Effect of food consistency on the shape of the articular eminence and the mandible

An experimental study on the rabbit

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The aim of this investigation was to ascertain what changes masticatory function could elicit in the shape of the articulating surface and the growth of the mandible in a growing rabbit. Forty-seven rabbits were divided into two groups, a control group fed whole pellets and a 'soft' group fed softened pellets and having their incisors shortened once a week. All the rabbits were killed at the age of 50 days and roentgenographed, after which the heads were freed of soft tissues, and the shape of the articulating eminence, the dimensions of the mandible and the maxilla, and intermaxillary relations were measured. The articulating surface of the glenoid fossa was steeper in the soft group, the lower border of the articulating eminence was located more inferiorly, and the mandible was more retrognathic. It is concluded that the difference in functional stress affects the shape of the articular eminence and the intermaxillary relationship. When the condyle is functioning more on the eminence, the latter becomes flatter, and the mandible moves forwards. ☐ *Articular surface; mandibular growth; masticatory function; temporomandibular joint*

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The morphology of the glenoid fossa can be affected by alterations in the functioning of the condyle. Thus a change in the location of the condyle in the fossa has been induced by inserting a functional appliance either into an experimental animal (1–3) or into the human mouth (4) or by displacing the glenoid fossa distally in rabbits (5). Moffett et al. (6) and Hinton (7) have shown a relationship between the amount of masticatory function and remodeling of the glenoid fossa in adult humans. On the other hand, formation of the glenoid fossa depends on the existence of the condyle (8).

A correlation between the shape of the glenoid fossa and the configuration of the mandible has been demonstrated in humans. Ingervall (9) found the height of the tubercle and the inclination of the condylar path to be associated with facial morphology, in that the tubercle tends to be high in persons with a curved mandible and low in persons with a straight mandible, whereas Kantomaa (10) suggested that the direction of growth of the mandiblar condyle is influenced by the inclination of the articulating surface of the fossa and that the direction of condylar growth affects the sagittal jaw relationship in rabbits (11).

The aim of this investigation was to determine whether masticatory function can produce changes in the shape of the articulating surface and the growth of the mandible in a rabbit.

Materials and methods

Forty-seven New Zealand rabbits of both sexes were divided into 2 groups at the age of 10 days—a control group of 20 and a soft-diet group of 27. The control group was fed whole pellets (Hankkija Oy, Finland) and water ad libitum, whereas the soft-diet group was fed softened pellets and water. The pellets were softened by moisturizing with water. The upper and lower incisors of the soft-diet group were shortened by cutting with a wire cutter once a week.

