A Radiographic Study of the Bony Trabecular Pattern in the Mandibular Rami of Certain Herbivores, Carnivores and Omnivores

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This study is concerned with the radiographically visible bony trabecular pattern of the mandibular rami of certain herbivores, carnivores, and omnivores. The several rami will be compared and contrasted.

It was originally postulated that the basic trabecular patterns of the three types of mammalian mandibular rami would have certain features in common in view of the gross outward similarities in the anatomy of the mandibles. It was further postulated that modifications of the presumed basic pattern might be present as a reflection of the variations in muscle attachments (temporal and masseter muscles) which account in part for the differing masticatory movements in the three animal types.

REVIEW OF LITERATURE

The trabecular patterns of various bones have been studied using a variety of techniques about which there is considerable dispute. Evans[3] summarized the various methods as well as the results achieved, and presented a series of objections to the interpretations given by the use of the several methods. His book also summarized recent knowledge of the effects of stress and strain on bones.

Enlow[1], in the introduction to his book on bone remodeling, reviews some of the early thinking on the relationship between the functions of bones and their trabecular patterns. He refers to Ward[16] and to Wyman[19] who related the forces acting on a bone to its pattern and trabecular arrangement. He also calls attention to Humphry[10] who suggested the effect of pressures as major influences determining the shape and form of a bone.

Koch[12] studied the human femur in gross sections. He concluded that bones reacted to stress in obedience to mechanical laws and he illustrated this mathematically.

Muscle changes have been induced in animals experimentally and the resulting bone changes have been studied.[6,7,8,14,15,17,18] In every instance bone changes resulted from induced changes in muscle stress.

Experimental work designed to test the genetic components of the form of bones was done by Felts.[4] His study of transplants of some embryonic rat bones to subcutaneous positions indicated that the gross form of a bone was genetically predetermined, but that the anatomic details were determined by the use to which the bone was put. Similar experiments were done by Murray and Selby,[13] using chick femora; their conclusions were similar. Glucksmann[5] subjected bone in tissue culture to mechanical stress and observed the changes in the bone resulting from the application of stress.

Evans[3] summarized the literature to that date as follows, "Mechanical fac-

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tors are not entirely responsible for bone form, which also has a hereditary basis as shown by experiments with chick limb buds in chorio-allantoic grafts. The requirements for maintaining normal shape and proportions of a bone during growth are involved in osteogenesis and the embryonic development of bone. The spatial relations between the periosteum and the diaphysis of a bone are also partly responsible for the increased thickness of the central part of the shaft of the long bone. Mechanical factors are thus seen to be just one of several operating in the development of a normal bone."

MATERIAL AND METHODS

The mandibles of three cows, three horses, three sheep, three dogs, one gibbon, one chimpanzee, three pigs, and one howler monkey were used in this study. The rami of the smaller animals were radiographed using a standard dental x-ray machine at sixty-seven volts and ten milliamperes. Dental occlusal film was used at a focal distance of twenty-five cm. The larger rami were radiographed on a standard medical x-ray machine. The bony outline and the bony trabecular pattern seen on the films were traced on clear matte acetate. The original films and the tracings served, along with photographs of the several mandibles, as the basis for the study.

RESULTS

Examination of the mandibles showed that the rami of the various animals, regardless of their type of masticatory function, had a similar gross morphology with such easily identifiable structures as condyloid process, coronoid process and retromolar area (Plate 1). The dog exhibited the only variation in the gross morphology as seen by the additional presence of the angular process (Figure 3). The sites of muscle attachments were similar in the three types of animals studied, but the extent of the attachment varied somewhat from type to type (Figures 1-4). As the extent of muscle attachments varied, so also did the size of the several bony areas to which the muscles attach to the mandible.

Study of the radiographs and tracings of the mandibular rami show a distinct distribution of the bony trabeculations. In the anthropoids studied, the trabecular pattern shows an "N" shape, previously described for the *Macaca rhesus* monkey.[6] Figure 5 in Plate 2 shows the pattern seen in the chimpanzee. The omnivorous pig shows the "N" pattern but it is apparent that the distal arm of the "N" is considerably greater mesiodistally than in the omnivorous anthropoids, at some places occupying as much as the distal half of the ramus (Figure 7). The attachment area of the masseter muscle appears to be about equal to the trabecular pattern area described.

In the herbivores the "N"-shaped pattern is also clearly visible, and the distal arm of the "N" is very wide compared to any omnivore observed, exclusive of the pig. In addition, herbivores exhibit distinct horizontally-directed trabeculations in the coronoid process not seen in other animals (Figure 6).

In the carnivores studied the "N"-shaped trabecular pattern is also visible, but the "N" appears to have been rotated so that it faces distally (Figure 8) instead of upward as in the omnivores and herbivores. The muscle attachment likewise varies from those of the other masticatory systems.

The several types of bony trabecular patterns are diagrammatically represented in Plate 3, Figure 9 (pig), Figure 10 (sheep), and Figure 11 (dog).

