Pneumatization of the Temporal Bone in Children with Cleft Palate

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Alterations of cranio-facial growth have been extensively studied in the cleft palate patient utilizing radiographic methods. The effect of cleft palate on the ear has usually been studied by audiometry and physical examination and little has been noted of the radiographic changes. During case presentations we have frequently observed a marked decrease in the pneumatization of the temporal bone when cephalometric studies were presented for discussion. This observation was previously made by Harvold (*6*) as an incidental finding: "the pneumatization was so strikingly abnormal... the structure of the cell system was compact". The observation is important to our understanding of the pathogenesis of ear disease in cleft palate patients and, if substantiated, would furnish evidence as to the age of onset and the mechanism for the high incidence of otitis media. The purpose of this study was to compare the pneumatization of the temporal bones of normal and cleft palate children.

Method and Results

The cephalograms of 68 cleft palate patients and 68 normal children ranging in age from 2 to 8 years were studied. All cephalograms were selected primarily on the basis of satisfactory definition of the air cell system of the temporal bone. These studies were obtained from the Growth Center at Children's Hospital of Philadelphia. Our method was to trace the pneumatized temporal bone region of each cephalogram and measure the total area (in cm^2) with a planimeter, as shown in Figure 1 (*8*). The average ages and standard deviations for each age group are listed in Table 1 and plotted in Figure 2. Comparison of these mean values using a paired t test reveals no difference at the 2-year level, but from 3 to 8 years significant differences are noted between

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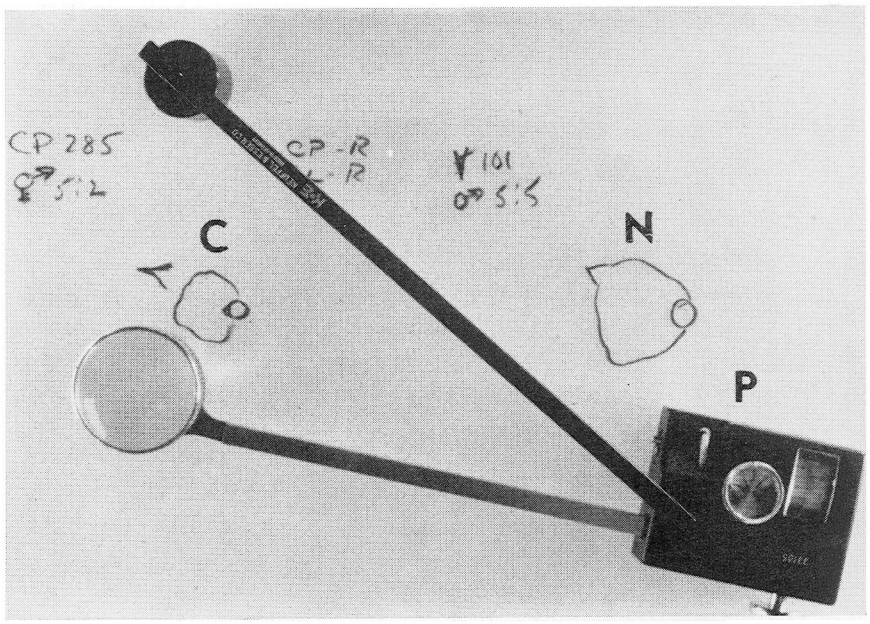

FIGURE 1. Typical tracings of pneumatized areas from a cleft and normal 5-year old are shown with the planimeter used for measurements. C-cleft palate, N-normal, P-compensating polar planimeter.

the cleft palate and normal children. As indicated in Table 1, the differences between the means at the 3- to 8-year levels are highly significant.

Comment

The process of pneumatization of the middle ear and related air cells has intrigued anatomists for many years (*1*). This process begins in the neonatal period when the embryonic connective tissue is replaced by

TABLE 1. Area of pneumatized temporal bone in normal and cleft palate children. Mean areas are in cm². Asteriked *t* values are significant at the .005 level.

age in years	*normal*			*cleft palate*			
	N	*mean area*	*SD*	*N*	*mean area*	*SD*	*t*
2	6	2.40	.36	10	2.46	.36	0.29
3	15	5.36	1.39	14	2.51	.67	4.83*
4	8	4.83	.42	9	3.10	.95	4.67*
5	10	6.20	.75	12	4.07	1.13	4.95*
6	10	7.39	.82	6	3.95	1.46	5.05*
7	10	9.00	.87	7	4.92	1.25	8.91*
8	10	10.87	1.23	8	6.00	.56	13.61*

