Associations between the location of the glenoid fossa and its remodeling

An experimental study in the rabbit

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The growth of the glenoid fossa is assumed to follow that of the cranial base. It has been observed recently that distal displacement in association with an obtuse cranial base angle is reduced on remodeling of the fossa anteriorly as a consequence of a more anterior position of the condyle in the fossa. The aim of this investigation was to simulate the increased distal displacement experimentally by causing a premature artificial cranial synostosis. Ten 10-day-old rabbits underwent glueing of the interparietal and temporoparietal sutures. These and ten controls were killed at 50 days for examination, and the articular surface of the right glenoid fossa was marked with a soft metal wire. The skulls were roentgenographed in standardized lateral projection. The articular surface was significantly shallower in relation to the skull base in the experimental group, and the glenoid fossa was located more superiorly and posteriorly. The most likely reason for the more horizontal direction of the articular surface is the more anterior location of the condyle, exerting increased pressure on the eminence. This becomes important, as it has recently been shown that in rabbits this shallowing of the fossa is associated with increased forward growth of the mandible. □ *Articular remodeling; articular surface; craniosynostosis; occlusal function; radiography; temporomandibular joint*

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According to Björk (1), the glenoid fossa follows the distal displacement of the temporal bone in association with an obtuse cranial base angle during growth, as it is regarded as a superstructure of the cranial base. It has been assumed recently, however, that displacement is reduced with remodeling of the fossa anteriorly, as would follow from an anterior position of the condyle in the fossa, since the mandible is connected to the maxilla rather than following the glenoid fossa distally. Indeed, it has been shown that when a functional appliance is inserted either into an experimental animal or in the human mouth, the functioning of the condyle can change the morphology of the glenoid fossa (2, 3). However, when a functional appliance is inserted, the functional movements of the mandible may be far from normal and are in most cases decreased. The aim of this investigation was to simulate more closely the situation during normal growth, when the cranial base is obtuse and the glenoid fossa is displaced more distally than on the average. The increased distal displacement was caused by artificial premature cranial synostosis.

Materials and methods

Ten 10-day-old New Zealand rabbits of both sexes underwent exposure of the calvarium by a flap incision while under local (prilocaine) anesthesia. The interparietal and temporoparietal sutures were glued with methylcyanoacrylate (4, 5). Body weights were recorded at the start and end of the experiment. The control group of ten rabbits did not undergo this operation.

All the rabbits were killed at 50 days for macroscopic examination. The heads were freed of soft tissues and examined. The articular surface of the right glenoid fossa, which was nearer to the film, was marked with a soft twisted metal wire, which ran sagitally along the middle of the articular surface, to reveal the exact shape of the

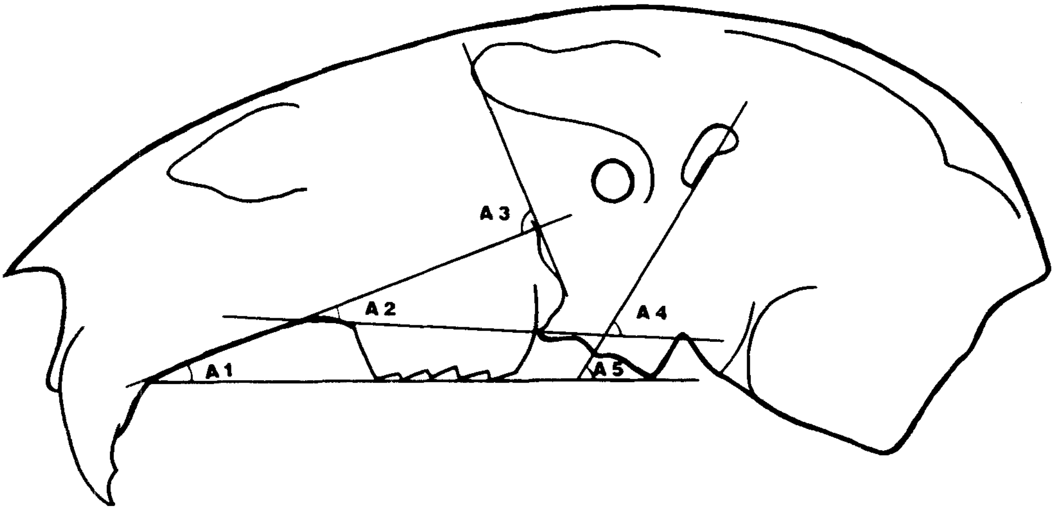

Fig. 1. Cranial angles measured on the roentenograms. A1 = angle between the anterior palatal and occlusal planes; A2 = angle between the anterior palatal plane and a line from the uppermost point on the inferior surface of the palatal plane to the intersection point of the inferior surfaces of the medial pterygoid lamina and the sphenoid bone in the lateral view; A3 = angle between the anterior palatal plane and a line tangential to the anterior cranial fossa and the posterior point of the alveolar bone of the maxilla; A4 = angle between the articular surface of the right glenoid fossa and the line from the uppermost point of the inferior surface of the palatal plane to the intersection point of the inferior surfaces of the medial pterygoid lamina and the sphenoid bone in the lateral view; and A5 = angle between the articular surface on the right glenoid fossa and the occlusal plane.

