The Zygomatic Arch and its Possible Influence on Craniofacial Growth and Development

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A great deal of research has been conducted regarding the effects of rapid palatal expansion. Much of the work performed in this area was concerned with applications to increasing nasal air flow in the individual subject.[1-5]

Some of the more recent investigations have indicated that expansion achieved with this method varies in the amount of expansion achieved in different regions of the palate.[6-8] Wertz reported that the opening of the midpalatal suture was greater anteriorly than posteriorly by a factor of either 3:2 or 2:1.[6] Furthermore, he stated that the resistance of the zygomatic arch to opening forces applied inferior to the buttressing prevented the parallel opening of the maxillary segments. This finding, of a greater opening in the anterior region, has been confirmed numerous times in the literature.

It is quite likely that the zygomatic arch does provide a restraining force to the palate in the posterior region when an expansion appliance is employed and, therefore, may present some problems in treatment of individuals who require such an appliance. If the zygomatic arch is a source of resistance to palatal expansion, it is quite conceivable that this same structure may present some limiting or restraining influence on normal craniofacial skeletal development in both anteroposterior and/or lateral growth. This study was designed to evaluate the possible role of the zygomatic arch as an inhibiting and/or controlling mechanism in skull growth in the rat.

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MATERIALS AND METHODS

In this investigation 48 healthy male rats, approximately 30 days of age, were divided into four major groups. The first group (Group I) underwent surgery for the removal of a section of the left zygomatic arch. Because of possible variations in symmetry and variations in chewing habits, a second group (Group II) underwent similar surgery on the right side. In Group III both zygomatic arches were sectioned. The remaining group (Group IV) served as an unoperated control.

The surgery performed in the appropriate groups consisted of a vertical incision posterior to the orbit, cutting down to the zygomatic arch, which can be palpated at the masseteric origin. Next, a horizontal incision was made inferior to the lower border of the arch and a small hemostat clipped to the arch isolating approximately an 8 mm segment. Surgical scissors were used to cut the zygomatic arch on either side of the hemostat. The free-floating section was then removed by cutting any fibers of the masseter muscle which remained attached. Aureomycin ointment was then applied to the area of surgery: closure was achieved with wound clips. Ether anesthesia was used during all surgical procedures.

Dorsal skull radiographs were taken with occlusal size films at the following time intervals: pre-operatively, immediately postoperatively, and 4 and 12 weeks later. The X-ray apparatus (Fig. 1) consisted of a lead table on which

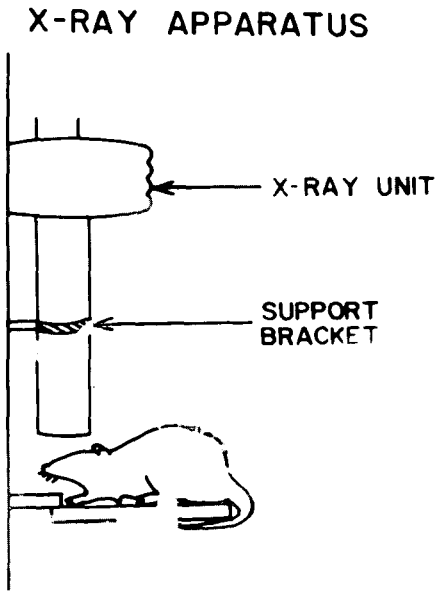

Fig. 1 Diagrammatic representation of the X-ray apparatus.

an occlusal film was placed. A small piece of plywood served as a support for the anesthetized rat. A long cone was used for the X-ray held in position by a wall mount which served to stabilize the cone. The rats were placed on the plywood table with their heads directly on top of the film. The exposure lasted for 1.6 seconds at a KVP of 55 and MA of 11. The orientation of the rat's skull during the X-ray procedure was random, since the measurements which were taken were linear and along the anteroposterior axis of the skull. It was felt, therefore, that any lateral deviations which might have occurred would not affect the measurements obtained. In view of this, no supporting or headholding apparatus was deemed necessary for the type of data collected. Tracings were constructed as follows: A line was drawn between the central incisors and projected back to basion. Perpendicular lines were then constructed to this reference line from