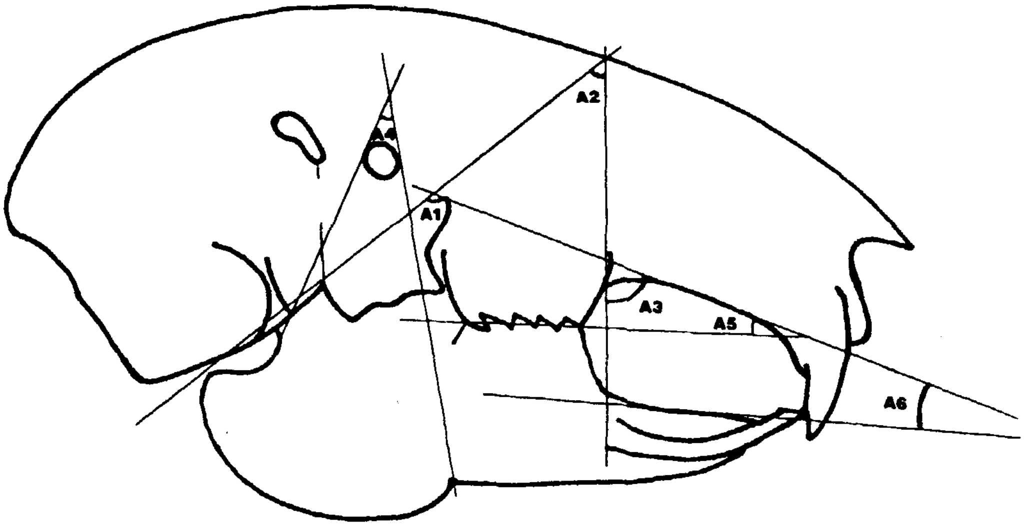

Fig. 1. Angles measured on the radiographs. A1 = angle between the palatal plane and the posterior cranial base; A2 = angle between the posterior cranial base and the line from the junction of the first upper molar with the jaw bone to the lower rim of the mental foramen; A3 = angle between the palatal plane and the line from the junction of the first upper molar with the jaw bone to the lower rim of the mental foramen; A4 = angle between the line from the lower border of the spheno-occipital synchondrosis to the posterior rim of the optic foramen and the line from the anterior rim of the optic foramen to the antegonial notch; A5 = angle between the palatal plane and the occlusal plane; and A6 = angle between the palatal plane and the plane of the floor of the mouth.

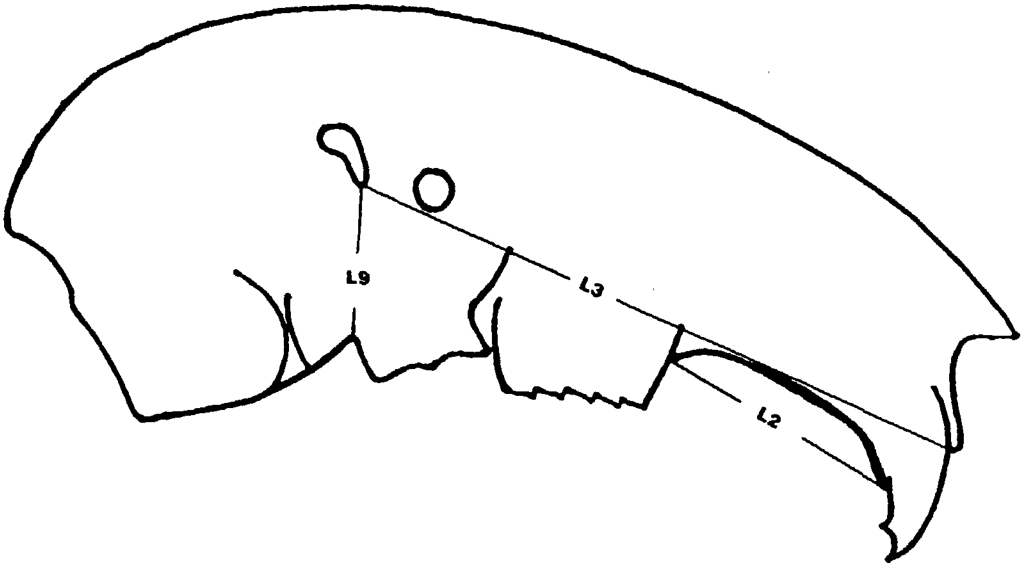

Fig. 2. Linear measurements made on the dry skulls. L2 = extreme anterior extent of the jaw bone between the incisors to the junction of the mesial surface of the first molar with the jaw bone; L3 = extreme anterior extent of the jaw bone between the incisors to the anterior border of the temporomandibular fossa; and L9 = the distance from the intersection point of the inferior surfaces of the medial pterygoid lamina and the sphenoid bone in the lateral view to the articular eminence.

