The Influence of Primary Unilateral Cleft Lip Repair on Facial Growth

Part I. Lip Pressure

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The *lip pressure* exerted by the *repaired cleft lip* was studied in 35 *rabbits* during a 20-week period. Animals were divided into four groups. Two of them were controls, and in the other two, two different surgical procedures were used for the lip repair. The results of this study indicate that there was reduction in lip pressure resulting from the surgically induced cleft lip, alveolus, and palate. Substantial increases in lip pressure were shown in both groups in which lip repair was completed. The influence of primary unilateral cleft lip repair on the facial growth of rabbits in this study will be presented in Part II of this report.

Introduction

The notion that facial growth inhibition in individuals with cleft lip and palate is primarily the result of palatal surgery is widely accepted. Although there is some evidence for that position from work such as that reported by Graber (1949, 1950, 1954); Herfert (1954, 1956, 1958); and Kremenak *et al.* (1957, 1970, 1971), nevertheless, the question is by no means fully resolved. Certainly, we believe that the continuation of such studies is necessary, but it is also necessary to evaluate the influence of lip repair on facial growth, either as a primary factor, or as a factor interacting with palatal surgery.

When considering surgical procedures as a main cause of facial growth inhibition and secondary maxillofacial deformities, it should be pointed out that, in children with cleft lip and palate, the operation on the palate is the second one to be performed. Primary lip repair in such patients is done earlier than the palate repair, and most surgeons perform it at the age of approximately three months. Palate repair is usually performed between the ages of 12–24 months. This sequence of surgical procedures should be taken into account when considering the influence of cleft lip and/or cleft palate repair on the inhibition of facial growth.

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Presently, primary lip repair apparently is not considered to be a highly probable cause of inhibition of facial growth, although there are some marginal remarks and a few publications which indicate that it may have such an effect (Law and Fulton, 1959; Hagerty and Hill, 1963; Bardach, 1967, 1973; Ritsilla, et al., 1973; Pruzansky and Friede, 1975). The only research involving animal study is that reported by Ritsilla *et al.* These authors closed the natural median "cleft" of the upper lip in rabbits and described subsequent changes in growth of the maxilla and mandible. Ritsilla *et al.*, however, have not yet, to our knowledge, reported any data from this study, and we know of no other clinical or animal longitudinal growth studies from which data have been published. We are convinced that there is great need for such research and have begun a project consisting of four studies designed to provide data about whether cleft lip repair may influence facial growth and how it interacts with the cleft palate repair.

The study reported here was designed as a preliminary test of whether the primary lip repair may result in increased pressure on the maxillary segments and subsequently inhibit facial growth in rabbits. This report contains data on postsurgical changes in lip pressure only. A subsequent paper will present information obtained in this same study by techniques involving direct cephalometry and measurements of maxillary casts.

Hypothesis

The basic hypothesis is that the pressure of the repaired cleft lip is an inhibitor of facial growth. Primary lip repair always results in some tension in the repaired lip which is transferred as pressure to the maxillary segments. This pressure may constitute a significant variable in the set of potential modulators of middle facial growth.

Material and Methods

Six-week old New Zealand white rabbits all weighing between two and three pounds were used in this study. The choice of animal was based on the experience of Verwoerd-Verhoef (1974) who published observations of the secondary deformities occurring in rabbits after the surgical creation of various types of cleft.

Our rabbits were randomly assigned to one of the following four groups:

Group I, six animals: unoperated controls

Group II, nine animals: surgically created cleft lip, alveolus, and palate—no repair

Group III, nine animals: surgically created cleft lip, alveolus, and palate—lip repair using rotation advancement technique (Millard type of repair)

Group IV, nine animals: surgically created cleft lip, alveolus, and palate—lip repair using two triangular flaps (Bardach type of repair.)

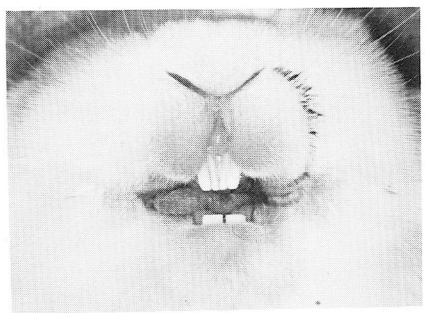

FIGURE 1. The portion of the upper lip to be excised is limited medially by the margin of physiological cleft and laterally by the ink mark.