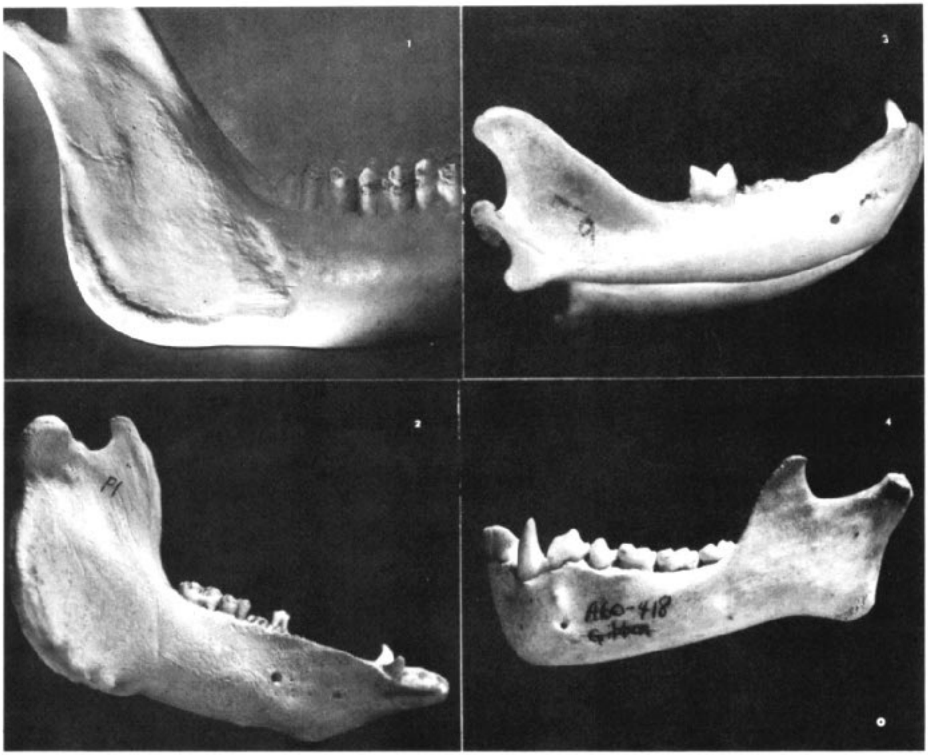

Plate 1 Photographs of the mandibles of various mammals showing the characteristic condyloid process, coronoid process, and retromolar areas, and the bony areas of attachment of the masseter and temporal muscles, (1) sheep, (2) pig, (3) dog and (4) gibbon.

Discussion

The carnivorous animals have a masticatory apparatus designed primarily to cut and tear flesh. The movements of the mandible are exclusively vertical in character with lateral movements eliminated by the interdigitation of the canine teeth. The herbivores, on the other hand, have a masticatory system designed to comminute vegetation; the mandibular movements are primarily lateral in character. The omnivores exhibit a masticatory system which, as far as mandibular movements are concerned, is a combination of vertical and lateral movements. However, in all three groups the masseter and temporal muscles act to close the jaws, and their attachments to the mandible are similar in all these animals. It is therefore not surprising that the internal trabecular architecture is basically similar in pattern in the mandibular rami of the several animals. The variations in pattern described are probably accounted for, at least in part, by the action of other masticatory muscles, as well as by differences in the respective dentitions. Studies of the effects on the mandibular ramus of the pterygoid muscles, as well as the lesser muscles of mastication, may shed further light on the variations in trabeculation here noted.

The commonly accepted assumption that muscle stress on a bone acts to cause deposition of bone, thus determining its outward configuration, has recently been questioned by Hoyte and