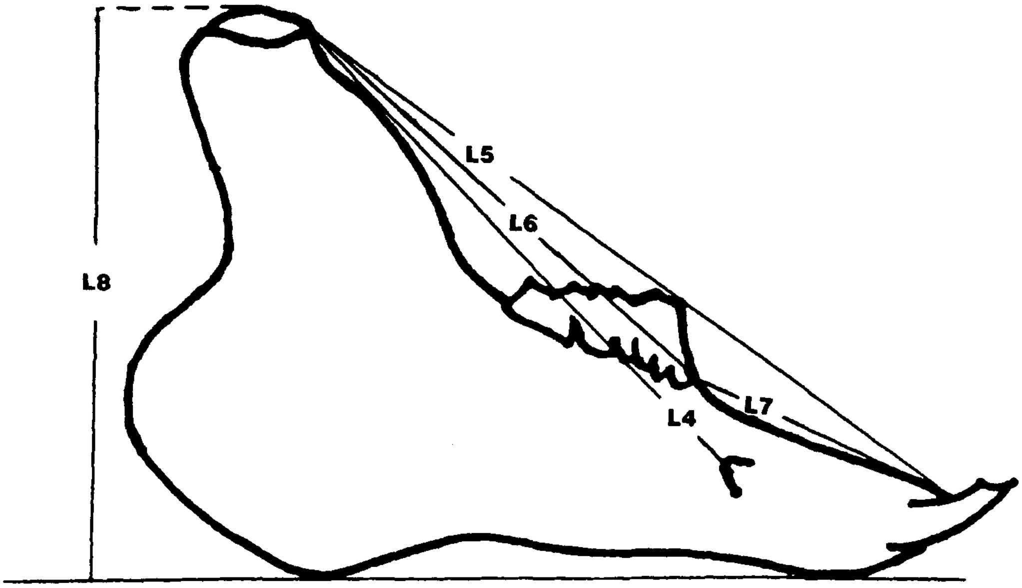

Fig. 3. Linear measurements made on the dry mandibles. L4 = distance from the posterior rim of the mental foramen to the anterior edge of the condyle; L5 = distance from the extreme anterior end of the jaw bone between the incisors to the anterior edge of the condyle; L6 = distance from the junction of the mesial surface of the first molar with the jaw bone to the anterior edge of the condyle; L7 = distance from the extreme anterior end of the jaw bone between the incisors to the junction of the mesial surface of the first molar with the jaw bone; and L8 = distance from the extreme superior surface of the condyle perpendicular to the tangent reaching the inferior border of the mandible.

All the rabbits were killed at the age of 50 days, whereupon their heads were frozen in an upside-down position and then roentgenographed in a standardized lateral projection (focus–film distance, 190 cm). The six angular measurements were made as shown and explained in Fig. 1.

The heads were freed of soft tissues. The extreme anterior extent of the jaw bone between the incisors and the anterior border of the foramen magnum (L1) and the three measurements shown and explained in Fig. 2 were made on the dry skulls.

The five measurements shown and explained in Fig. 3 were made on the dry mandibular halves.

To reveal the shape of the articular surface of the glenoid fossa, the deepest point of the greatest transversal concavity of the eminence was marked under the microscope, and the zygomatic process was cut sagittally at this point. The measurements shown and explained in Fig. 4 were made.

The differences between the groups were tested using Student's *t* test for small samples.

Results

The weights of the animals did not differ significantly between the two groups.

The angular measurements (A2, A3, A4) showed the lower jaw to be more retrognathic in the soft-diet animals than in the controls (Table 1). The angle between the palatal plane and the posterior cranial base (A1) did not differ significantly between the groups (Table 1). The measurement (A6) showed the mandible to be more posteriorly rotated in the soft-diet group (Table 1).

The cranial measurements (L1, L2, L3)