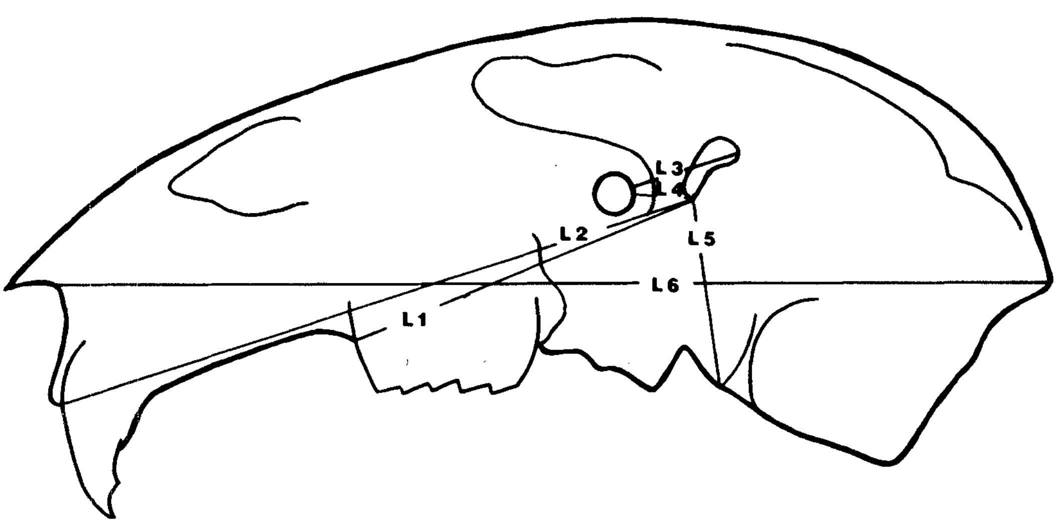

Fig. 2. Linear cranial dimensions measured on the roentgenograms. L1 = distance from the junction of the mesial surface of the first maxillary molar to the right articular eminence; L2 = distance from anterior extension of the upper jaw between the incisors, to the right articular eminence; L3 = distance from posterior edge of the optic foramen to the posterior point of the right articular surface; L4 = distance from posterior edge of the optic foramen to the right articular eminence; L5 = distance from the right articular eminence to the lower anterior border of the spheno-occipital synchondrosis; and L6 = longest saggital length of the skull.

Table 1. Angular measurements made on the lateral roentgenograms of 10 50-day-old experimental rabbits and 10 control rabbits

	Control		Experimental			
Variable	$\bar{x}$	SD	$\bar{x}$	SD	Difference	p*
A1	22.3	1.89	22.7	1.90	−0.4	0.460
A2	24.4	2.37	21.5	2.27	2.9	0.012
A3	90.0	4.90	88.0	2.21	2.0	0.260
A4	52.3	10.54	32.6	12.06	19.7	0.001
A5	50.8	6.27	30.9	15.16	19.9	0.001

* t test.

fossa for roentgenographic purposes. The roentgenograms were taken in standardized lateral projection, at a focus–film distance of 190 cm. The 11 measurements shown and explained in Figs. 1 and 2 were made on the roentgenographs. No corrections were made for magnification. The differences between the groups were tested with Student's t test.

Results

The animals tolerated the operation well and the weight gain was similar in the two groups. The articular surface of the glenoid fossa was significantly shallower in the experimental group, as measured in relation either to a line from the pterygoid process to the palatal plane (A4) or to the occlusal plane (A5), the mean difference ranging from 19.7° to 19.9° (Table 1 and Fig. 3). The glenoid fossa was more superiorly and posteriorly located in the experimental group (L1, L2, L3, L4, and L5 were greater). There was no significant difference in total skull length between the groups (L6) (Table 2).

The angles between the anterior palatal plane and the occlusal plane and between the anterior palatal plane and a line tangential to the anterior cranial fossa and the posterior point of the alveolar bone of the maxilla did not differ significantly between the groups (A1, A3) (Table 1).

The angle between the palatal plane and a line from the pterygoid process to the palatal plane (A2) was smaller in the experimental group (Table 1).