All surgical procedures were performed during the rabbits' seventh postnatal week. After properative pressure determinations had been recorded, the animals were anesthetized by an intravenous injection of pentobarbital solution. Maxillary impressions were then taken, and casts were poured.

The cleft of the lip, alveolus, and hard palate was then created surgically in animals in Groups II, III and IV. The length of the upper lip was measured as the distance from the anterior border of the buccal pouch to the median line (Figure 1). One-half of this distance was the portion of the lip removed unilaterally (on the left side). The excised portion of the lip extended laterally from the median line and included the nasal sill. Creation of the cleft in the hard palate was performed by removal of a strip of tissue 4 mm wide, including the oral mucoperiosteum, the horizontal processes of maxillary and palatine bones, and the nasal mucoperiosteum (Figure 2). Finally, the alveolar portion of the cleft was created by removal of a portion of tissue 5 mm wide just lateral to the maxillary incisor. The result of the surgical procedure was a complete unilateral cleft of the lip, alveolus, and hard palate.

Cleft lips in the animals in Group II were left unrepaired. Lip repairs were performed in animals in Groups III and IV immediately after creation of the clefts and by two surgical methods which are completely different in concept (Millard type of repair and Bardach type of repair). These two surgical techniques were used to determine whether or not they result in different lip pressures.

All animals were sacrificed after twenty weeks of observations and periodic measurements of lip pressure. Length of the observation period was chosen after reviewing data reported by Engdahl (1972) who concluded that the growth of the facial skeleton in rabbits was essentially completed by the 20th postnatal week.

The following data were collected:

(a) Periodic measurements of the amount of pressure exerted on the maxillary segments by the repaired and unrepaired lips.

(b) Direct cephalometry on the skull performed after sacrifice.

(c) Measurements on maxillary casts made from impressions taken before the cleft was created and at the time of sacrifice.

The present report, as noted above, contains a presentation of the longitudinal lip pressure data only.

Determinations of amount of pressure exerted on maxillary segments by repaired lips were made by use of a hydraulic transducer system which was designed and fabricated especially for this study (Figure 3). The pressure sensor was a Statham model P23Db arterial pressure transducer with a range 0–75 mm Hg. The transducer was connected by IV tubing three mm's in diameter to a fluid filled appliance molded from Dow Corning 382 medical grade Silastic (Figure 4). This appliance was shaped to fit between the anterior maxillary alveolus and the upper lip in rabbits. The dimensions of the appliance are 8.5 mm × 5 mm × 3 mm. The recorder was an Offner type R Dynagraph with a Beckman type 9803 strain gauge coupler, an Offner type 481 preamplifier, and a Beckman 482 amplifier. The transducer was calibrated by measuring the deflection on the polygraph produced by the hydrastatic pressure of a column of water. In our calibration, one mm of pen deflection equaled one cm of water pressure. Initially the transducer was calibrated daily and then at less frequent intervals after the system was found to be stable and consistent. Calibration accuracy was always to less than 0.5 cm of water.

Pressure determinations were made by placing of Silastic appliance between the upper lip and the anterior maxillary alveolus (Figure 5). Initially the appliance was kept in place one minute for laboratory conditioning of the animal. Ten successive individual pressure determi-

