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Anatomy of Digastric Muscle in Old World Hamsters

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Abstract *The anatomy of the digastric muscle is described in four genera of Old World hamsters (cricetine murids). The anterior bellies of the muscle on both sides are in contact along the mid-sagittal line, and represent the sciuromorphine type in Tscherskia. In Cricetulus, however, there are some hystricomorphine-like features, such as clear separation of both anterior bellies and the anterior belly alignment with the posterior belly. The digastric muscles of Mesocricetus and Phodopus are intermediate between those of Tscherskia and Cricetulus. On the basis of phylogenetic relationships proposed by Kartavtsev et al.*[1]*, the linear arrangement of the anterior and posterior bellies appeared at least three times within the divergence of cricetine murids. This hystricomorphine-like structure might be advantageous for lateral tongue movement with relation to food storage into the cheek pouch. Further experimental studies on movement of the hyoid and tongue are needed to test this hypothesis.*

For the digastric muscle in rodents Parsons defined sciuromorphine and hystricomorphine types[2,3]. The sciuromorphine type is defined by 1) anterior and posterior bellies firmly attached to the hyoid, 2) the presence of an interbelly tendon connecting the two bellies, 3) two bellies acting in different directions, and 4) anterior bellies on both sides in contact along the mid-sagittal line. On the other hand, the hystricomorphine type is characterized by 1) anterior and posterior bellies without junction to the hyoid, 2) absence of the interbelly tendon, 3) linear arrangement of the two bellies, and 4) the anterior bellies on both sides completely separated.

Sciuromorphine and hystricomorphine digastric muscles are generally reported in the suborders sciurognathi and hystricognathi, respectively[4~11]. Similarity of digastric muscle, however, does not necessarily reflect the phylogenetic relationships among rodents. For example, in some sciurognath rodents (e.g., the pocket gophers and some genera of vole), the hystricomorphine features were acquired through parallel evolution[3,12~15]. These findings suggest that the form of the digastric muscle results from an adaptation to a certain function as well as phylogeny. Several electromyographic studies on mammals indicate strong to moderate activation of the anterior or posterior digastric muscle during jaw opening[16~23], masticatory power stroke[24~29], and tongue movement[30,31]. Thus, the anatomy of the digastric muscle is closely related to the feeding mechanism, such as use of tongue and chewing pattern.

Old World hamsters, murid rodents classified into the subfamily cricetinae, are characterized by a cheek pouch for temporary storage of food such as seeds. When these animals collect food into the cheek pouch, the tongue has an important role[26]. The structure of the digastric muscle might reflect the presence of the cheek pouch. Previous authors[3,26] have provided only a brief description of this muscle in a few cricetine species. In the present study, the anatomy of the digastric muscle was observed in four cricetine genera.

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MATERIALS AND METHODS

In the present study, comparisons were made among the following four species: *Mesocricetus auratus* (n = 6 ; 3 males and 3 females), *Phodopus sungorus* (n = 4 ; 1 male and 3 females), *Cricetulus griseus* (n = 4 ; 2 males and 2 females), and *Tscherskia triton* (n = 4 ; 2 males and 2 females). The specimens were donated by Experimental Animal Center, Miyazaki Medical College. The heads of the specimens were preserved in 10% formalin after removal of the skin, then the architecture of the muscles was observed.

RESULTS

For all genera examined, the anterior and posterior bellies were connected by the interbelly tendon. The anterior belly originates from the interbelly tendon and the anterior surface of the tendinous arch arising from the central raphe of the mylohyoid. Thus, the anterior belly is connected with the hyoid via the mylohyoid. The tendinous arch is anteriorly convex and laterally continuous with the interbelly tendon. The anterior belly inserts to a small flat area just ventral to the transverse mandibular muscle and posterior to the mandibular symphysis. In *Phodopus, Cricetulus,* and *Mesocricetus,* the anterior belly inserts with a tendinous sheet (Fig. 1b, c, and d). In *Tscherskia,* however, a fleshy insertion is observed (Fig. 1a).

The posterior belly of the digastric originates from the paroccipital process. The superficial fibers of this muscle insert on the posterior end of the interbelly tendon. The deep fibers attach to the dorsal aspect of the interbelly tendon and the posteromedial part of the tendinous arch.