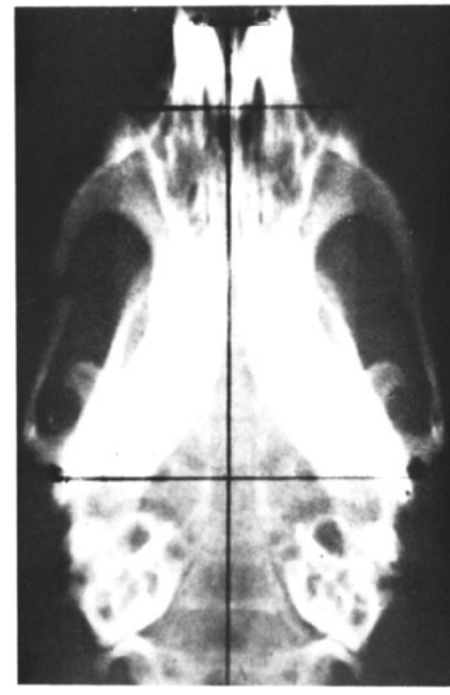

Fig. 2 Construction of tracing for analysis, superimposed on X-ray film.

the dentoenamel junction of the incisors, the anterior and posterior roots of the zygomatic arches, and basion (Fig. 2). When completed, the tracing divided the skull into three regions: 1) the DEJ of the incisors to the anterior root of the arch (anterior zone), 2) the anterior root to the posterior root of the arch (middle zone), and 3) posterior root of the zygomatic arch to basion (posterior zone) (Fig. 3). All findings obtained in this study were subjected to statistical analysis by means of the analysis of variance. All data presented in this study were obtained from the radiographs taken twelve weeks postsurgery. All the findings observed at four weeks were consistent with those found in the later stages with the exception that there was a lesser magnitude of growth or change noted.

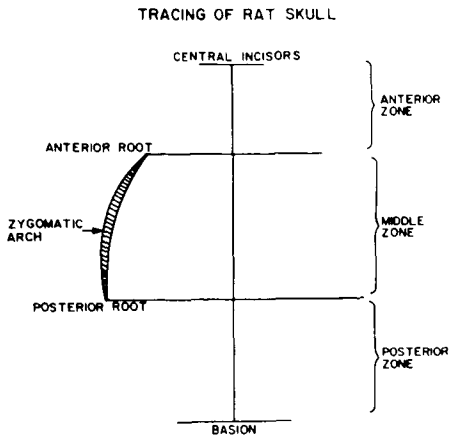

Fig. 3 Diagrammatic representation summarizing tracing procedure.

Findings

Examination of the anterior zone indicates that no significant difference existed between any of the groups after twelve weeks. The control group increased by 1.20 mm on the average. The unilateral surgery group increased by 1.19 mm and the bilateral surgery group by 1.33 mm.

In the middle zone the control group experienced a mean growth increase of 5.55 mm. The bilateral surgery group showed a mean growth increase of 3.60 mm. In the two groups in which unilateral surgery was performed, the same general decreased growth rate was observed. The mean growth increase of 3.08 mm on the intact side and 4.61 mm on the sectioned side was significantly less than the 5.5 mm noted in the control group (Fig. 4). This smaller dimension compared with the control amounts to 1.95 mm in the group in which bilateral surgery was performed, and 2.47 mm on the intact side and 0.94 mm on the operated side in the two groups in which unilateral surgery was performed.

In evaluating the middle zone, and specifically the groups in which unilateral surgery was performed, it was noted that there was a large difference

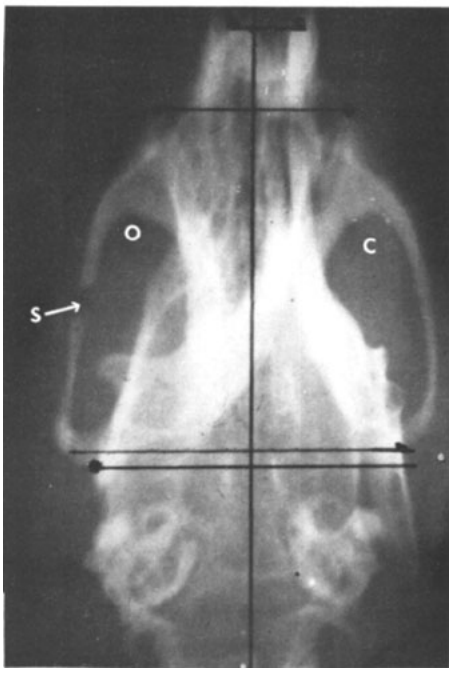

Fig. 4 Tracing obtained from unilaterally sectioned case. Note posterior displacement of zygomatic arch on operated side (o) as compared with control side (c). Surgical site (s) is indicated.

