ASSESSING CRANIOCERVICAL FUNCTIONAL MORPHOLOGY IN THEROPOD DINOSAURS FROM AN OSTEOLOGICAL AND ARTHROLOGICAL PERSPECTIVE

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INTRODUCTION

Mesozoic theropod dinosaurs were bipedal, primarily carnivorous, and of variable size; ranging in length (snout to tip of the tail) from less than a meter to over 10 meters. A large variety of theropod dinosaurs have been found in North America; many important specimens have been recovered from the badlands of Alberta, Canada. The extraordinarily rich fossil resources of Alberta, Canada, present an enviable opportunity to consider dinosaurs as living animals, instead of as mere bones in a museum.

The functional morphology of the neck vertebrae of theropods has not been well studied, as specimens with complete cervical series are uncommon, and functional studies of dinosaurs generally focus on limb function and locomotion. Investigations into feeding behaviour and mechanics usually focus on the teeth and skull; when the neck is considered, it is from the perspective of phylogenetic relationships [1] or of muscular action [2, 3].

In contrast to the elongate and comparatively fragile cervicals of small theropods such as ornithomimids, those of tyrannosaurids are anteroposteriorly shortened and robust; their large skull was probably unsupportable by a long, slender neck. The variation in size, shape, and articulation of theropod neck vertebrae result in different constraints on range of motion for the different taxa.

METHODS

This foundational study [4] involved comparative anatomical studies of theropods within phylogenetic, ecological, and functional contexts, comparative anatomical studies of the closest living relatives to dinosaurs, and the use of computer modelling techniques. DinoMorph™ is an interactive graphics software package that is used to construct and articulate three-dimensional models of dinosaur skeletons [5], and is being used in collaboration with Dr. Kent Stevens (Department of Computer & Information Science, University of Oregon, Eugene, U.S.A.).

The articular surfaces of the joints of theropod dinosaurs are modelled digitally as complex three-dimensional surfaces using both mensural and photographic data. Comparative examinations of birds are performed using dissection, physical manipulation, and radiography to constrain the limits of range of motion of the dinosaur models. The digital models are manipulated in real time using the DinoMorph™ software package in order to determine the limits of movement of a given structure in the extinct dinosaur taxa. The mechanics of feeding and foraging in these animals are considered in light of their craniocervical mobility.

RESULTS AND DISCUSSION

Analysis of these data revealed that cartilage on both zygapophyseal and central articular faces of cervical vertebrae in extant and extinct taxa is proportionally thin, and serves as a surface upon which the parts of the joint glide. These data also provided insight into the restrictions on mobility enforced by the synovial joint capsule, and the variation in degree of zygapophyseal overlap along the cervical series within individual specimens. Based on these results, all studied coelurosaurian taxa, extinct and extant, have sufficiently mobile necks to engage in inertial feeding. Of the extinct taxa, tyrannosaurid necks are the least flexible. Ornithomimid necks are the most flexible, with the neck of *Troodon* demonstrating a similar range of motion. The extremely bevelled cervical centra of dromaeosaurids likely made them the least flexible of the small theropod taxa examined. An experimental model of *Tyrannosaurus rex* was created using an alpha version of DinoMorph™. The experimental model demonstrated the utility of such software for craniocervical functional morphological analyses tailored to the specificities of theropod cervical vertebrae. Ongoing studies of osteology and arthrology in addition to myology, as well as the use of parametric modeling techniques, will provide further insight into theropod feeding and foraging behavior.

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