Among the cricetine genera examined, three types of digastric muscle were observed. In the *Tscherskia* type, the anterior bellies on both sides contact each other along the mid-sagittal line except near their insertion (Fig. 1a). Because both anterior bellies meet on the tendinous arch, the margin formed by the posterior ends of these muscles is slightly convex anteriorly. The mylohyoid, situated beneath the anterior bellies, is entirely concealed. The anterior and posterior bellies of *Tscherskia* run in different directions.

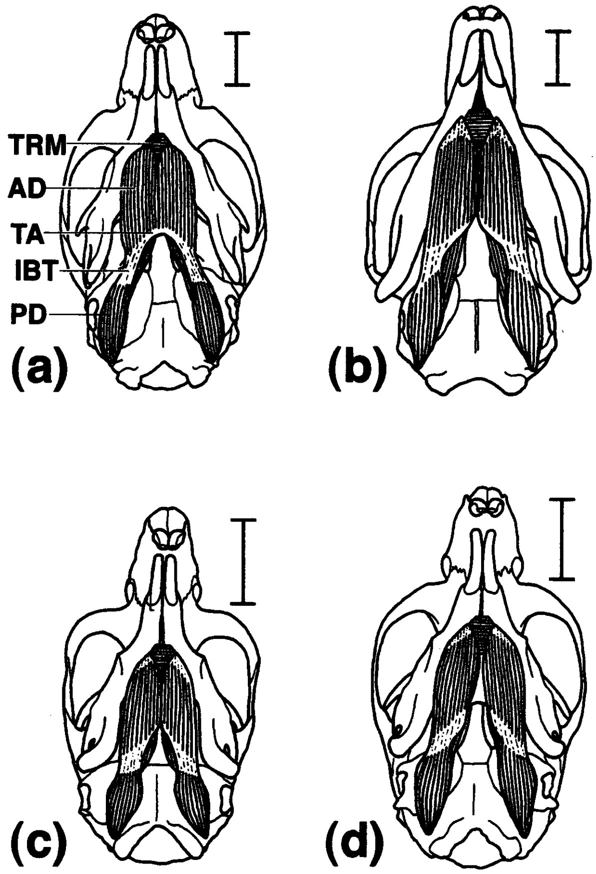

Figure 1. Digastrics of Old World hamsters. a : *Tscherskia triton.* b : *Mesocricetus auratus.* c : *Phodopus sungorus.* d : *Cricetulus griseus.* AD, anterior belly of the digastric muscle ; IBT, interbelly tendon ; PD, posterior belly of the digastric muscle ; TA : tendinous arch ; TRM, transverse mandibular muscle. Scale bars are all 5 mm.

The *Mesocricetus* type is found in both *Mesocricetus* and *Phodopus.* The anterior bellies meet at their middles, but not on the tendinous arch. Thus the posterior margin of the two anterior bellies is notched and a small area of the mylohyoid is not concealed by the digastric. The anterior and posterior bellies are situated along nearly the same line.

The *Cricetulus* type is characterized by a clear separation of the left and right anterior bellies. The posterior half of the mylohyoid does not lie beneath the anterior bellies. As in *Mesocricetus* and *Phodopus,* the anterior belly is arranged in a line with the posterior belly.

DISCUSSION

With respect to the connection to the hyoid and the presence of an interbelly tendon, the Old World hamsters examined basically possess the sciuromorphine digastric muscle. The digastric muscle of *Tscherskia* represents a typical sciuromorphine type. In *Cricetus*, which was not examined in the present study, the digastric muscle is similar to the *Tscherskia* type with exception of a reduction of the interbelly tendon[3]. In *Mesocricetus*, *Phodopus*, and *Cricetulus*, the anterior belly alignment with the posterior belly resembles the hystricomorphine condition. In addition to this feature in *Cricetulus*, clear separation between the anterior bellies on both sides is observed as in the hystricomorphine type.

