNAL AND INTERNAL TENDONS OF THE MASTICATORY MUSCLES WITH THOSE OF HEINZE AND SICKER & DUBRUL

MUSCLE	THIS STUDY		HEINZE'S STUDY		SICKER & DUBRUL'S STUDY	
	O	I	O	I	O	I
DOG						
TEMPORALIS	1	1	1	1	-	-
MASSETER	3	2	3	2	-	-
PTERYGOID	2	3	2	3	-	-
OX						
TEMPORALIS	1	4	1	1	-	-
MASSETER	5	4	5	5	-	-
MEDIAL PTERYGOID	4	3	3	3	-	-
LATERAL PTERYGOID	2	3	-	-	-	-
MAN						
TEMPORALIS	1	1	-	-	-	-
MASSETER	3	7	-	-	3	2
MEDIAL PTERYGOID	6	5	-	-	3	3
LATERAL PTERYGOID	-	2	-	-	-	-

Abbreviations:

"O" represents the external and internal tendons of origin,

"I" represents the external and internal tendons of insertion,

"-" represents that there are no evidence of the internal tendon.

Sicker & Dubrul (1975). Racial factor between Caucasean and Mongolian attributes to such difference should be thoroughly investigated. However genetic variation seems to be the most possible explanation at hand.

6. Concepts on the Division of the Masticatory Muscles.

Two schools of thought for the division of the muscles of mastication were proposed previously. The first group stated that the masseter muscle can be divided into several parts by the internal tendons. This idea brought about " the lamination theory " which was supported by Allen, 1880; Poglayen-Neuwall, 1953; Yoshikawa & Suzuki, 1969. The other group gave the opposite idea to the former group in that the masseter muscle should not be divided by the internal tendon, since the internal tendon was a one component of the muscle. This concept was named " the polypinnation theory " (Heinze, 1963, 1964, 1969; Iordansky, 1964). According to the muscle fibers arrangement, they resemble that of a feather, which had a tendon as a shaft. Thus, the muscle may consist of one or more than one of this functional unit(s) as the name imply " polypinnation". The findings of the present study supported the second theory in that the muscle was not divided by the internal tendon. There was no fascial sheath found between these muscle fibers which would indicate the existence of another muscle.

In addition, Tanuma (1978) studied the development of some mastication muscles in a fetal life. This paper intended to support the lamination theory in the division of the masticatory muscles when the man was a fetus. However, with a detail examination, the lamination theory was only true in the fetal life but was not the case in the adult because when the fetus grew up, these muscles combined together tightly with the internal tendon within the muscle. Thus, the polypinnation theory should be accepted in the adult. However, this conflict leads to further investigation in this field of reserch before any conclusion will be made.