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A pilot study on the effect of alteration of the suprahyoid muscles on the growth of the marmoset monkey

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ABSTRACT – A pilot study was undertaken to determine the effect, if any, of alteration of the suprahyoid muscles on mandibular growth in the marmoset. It was postulated that releasing the attachment of the digastric and geniohyoid muscles at their junction with the mandible might produce a growth change in the rotation pattern of mandibular growth. Similarly, shortening these muscles might produce a different but significant growth change. Ten animals were used, five of which were controls. Two animals had their suprahyoid muscles sectioned, and three others had their suprahyoid muscles shortened by plication. The animals were examined with cephalometric radiographs at the commencement of the experiment and at specific intervals thereafter until they reached maturity (approximately 1½ years of age). The results indicate that releasing the digastrics and the suprahyoids at the mandible causes no significant change in the length of the mandible. Shortening of the suprahyoids through plication, however, appears to result in a notable change in the mandible and possibly the face. This study suggests that further research in this area may be fruitful in producing a primate model with a retruded genial area or a tongue protrusion by plication or otherwise shortening the suprahyoid muscles.

Extremely retrognathic and prognathic mandibles create functional and social problems. The question of when and how to alleviate these problems is attracting increased attention. Because abnormal growth patterns often persist to maturity, early prediction of a deformity may permit preventive intervention. Many procedures for changing growth patterns are being attempted; most require prolonged use of orthopedic type appliances. If a relatively benign procedure could be performed that would correct the adverse growth pattern, it could alleviate considerable psychologic trauma as well as reduce or eliminate the need for later extensive orthodontic and surgical procedures.

Additionally, if a model of the retrognathic mandible could be created easily, it would be beneficial to future research.

The present methods for producing jaw deformity models by the use of orthopedic appliances are difficult to perform in a primate[4,19]. Because alteration of muscle length may alter the shape or size of the mandible during growth, a pilot study was undertaken to identify what, if any, effect certain surgical alterations of the suprahyoid muscles might have on patterns of jaw growth.

It was postulated that the release of the attachment of the digastric and geniohyoid muscles at their junction with the mandible might produce a change in the rotation pattern of mandibular growth. Similarly, a shortening of these muscles might also produce a different but significant growth change.

Material and methods

For a pilot study which could be extrapolated to man, a primate model was desirable. For this model, accurate age determination was necessary, as was reasonably rapid maturation. Accordingly, the common marmoset *(Callithrix jacchus)* was selected. Ten animals were used, only one of which was female. Two of the animals were adults captured in the wild. The remaining eight were born in the colony.

The animals were allocated into three classes:

C – controls

S – those animals whose muscles were sectioned at the mandible

P – those animals whose muscles were shortened by plication.

Animals which were adult at the onset of the experiment were designated "a". Thus, the control animals will be referred to as C1a, C2a, C3, C4, C5; the sectioned animals will be referred to as S1, S2; and the plicated animals will be referred to as P1, P2, P3. The eight colony animals were from 6 to 7 months of age at the beginning of the experiment. This corresponds to approximately 6–8 years of age in the human. The marmoset attains full growth by 1½ years of age, and all animals had final records made after 1½ years of age, except P2 who died before complete maturity.

Lateral and anterior-posterior radiographs were made for all animals at the beginning of the experiment and at approximately monthly intervals until the animals were 12 months of age. After this, radiographs were made every 4 months until the animals had reached maturity (approximately 1½ years of age).

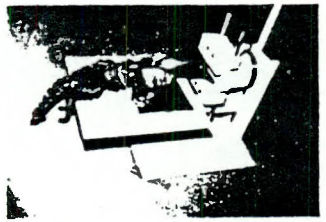


Fig. 1. A specially constructed headholder was used which was adjustable to accommodate the marmoset as well as the rhesus head. It also adjusted for lateral and posterior-anterior oriented radiographs.

A specially constructed head holder (Craniostat by Quint X-Ray Co., Inc., 1322 W. 12th St., Los Angeles, CA 90015) (Fig. 1) was used which was adjustable to accommodate the marmoset as well as the rhesus head size. The target film distance was 142 cm. Because the head of the marmoset is so small, it was desirable to magnify the radiographs for evaluation. Several methods were tried, and the best results were obtained using Translite film with 3.8X enlargement[1].