The sciuromorphine digastric muscle is thought to be more primitive pattern for rodents[13, 32]. The *Cricetulus* type of digastric muscle might have evolved from the primitive *Tscherskia* type via the intermediate *Mesocricetus* type. On the basis of the phylogenetic study by Kartavtsev et al.[1], the alignment of the anterior and posterior bellies appeared three times within the divergence of cricetine murids (Fig. 2). Therefore, the form of the digastric muscle does not reflect the phylogeny, but rather a particular feeding function. Because the hystricomorphine type has been known in rodents processing food in an antero-posterior direction in general, its functional advantage has been discussed in terms of a propalinal chewing motion[15, 32, 33]. Woods[32] proposed that the linear arrangement of the anterior and posterior bellies acts as a functional unit for moving the mandible in the antero-posterior direction. Studies using cinematography[26] and wear facets on the molars[34], however, have revealed that Old World hamsters chew transversely, not antero-posteriorly .

The anterior belly of *Mesocricetus auratus* is in active during molar occlusion, as well as jaw opening[26]. Wahlert[34] pointed out that the chewing motions of *Cricetulus* and *Phodopus* are identical with that of *Tscherskia*, and slightly different from those of *Mesocricetus* and *Cricetus*. His observations are not consistent with the similarity of the digastric muscle. Therefore the digastric muscle types in Old World hamsters have little correlation with chewing direction.

The Old World hamsters temporarily store food into the cheek pouch using lateral tongue movements[26]. On the basis of electromyographic studies in man, the anterior belly of the digastric contracts during tongue movement, such as protraction, lateral movement, and placement on the hard or soft palate[30, 31]. These studies suggest that the linear arrangement of the anterior and posterior bellies is an adaptation to the use of the cheek pouch accompanied by lateral tongue movement. If this hypothesis is correct, the acquisition of the cheek pouch, which occurred in the common ancestor of the cricetine murids, might precede acquisition of the apparatus for efficiently pushing food into the pouch. Electromyographic study of the digastric muscle and information on the correspondence between the tongue and hyoid movements are required to test this hypothesis and to determine the functional significance in form of the muscle.

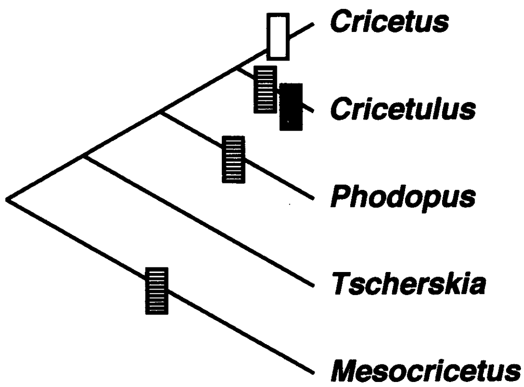

Figure 2. Transition of anatomical characteristics of the digastric muscle within the phylogeny of Old World hamsters. Phylogenetic relationship is based on Kartavtsev et al.[1]. Small rectangle indicates branch on which each feature appeared. Black : complete separation of both anterior bellies, Hatched : anterior belly aligned with posterior belly, White : reduction of interbelly tendon. *Cricetus* was not dissected in the present study ; information is cited from Parsons[3].

CONCLUSION

The present anatomical study established that there are some intergeneric variations in the form of the digastric muscle among Old World hamsters. The linear arrangement of the anterior and posterior bellies seems to have been acquired independently within several lines of cricetine murids. This convergence suggests that the alignment of the two bellies is an adaptation for a particular function, such as tongue movement for pushing food into the cheek pouch.

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旧世界ハムスター類の顎二腹筋形態

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キーワード：顎二腹筋，キヌゲネズミ亜科，リス型，ヤマアラシ型

抄録　旧世界ハムスター類（齧歯目ネズミ科キヌゲネズミ亜科）4 属の顎二腹筋の肉眼解剖学的な形態について検索をおこなった．*Tscherskia* 属では両側の前腹が正中線に沿って接する典型的なリス型の顎二腹筋が見られた．他方 *Cricetulus* 属では両側の前腹が正中部で分離し，前後腹がほぼ一直線上に並ぶというヤマアラシ型顎二腹筋に類似した特徴が見られた．*Phodopus* 属，*Mesocricetus* 属では前二者の中間型を示した．Kartavtsev et al.[1]が提唱した系統樹に基づくと，顎二腹筋の前後腹が一直線上に並ぶという特徴は旧世界ハムスター類の系統発生において 3 回以上独立に出現したと考えられる．この特徴は頬袋に食物を詰め込む際の舌の側方運動に対して何らかの利点をもつ可能性があり，今後舌骨や舌の運動，および筋電図等を記録して検証する必要がある．