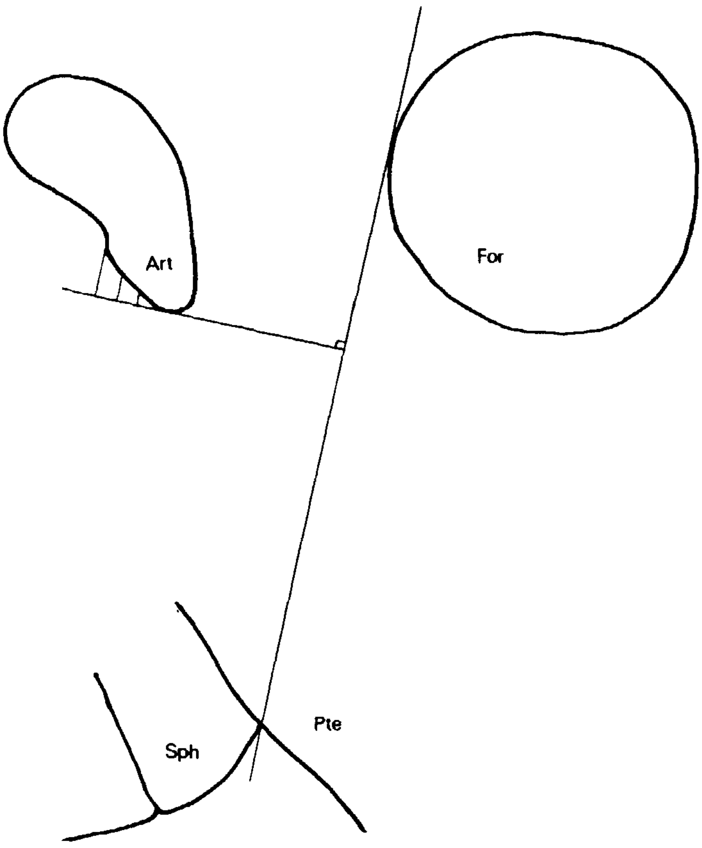

Fig. 4. The measurements of the articulating surface of the glenoid fossa were made anteriorly from the extreme posterior point of the articular surface in relation to the line from the intersection point of the inferior surfaces of the medial pterygoid lamina and the sphenoid bone in the lateral view to the posterior edge of the optic foramen. Art = articular surface; For = optic foramen; Sph = sphenoid bone; and Pte = pterygoid lamina.

did not differ significantly between the groups (Table 2).

The size of the mandible did not differ significantly between the groups except for an increased distance from the extreme anterior extension of the jaw bone to the junction of the mesial surface of the first molar with the jaw bone (L7) in the soft-diet group (Table 3).

The articular surface of the glenoid fossa was steeper in the soft-diet group (Fig. 5). The lower border of the articulating emi-

Table 1. Angular measurements performed on the control and soft-diet rabbits, in degrees

	Control		Soft diet		
Variable	*x*	SD	*x*	SD	Difference
A1	127.6	4.50	126.6	4.78	−1.0 NS
A2	59.8	3.81	55.4	4.10	−4.4***
A3	69.3	3.28	72.2	2.93	2.9**
A4	35.6	1.95	33.4	2.89	−2.2**
A5	18.9	3.29	18.7	2.47	−0.2 NS
A6	13.1	2.39	9.6	2.92	−3.5***

Controls, 20; soft, 27.
** $p < 0.01$; *** $p < 0.001$.

Table 2. Cranial measurements performed on the control and soft-diet rabbits, in millimetres

	Control		Soft diet		
Variable	*x*	SD	*x*	SD	Difference
L1	54.9	1.70	55.4	2.14	0.5 NS
L2	20.6	0.70	21.2	1.34	0.6 NS
L3	47.3	1.46	48.1	1.65	0.8 NS
L9	11.1	0.63	10.7	0.57	−0.4*

Controls, 20; soft, 27.
* $p < 0.05$.