To evaluate the change in the mandible, a series of angles and linear measurements had to be devised for the lateral cephalometric radiograph as some of the human, as well as rhesus, landmarks were not appropriate for the marmoset. Basion (Ba) was a rather well-definable landmark. Nasion was not identifiable, but a substitute was found at the junction of the orbital roof and the internal surface of the calvarium, designated "supraorbital" (So). A cranial base line was thus constructed from Ba to So.

To assess the anterior-position of the symphysis of the mandible, an angle was used from Ba to So to a constructed menton (Me) (Fig. 2a). Menton was located at the point of intersection of the inferior border of the mandible and a line from So passing tangent to the most posterior point of the symphysis and on to the inferior border. The angle formed

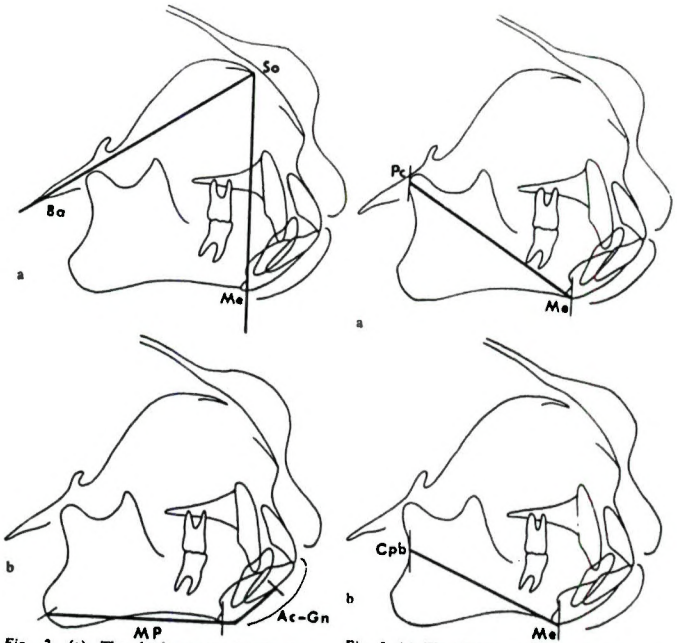


Fig. 2. (a) The basion-supraorbital-menton angle was used to assess the position of menton related to the cranial base. (b) The mandibular plane-anterior symphyseal plane angle was used to evaluate the change in symphysis rotation and dental compensation.

by the body of the mandible and the symphysis was measured by the usual mandibular plane (MP) intersecting with a plane from the anterior surface of the symphysis (Ac–Gn) (Fig. 2,b). Ac–Gn was constructed as a line from the labial alveolar crest paralleling the anterior symphysis to the anterior point of contact of the mandibular plane with the gnathion area. If the menton area is retracted or flattened, the symphysis angle will reflect the menton change and the lower incisor compensation.

Fig. 3. (a) The linear measurement from the most posterior point on the condyle to menton was used to assess the anterior-posterior length of the mandible. (b) The linear measurement from the most concave portion of the posterior border of the ramus to menton was used to assess the anterior-posterior length of the mandible.

The mandibular length was measured by recording the distance from Me to the most posterior point of the condyle (Pc) (Fig. 3a) and from Me to the most concave portion of the posterior border of the ramus (Cpb) which was usually more easily identified than the condyle (Fig. 3b).

Tantalum pins were placed, similar to the method of Bjork, in all animals except one, C2a.

