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Nasal obstruction and skull base development: Experimental study in the rat*†

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SUMMARY

The influence of nasal obstruction on the development of the anterior skull base, of the tympanic bulla, and of the Eustachian tube was investigated in three groups of 20 albino Wistar rats in which one (group B) or both nostrils (group C) had been experimentally obstructed by means of synthetic resin mixed with radiopaque material. After two months, a cephalometric investigation demonstrated that the angle formed by the median line passing through the superior interincisive point and the most posterior median point of the occipital bone and by the line connecting the tympanic bulla and the superior interincisive point was significantly increased when the homolateral nostril had been obstructed if compared to controls (group A). On the basis of these preliminary cephalometric observations we suggest that nasal obstruction is able to determine anatomical changes of the superior maxilla, the skull base, and the jaw, with abnormal skeletal growth and consequent possible Eustachian tube dysfunction.

Key words: nasal obstruction, cephalometry, skull base development

INTRODUCTION

Several studies have emphasized the relationship that exists between nasal respiratory function and craniofacial development (Vig et al., 1981; Miller et al., 1984; Solow et al., 1984; Vaggervik et al., 1984; Jennings et al., 1985; Behlfelt and Linder-Aronson, 1988; Wenzel et al., 1988; Fricke et al., 1993).

Enlow (1982) has stated that balanced cranio-facial development was regulated by the principle of the 'counterparts'. Every part of the skull grows in harmonic relation to another region representing its skeletal counterpart. The supramaxilla behaves as the structural counterpart for the jaw, but also for the skull base. The correlation between the growth of the jaw and the supramaxilla has been emphasized both in animal (Harvold, 1975, 1979, 1981; Miller and Vagervik, 1980; Tomer and Harvold, 1982) and human studies (Adamis and Syropoulos, 1983; Solow et al., 1984; Recamier, 1985; Solow and Siersbaek-Nielsen, 1986; Hannuskela and Vaananen, 1987; Trask et al., 1987; Behlfelt et al., 1989), while the relationship between the development of the supramaxilla and the skull base (Moore, 1965, 1966; Moss, 1976) has been scarcely considered.

The aim of the present work was to evaluate the influence of nasal obstruction on the development of the anterior skull base and especially of the tympanic bulla and Eustachian tube.

MATERIAL AND METHODS

Albino Wistar rats at the 28th day of life were chosen because they show minimal genetic variability and the growth of their condyles and sutures is very similar to that of most mammals. The rats were divided into three groups of 20 animals each. The first group (A) was the control one; the rats belonging to the second group (B) underwent occlusion of the right nostril by means of synthetic resin mixed with radiopaque material, while those of the third group (C) underwent occlusion of both nostrils by the same material. After two months - i.e. the time needed to reach 90% of the complete growth - the rats were sacrificed and their skulls teleradiographied by means of a craniostat in the submento-vertical projection. Roentgenograms were performed on occlusal films of 75x57 mm and developed on inverted paper in order to obtain magnifications without imaging corrections. The following cephalometric investigation was performed in order to evaluate differences of the angle formed by the median line passing through point I (superior interincisive point) and A (the most posterior median point of the occipital bone), and the line connecting the N point (tympanic bulla) to the I point (Figure 1).

Statistical evaluation was performed by means of the Student's t-test.

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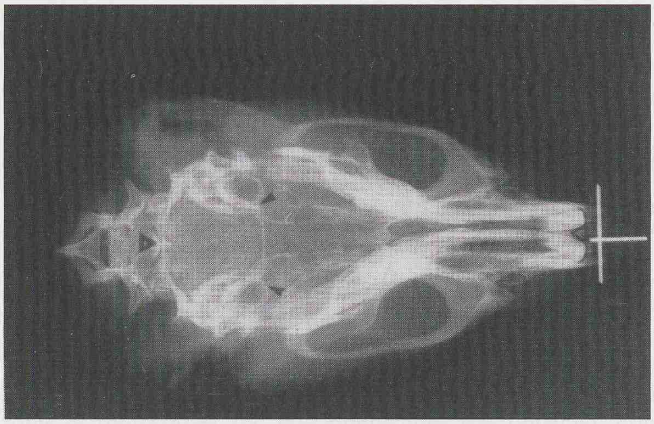

▷ : posterior occipital point
▶ : superior interincisive point
► : tympanic bullae

Figure 1. Roentgenogram of rat with cephalometric reference points used in this study.

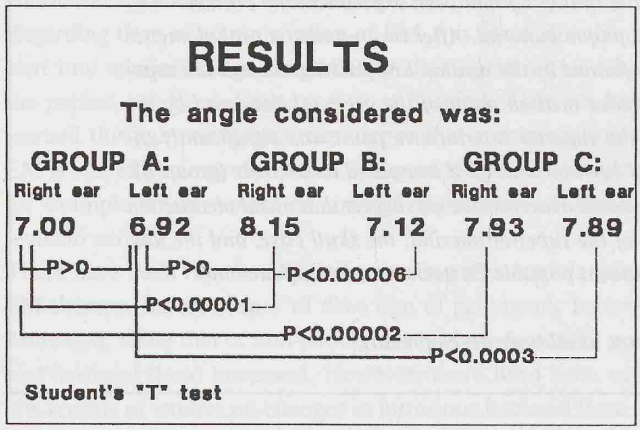

Figure 2. Statistical significance of the angles measured.

RESULTS

In group A the considered angle was 7.00±0.3° on the right side and 6.92±0.4° on the left one. In group B it was 8.15±0.7° on the right side (i.e. homolaterally to the obstructed nostril), showing a statistically significant increase ($p < 0.00001$) in comparison to the same side of group A.

The left angle of group B rats was 7.12±0.5°, showing no significant difference with the same side of group A rats. In group C the angles were 7.93±0.5° on the right side and 7.89±0.7° on the left side, showing both a statistically significant increase (right side $p < 0.00002$; left side $p < 0.0003$) when compared with group A rats. In group B we observed a statistically significant difference ($p < 0.00006$) between the right and the left sides; this difference was not significant in group A, nor in group C (Figure 2).

DISCUSSION AND CONCLUSIONS

Although animal conditions cannot be directly reproduced in human beings, we believe that our animal model is particularly interesting because: 1) albino Wistar rats represent a homogenous population, excluding marked interindividual genetically-induced differences in the development of the skull base; and 2) the anterior base of the skull in the rat is the equivalent of the limit between the neurocranium and viscerocranium that can be observed in human beings and its growth is related to the latter (Moore, 1966).

These preliminary cephalometric observations show that nasal obstruction is able to determine an increase of the angle between the median line and the tympanic bulla. These anatomical changes are probably due to the fact that respiration becomes oral and new groups of muscles are activated (Harvold, 1979; Miller and Vargervick, 1980; Tomer, 1982; Helling et al., 1986). Growth direction of skeletal structures of the skull base and even bone deposition mechanisms (Harvold, 1968, 1979) are affected in the experimental animal. The anatomical changes of the superior maxilla, skull base and jaw, and of the inserted muscles, may cause insufficient function of the peritubaric muscles. The development of cranio-facial cavities such as the rhinopharynx is also influenced by anomalous skeletal growth and this may relate with Eustachian tube dysfunction and consequently with the occurrence of secretory otitis media (Niemela, 1994).

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