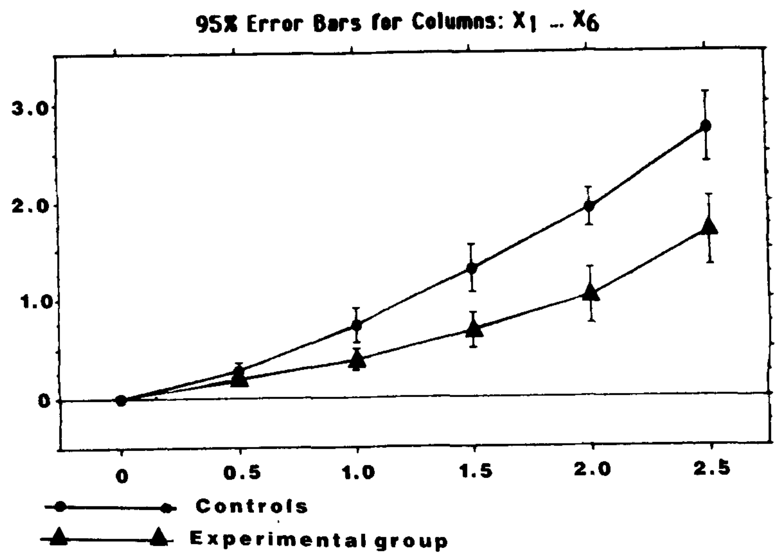

Fig. 3. The position of the right articular surface of the glenoid fossa in relation to a line from the uppermost point of the inferior surface of the palatal plane to the intersection point of the inferior surfaces of the medial pterygoid lamina and the sphenoid bone in the lateral view. The measurements are made posteriorly from the extreme inferior point of the articular surface, at intervals of 0.5 mm.

Table 2. Measurements (distances, L, in mm) made on the lateral roentgenograms of 10 50-day-old experimental rabbits and 10 control rabbits

Variable	Control $\bar{x}$	Control SD	Experimental $\bar{x}$	Experimental SD	Difference	p*
L1	26.8	0.72	28.2	1.72	−1.4	0.003
L2	47.3	0.82	48.9	1.92	−1.6	0.029
L3	7.1	0.23	8.7	0.80	−1.6	0.000
L4	3.7	0.69	5.6	0.68	−1.9	0.001
L5	13.7	0.91	15.5	0.61	−1.5	0.001
L6	71.8	1.70	71.9	2.36	−0.1	0.110

* *t* test.

Discussion

The results provide further clarification of the interrelations between articular function and the morphology of the glenoid fossa and between the location of the glenoid fossa and its morphology.

The experimental craniosynostosis obtained by glueing the cranial sutures has earlier been confirmed to be valuable in experimental craniofacial research (4, 5). With this method a selective synososis can be created in a specific area, not causing unnecessary traumas to the adjacent structures.

The inclination of the articulating surface of the glenoid fossa became considerably shallower when the fossa was moved posteriorly and superiorly with the aid of artificial cranial synostosis. The increased posterior and superior movement of the glenoid fossa is quite comparable to the phenomenon occurring during normal growth, in which, according to Björk (1) and Kerr & Adams (6), the glenoid fossa follows the distal displacement of the temporal bone in association with an obtuse cranial base angle. It has been noted in earlier experiments, however, that the mandible itself tends to follow the maxilla rather than the temporal bone, whereas the condyle becomes simultaneously more anteriorly located with regard to the glenoid fossa (5). The concordance between the jaws has been explained primarily by occlusal factors (7) or by the role of elastic soft tissues maintaining the relationship between the jaws (5).

Hinton's anthropologic studies (8) have shown a relationship between the amount of masticatory action and the shape of the glenoid fossa, and it is known that forced anterior relocation of the mandible also affects the morphology of the fossa in humans (3, 9) and in animals (2, 10, 11). While the amount of masticatory action and, obviously, its pattern may have changed in the investigations mentioned above, these aspects were not actively altered in the present experiment. Thus the most likely reason for the more horizontal direction of the articular eminence found here is the more anterior location of the condyle in the glenoid fossa, exerting increased pressure on the eminence. Whereas, in accordance with the model of Epker & Frost (12) as modified by Hinton (8) this would induce steepening of the articular eminence, the present findings indicate the opposite. It is possible that increased pressure simply slows down the growth of the eminence, analogously to the reactions of bone elsewhere (13) and to those of secondary cartilage, which also show diminished growth in response to increased pressure (14).

It must be remembered, however, that the continuous anterior relocation of the condyle used in this experiment is quite different from the intermittent anterior movement of the condyle on the eminence in association with masticatory function, which may well induce increased growth of the eminence, as formation of the fossa has been found to depend on the existence of the condyle (15).

So far, investigations dealing with mandibular growth have regarded the location of the condyle in the fossa as an important feature (16, 17), although more attention has been assigned recently to the shape of the glenoid fossa. A correlation between the configuration of the glenoid fossa and mandibular growth has been demonstrated in humans (18, 19), and experimental alteration of the contour of the articular eminence in the rat seems to affect the mandibular morphology (20). The shallowing of the fossa seen here, which is most likely caused secondarily by the functioning of the mandible, may thus further affect the direction of mandibular growth. This change seen in the contour of the eminence becomes important, as it has recently been shown (21) that this posterior relocation and shallowing of the glenoid fossa are associated in older rabbits with increased forward growth of the mandible. Furthermore, asymmetric growth of the mandible in association with a unilateral crossbite has been shown to be related to asymmetric remodeling of the fossa (22).

In conclusion, a marked shallowing of the articular surface of the glenoid fossa was achieved after its posterior and superior relocation in rabbits, which was in accordance with our recent experimental results with increased anterior mandibular growth during later development.

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