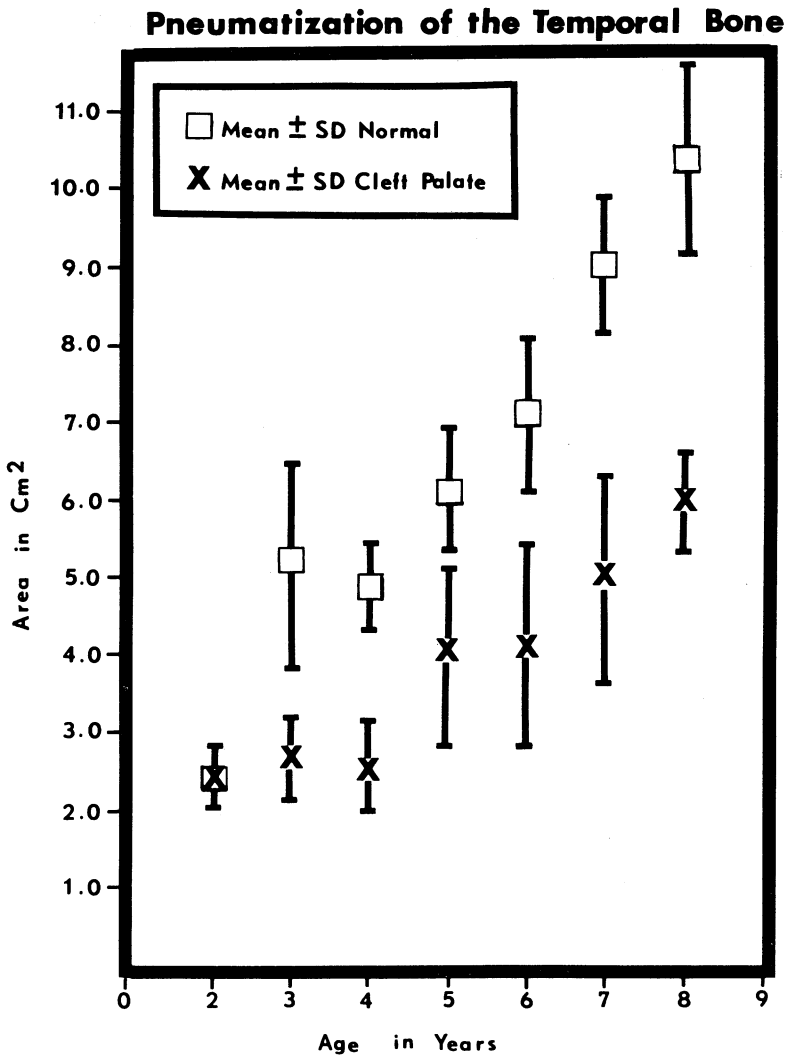

FIGURE 2. Mean areas and standard deviations of pneumatized areas of temporal bones. Marked differences between the cleft and normal population after age 2 years is apparent.

air, and proceeds until adolescence, unless there is an intervening insult to alter its course. There are slight sexual and racial variations. The controversy of whether this process is governed by genetic factors or environmental factors is similar to the discussion regarding the etiology of cleft palate. These questions await further investigation and, in all probability, both mechanisms may operate in some patients. In support of the environmental theory would be the previous demonstration of the high incidence of infantile otitis in the cleft palate patient (*9*). Failure of pneumatization, as demonstrated in the present study, supports the finding that ear disease begins in early childhood.

The penumatic system of the ear includes the eustachian tube, middle ear, and a group of interconnected air cells. This system is shown diagrammatically in the left half of Figure 3. The air cells are frequently referred to as the mastoid; however, they occupy most of the temporal bone. The eustachian tube functions to provide a continuous supply of air to the middle ear and mastoid, and acts as a drain for fluid that may accumulate in the middle ear. The tympanic cavity houses the ossicular chain, and its lateral wall (the tympanic membrane) responds to the vibration of sound. The tympanic membrane and ossicles function best when the middle ear pressure equals the external ear pressure. One function of the air cell system is to act as a reservoir of air to the middle ear. The blood supply for the mucosa of the middle ear is great in contrast to that of the mastoid; therefore, gas exchange occurs at a faster rate in the middle ear.