on the surgical side (4.61 mm) as opposed or as compared with the intact side in which the growth rate was 3.08 mm. This discrepancy is quite obvious and can be noted on many radiographs visually without a need for measurement. The smaller arch is on the intact side while the larger is on the surgical side in the middle zone (Fig. 4).

In the posterior zone a compensatory change appeared to occur in the groups in which unilateral surgery was performed. The intact side of the posterior zone showed a mean growth change of 2.73 mm compared with the sectioned side which increased an average of 1.54 mm (Fig. 5). This might indicate the possibility that the posterior root of the arch is being displaced posteriorly on the side in which surgery was performed unilaterally. In the groups in which a unilateral surgery

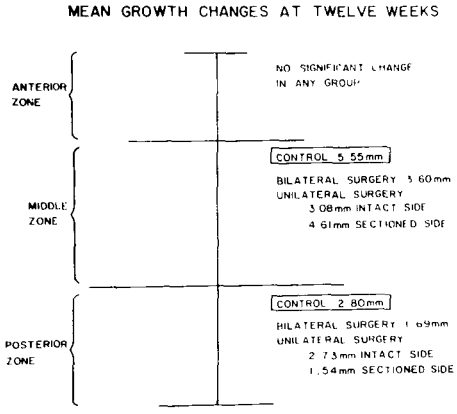

Fig. 5 Summary of statistical data by zone at 12 weeks.

was performed, further evaluation of the posterior zone indicates little change between the intact side and the surgically operated side as follows: On the control side there is a 2.08 mm increase, while on the operated side there is a 2.73 mm increase. If the posterior zone in the bilateral surgical group is compared with that in which unilateral surgery was performed, one finds that the growth change in the bilateral surgical group was 1.69 mm, which was statistically identical with the 1.54 mm increase noted on the sectioned side of the unilateral group. These latter findings tend to indicate a decrease in anteroposterior zygomatic arch dimension due to surgical intervention in this zone regardless of whether that intervention was a unilateral or bilateral surgical procedure. All data reported here were statistically analyzed and were significant in all instances at or above the 99.9% level of confidence.

Discussion

The data obtained in evaluating the posterior zone indicated a possible posterior displacement of the posterior root of the zygomatic arch. This may be related to the masseter muscle. If altered mandibular function influenced masseteric function, it may indeed influence the position of the posterior segment of the zygomatic arch while the skull is growing and developing.

The normal growth and development of the craniofacial complex may also act to produce the results reported here. Enlow and Bang,[9] in summarizing the growth and development of the zygomatic arch in humans, stated that the arch coordinates its development with that of the maxilla by progressively moving in a posterior direction. This serves to increase the entire maxillary body in an anteroposterior dimension. The possibility exists, therefore, that sectioning or removing a piece of the zygomatic arch may allow for a greater posterior displacement of the isolated posterior root than is permitted with the natural growth process.

The integrity of the zygomatic arch is apparently important for full development of the skull in the regions described above. In the control group the mean growth rate change in the middle zone was 5.55 mm, larger than in any of the surgical groups, thus indicating a more complete development of the zygomatic arches' growth potential.

Summary and Conclusions

This study was designed to investigate the role of the zygomatic arch and craniofacial growth along the anteroposterior axis. One may conclude that:

1. Surgical intervention on the zygomatic arch results in a generalized inhibition of regional zygomatic arch growth.

2. When only one zygomatic arch is sectioned, the posterior root of the sectioned side appears to be displaced posteriorly. This is a possible result of the normal growth process proceeding without the restraints of an intact zygomatic arch.

3. A decrease in anteroposterior dimension occurs in the posterior zone as a result of surgical intervention.

4. Further studies to determine the

influence of the zygomatic arch on transverse maxillary growth must be completed before any clear or complete concepts of its role in craniofacial growth and development may be more fully elucidated.

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