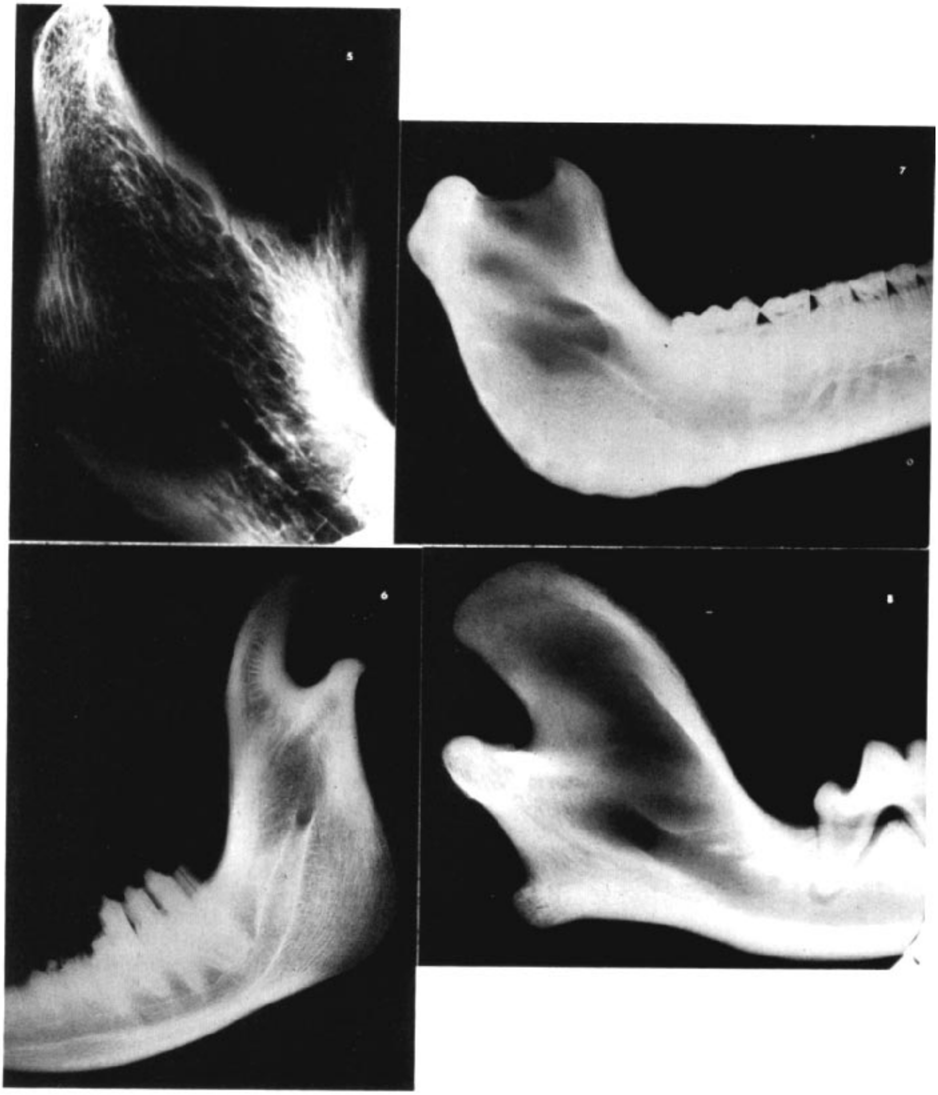

Plate 2 Photographs of the radiographs through the mandibular rami of some of the species studied, (5) chimpanzee, (6) sheep, (7) pig and (8) dog.

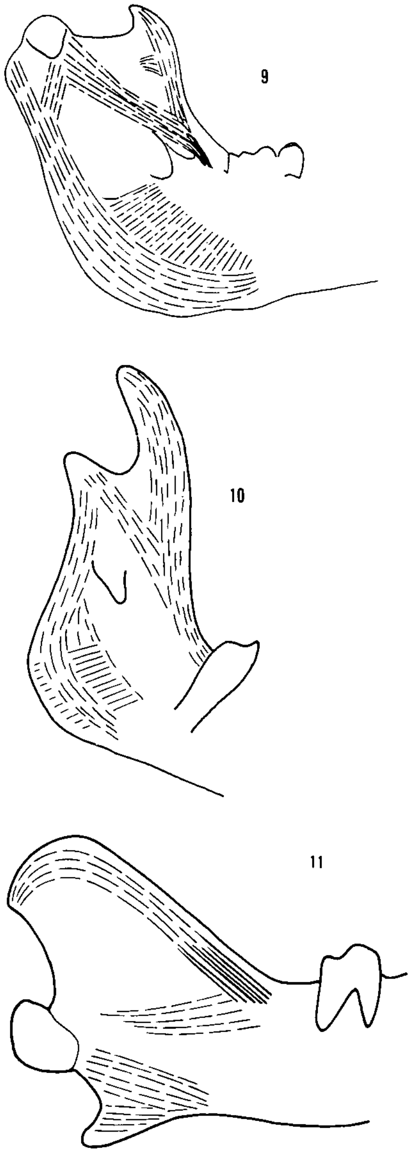

Plate 3 Diagrammatic representations of the tracings of the mandibular rami radiographs of several species, (9) pig, (10) sheep and (11) dog.

Enlow.[9] They point out that areas of muscle attachment may show not only areas of bone deposition, but also areas of bone resorption. In fact, they observed that in some muscle attachment areas part of the muscle may be inserted on a region showing bone deposition and another part of the same muscle may be inserted on a resorptive surface at the same time. In view of these observations they recommend a re-evaluation of the assumption that muscle stress leads only to bone deposition.

Epker and Frost[2] have suggested that sufficient theoretical understanding of bone drift now exists to permit consideration of the possibility of applying such knowledge. Additional data concerning internal trabeculations may bring closer the time of such application.

CONCLUSION

It is concluded that the basic trabecular patterns in the mandibular rami of the herbivores, carnivores and omnivores are essentially similar. The pattern is seen radiographically as stress lines from condyle to angle of jaw, condyle to retromolar area, and coronoid process to retromolar area, assuming in total an "N"-shaped form.

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