The significance of decreased pneumatization becomes apparent when one considers the age range included in this study, the childhood years during which there is a marked increase in respiratory infections. Respiratory infections will interfere with eustachian tube function as any adult who has had a "cold" and has noted a feeling of "stuffiness" in the ear will attest. The infant or child may experience this but will not be articulate enough to complain. A child who has frequent "colds" and a small pneumatized mastoid will be at increased risk in developing pathological changes in the middle ear. This occurs in the following manner. The respiratory mucosa of the nasopharynx, eustachian tube and middle ear are continuous. A "cold" results in loss of

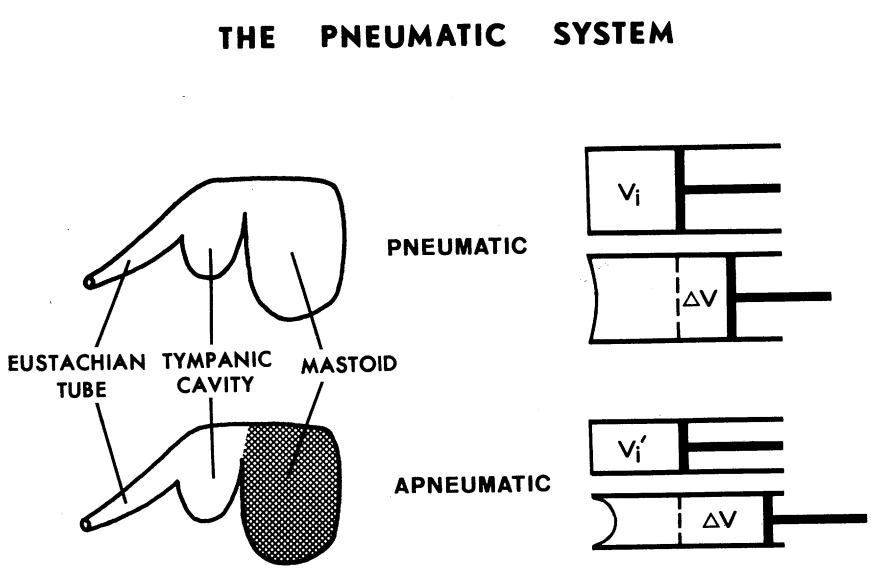

FIGURE 3. The pneumatic system included the Eustachian tube, tympanic cavity and mastoid. The effects of pressure changes in systems of unequal volumes are diagrammatically represented.

function of the tube due to edema of the mucosa (*3*). With loss of tubal function the middle ear may also be subjected to pressure changes because oxygen is absorbed from the middle ear through the mucosa creating a negative pressure in the middle ear. This is a normal phenomenon in the middle ear where a slight negative pressure usually exists and is relieved when the child swallows and the tube opens. In the child with a respiratory infection and a small air system this may be exaggerated and the increased negative pressure results in a "locking phenomenon" preventing the tube from opening (*4*). Negative pressure develops in the middle ear and the tympanic membrane becomes retracted. This is illustrated in the right half of Figure 3. Removal of an equal volume of air from unequal reservoirs results in more distortion of a movable membrane in the smaller reservoir. The middle ear becomes filled with fluid. This fluid, which may be thick or thin, further decreases the function of the eustachian tube. The retracted tympanic membrane plus the fluid interferes with hearing. In order to break this cycle, restoration of tubal function and removal of fluid is necessary. In the vast majority of normal individuals this occurs spontaneously; however, in a child with a cleft palate who may have marginal tubal function this may not occur and a permanent alteration of hearing may result. If the child had a normal air system he would be able to compensate for the minor pressure changes and maintain normal physiologic relationships. This would avoid repeated pressure changes in the ear with the subsequent alteration of the tympanic membrane and mucosa. The most serious alterations of the tympanic membrane subjected to repeated insult are loss of elasticity and collapse of the membrane against the medial wall of the middle ear.

There are very few reports describing radiographic study of the ears of cleft palate patients (*2, 5, 6, 7*). This is surprising when one considers the large number of studies performed for the evaluation of various aspects of craniofacial growth. It is the hope of the authors that others will add the available knowledge concerning findings in the temporal bone. This information may ultimately aid in the evaluation of procedures such as early palatal closure, myringotomy and the use of prosthetic devices.

Summary

Comparison of cephalometric studies in 68 cleft and 68 noncleft children 2 to 8 years old revealed significantly less pneumatization of the temporal bone in children with cleft palate.

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