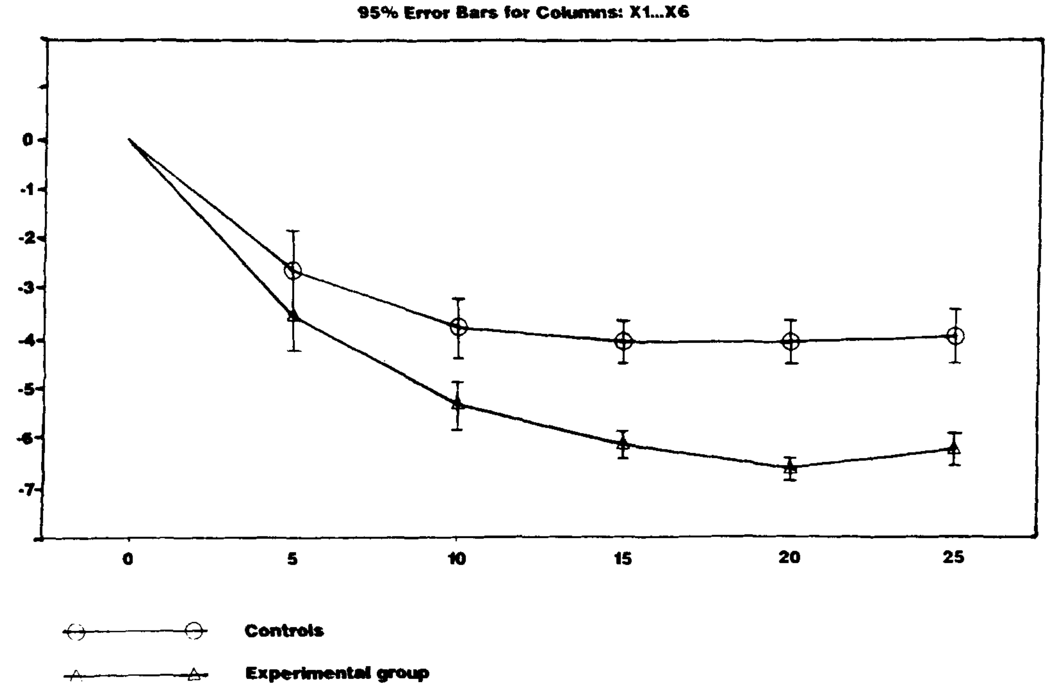

Fig. 5. Diagram of the shape of the articular surface of the glenoid fossa in control and soft-diet groups.

nence (L9) was located more inferiorly in the soft-diet group (Table 2, Fig. 6).

Discussion

Hinton's anthropologic investigations of human populations with different patterns of tooth use (7) suggested that dental function affects the shape of the articular eminence and the manner by which remodeling takes place, depending on the position of the condyle along the crest while under load. Investigations into movements of the lower jaw during mastication and biting in rodents have shown that the condyle remains in the anterior two-thirds of the fossa during biting (12), compressive forces being greater at the rat mandibular joint during incising (13), whereas cutting of the incisors will reduce the protrusion of the lower jaw (14).

Table 3. Measurements performed on the mandibles of the control and soft-diet rabbits, in millimeters

	Control		Soft diet		
Variable	x	SD	x	SD	Difference
L4	34.1	1.18	34.0	1.16	−0.1 NS
L5	44.0	1.50	44.9	1.82	0.9 NS
L6	30.3	1.08	30.1	1.03	−0.2 NS
L7	14.6	0.50	15.5	0.95	0.9***
L8	28.2	1.22	28.4	1.27	0.2 NS

Controls, 20; soft, 27.
$^{***}p < 0.001$.

The method used here, a soft diet and cutting of the incisors, obviously reduced the functional stress against the articular eminence, and the results provide further evidence of a relationship between masticatory function and the morphology of the glenoid fossa.

The inclination of the articular surface of the glenoid fossa was steeper in the present experiment when the functional pressure was reduced by cutting the incisors and feeding the animals a soft diet. Findings both supporting and opposing this result exist in the literature.