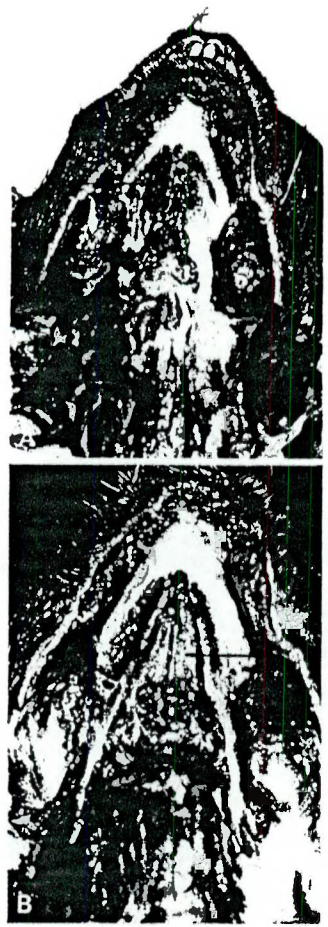
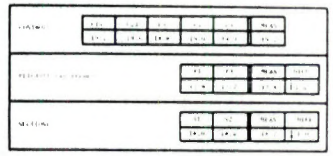
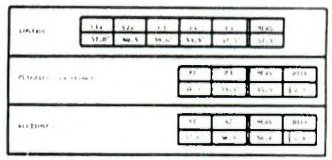


Fig. 4. (a) In the marmoset, the anterior bellies of the digastric muscles are fused with an aponeurosis. Immediately beneath lies the very thin mylohyoid. (b) After separating the anterior bellies of the digastrics and the very thin mylohyoid, the geniohyoid is easily identifiable.

Table 1. Length of mandible at maturity. A. Concavity of posterior border to menton in millimeters



B. Angles of basion, supraorbital, menton



Note anterior-posterior changes in the position of the symphysis related to the controls.

The surgical approach to the muscles was through a tongue-shaped skin incision along the inferior border of the mandible. A large magnifying glass with a peripheral light source expedited the dissection. The first muscles encountered were the anterior bellies of the digastrics which in the marmoset are fused by an aponeurosis (Fig. 4a). They were separated along with the very thin mylohyoid to expose the geniohyoids (Fig. 4b).

Three of the animals, P1, P2, and P3, had their digastric and geniohyoid muscles shortened by tenting the muscles and ligating them with plicating sutures.

In two of the animals, S1 and S2, the anterior bellies of the digastrics and the geniohyoids were released where they contacted the mandible. Marking wires were placed near the incised edges of the muscles. No other surgical procedures were performed.

Results

Because of the expense of a primate ex-

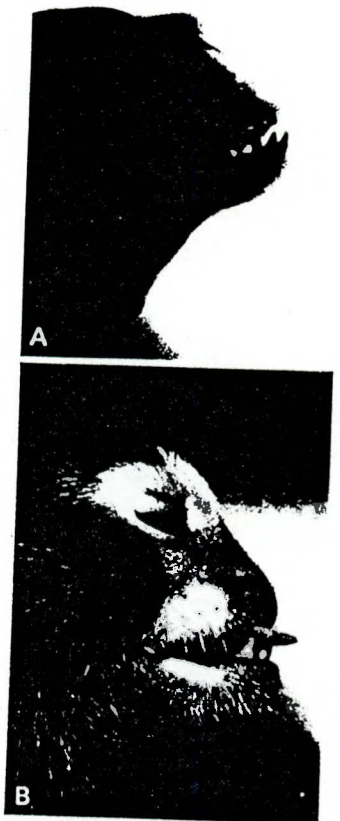
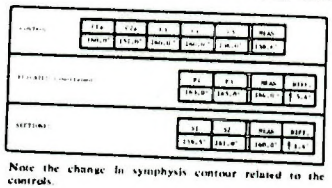


Fig. 5. Radiograph (a) and photograph (b) of the plicated animal, P2, showing protrusion of the tongue that was this animal's usual posture following shortening of the anterior bellies of the digastrics and the geniohyoid. Note the incisor open bite.

Table 2. Change of configuration at symphysis. Mandibular plane to gonion to alveolar crest



Note the change in symphysis contour related to the controls.

periment, a small number of animals was used in this pilot study. Although no firm conclusions can be achieved, the following inferences can be drawn.

Table 1A indicates that releasing the digastrics and the suprahyoids at the mandible appeared to cause no significant change in the length of the mandible, although a slight shortening was suggested by the 1.0 mm decrease in the mean of sectioned animals compared to the mean of the controls. Nor did the position of the symphysis of the mandible change significantly in relation to the cranial base (Ba-So-Me), as shown in Table 1B. This angle decreased by 0.75° in the mean of the sectioned animals compared to the mean of the controls.