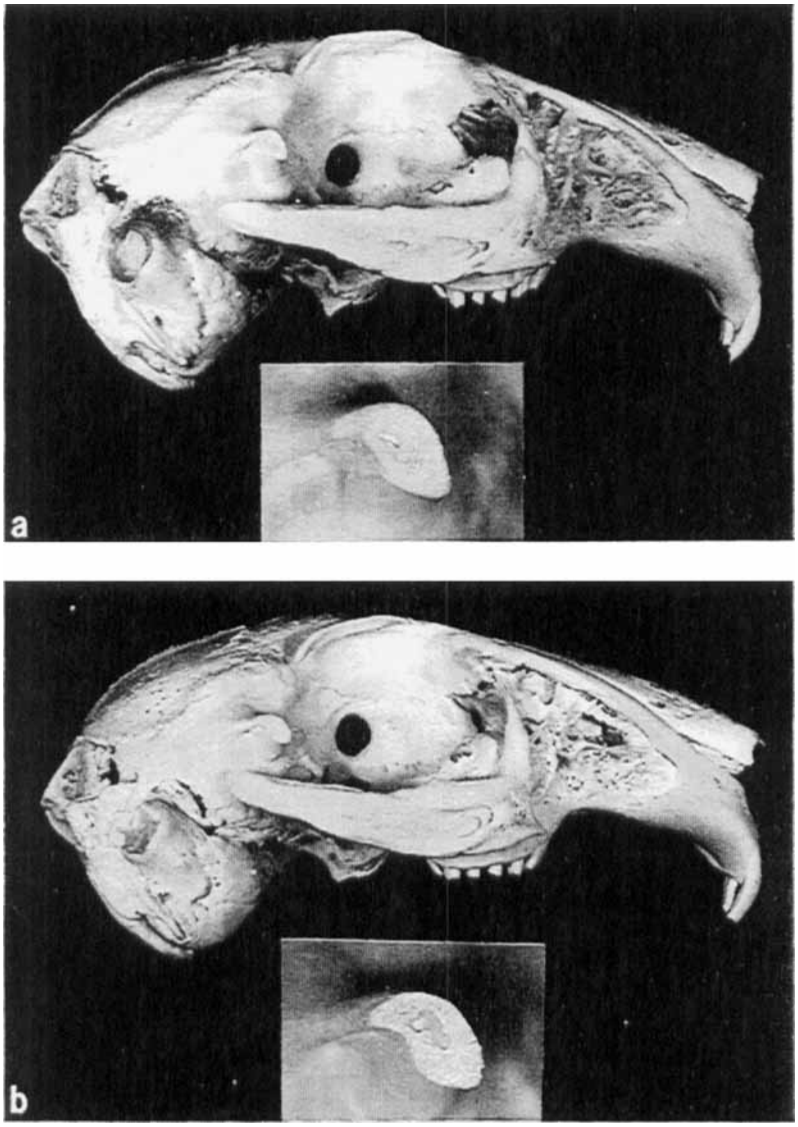

Fig. 6a. Skull of a control rabbit.
Fig. 6b. Skull of an experimental rabbit. The articulating surface of the glenoid fossa is more convex, and the lower border is located more inferiorly than in the control rabbit (Fig. 5a).

Breitner (1) in his animal experiments found bone resorption to occur under pressure against the articular fossa when the mandible was forced forwards. Shallowing of the fossa has been observed when the condyle is located more mesially in relation to it in rabbits—that is, on displacing the glenoid fossa distally by causing an artificial cranial synostosis (5, 15). Clinical observations point to flattening of the fossa in response to forward positioning of the fractured condylar head (16–18) and suggest that the function of the stump of the ramus after fracture of the condyle is to flatten the articular eminence.

On the other hand, Hinton (19) found resorption on the crest and posterior slope of the articular eminence in association with a lack of functional movements in juvenile monkeys. The assumption that the development of the glenoid fossa depends on function is supported by the findings of Stöckli & Willert (2) in monkeys and Thilander et al. (21) in man; the latter describe a zone of secondary cartilage on the crest and posterior slope of the articular eminence.

It is possible that the articulating eminence may react like the condyle, where an applied force can inhibit just as well as stimulate the rate of growth of the condylar cartilage, depending on the magnitude, exposure time, and mode of the force (22). The present findings show that an increase in function alone is not able to increase growth in the articular eminence and that we have to change either the exposure time or the mode of the force, whereas when a shallowing of the fossa is aimed at, a mere increase in functional stress will be sufficient.

It has been shown recently that the shape of the glenoid fossa affects the direction of condylar growth and the sagittal jaw relationship (11). When the glenoid fossa is shallow, the mandibular condyle can move forward more easily, and this could explain the more distal position of the mandible in this experiment, as the fossa was observed to become steeper in the soft-diet animals. On the other hand, the mandible could be situated more distally, since the protruder muscles are probably weaker in the soft-diet group because of reduced exercise. Kiliaridis (23) found reduced functional forces and changes in masticatory muscle contraction in rats fed a soft diet. The reason for the more retrognathic mandible could also be the posterior rotation of the mandible in the soft-diet group, as seen in the angle between the palatal plane and the floor of the mouth. The lack of attrition could cause overeruption of the molars and posterior rotation of the mandible.

The fact that the distance between the anterior and posterior teeth in the mandible tended to be longer in the soft-diet group could be explained by the observation that 16 of the 27 animals in this group had an edge-to-edge bite, but only 1 of 20 in the control group did. The lower incisors would have had the opportunity to incline forward when they were cut.

In conclusion, the change in functional stress affects the shape of the articular eminence and the intermaxillary relationship. When the condyle is functioning more on the eminence, it becomes flatter and the mandible can move forward.

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