One of the animals, P2, whose digastric and geniohyoids were plicated, had a markedly protruded posture of the tongue, although it could be contained within its dentition. A marked incisor open bite developed that was quite obvious 3 months after surgery. Figure 5a and b show a radiograph and a photograph at 5 months post-plication (10 months of age). This animal had the tip of its tongue bitten off by its cage mate at 1 year of age. In the next 3 months, the open bite tended to close, but the animal died at 15 months of age.

The other two plicated animals, P1 and P3, showed notable change in the mandible and possibly the face. Table 1A suggests that the length of the mandible was reduced in the plicated animals. There was a 1.4 mm decrease (7 %) in the mean length of the mandible compared with the mean length of the controls. Table 1B also indicates a shortening of the mandible as the Ba-So-Me angle decreased by 2.5°. Table 2 indicates that the angles formed by the inferior border and the anterior of the symphysis were notably more obtuse in the plicated animals than the controls, with a difference of 5.4 .

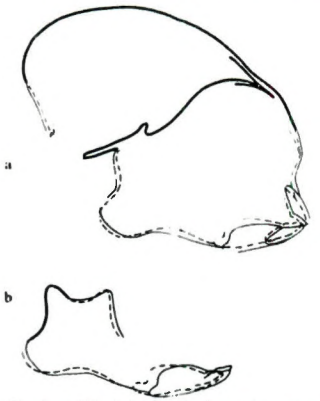
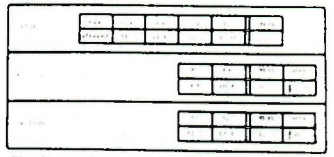


Fig. 6. (a) The bold line indicates the virtual exact fit of the crania of the littermates, control and plicated animals, C5 and P3. The dashed line indicates changes probably created in the facial bones of the plicated animal. (b) The bold line indicates the area of "best fit" of the posterior portion of the mandibles of the littermates, control and plicated animals, C5 and P3. The dashed line indicates the retrusion of the mandibular symphysis and dentoalveolar compensation probably created in the plicated animal.

Table 3. Distance of hyoid to menton. Anterior of hyoid to menton — in millimeters



The distance from the hyoid bone to the symphysis is greater in the sectioned animals and shorter in the plicated animals, as might be expected.

Overlaying tracings of the postoperative radiographs of the littermates P3 and C5 on a "best fit" basis (Fig. 6a) demonstrated a remarkable fit of the crania. The change in the facial bones suggested an inferior and posterior rotation in the plicated animal. The overlying of the tracings of the mandible in the posterior regions on a "best fit" test also showed a remarkable fit and a significant change in the symphysis of the plicated animal, P3 (Fig. 6b).

Table 3 illustrates the change related to the distance of the hyoid bone in all three groups. As expected, the distance was shorter in the plicated group and longer in the sectioned group.

Discussion

The use of marmosets for this study reaffirmed the ease of producing anesthesia with Saffan® (alphazalone and alphadolone) in these animals, as previously reported[1].

The use of colony-bred animals is advantageous in providing immature animals of similar ages. As previously noted, the relatively rapid maturity of these animals enhances their use in growth studies.

The use of marmosets in future growth studies is further enhanced by the production through this study of an apparently

practical method of lateral cephalometric analysis.

It is apparent through this study that the Bjork pin method of growth analysis is not practical in this animal, due to the extremely small size of the bones of the maxilla and mandible. Even the tiny Bjork pins often penetrate either too far into the bone or through the bone. Also, the position of the pins apparently changes with tooth eruption. The small size of the animals also makes this type of delicate surgery somewhat difficult.

This study suggests that further research in this area may be fruitful in producing a primate model with a retruded genial area or a tongue protrusion by plication or otherwise shortening the suprahyoid muscles.

While the sources of individual growth variations have not as yet been adequately identified, evidence is accumulating on the significance of the patterns of rotation of the maxilla and mandible during human growth[2,3]. The experimental method described in this paper would appear to offer the opportunity to study, in the near-human primate, some of the effects which changes in rotation patterns may have on the facial form.

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