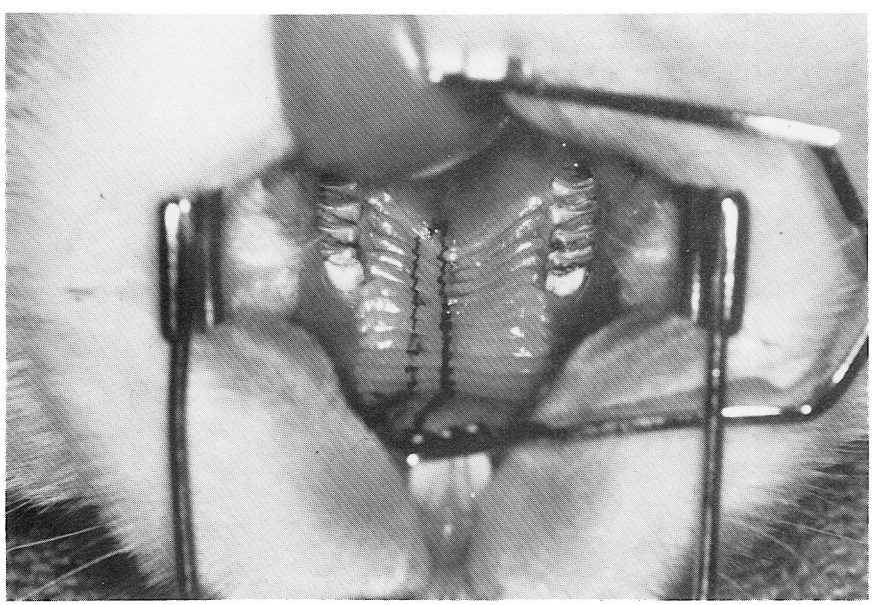

FIGURE 2. Ink marks indicating the strip of tissue to be excised from the hard palate and alveolus.

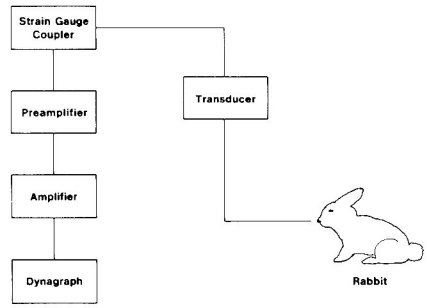

FIGURE 3. Schematic representation of the recording device for lip pressure determination.

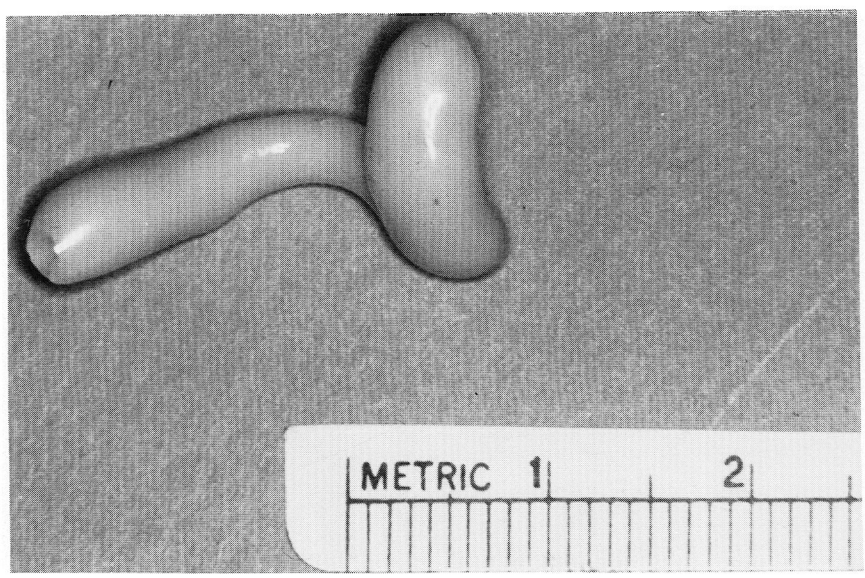

FIGURE 4. Prefabricated silastic appliance for lip pressure determination.

nations were taken. The first two were also used for laboratory conditioning of the animal. The last eight readings were averaged to obtain the mean pressure for each animal.

The first postoperative pressure determinations were made at two weeks, earlier determinations not being made to avoid trauma to the repaired lip. The second determination was at four weeks postoperatively, and subsequent determinations were made at four-week intervals.

Results

Mean pressure determinations for the four groups over the twenty-week period are shown in Figure 6. Lip pressure for the control group was relatively constant. It decreased markedly in Group II between the preoperative measurement and the two weeks postoperative measurement. Subsequently, lip pressure in this group remained relatively constant. Lip pressure measured two weeks postoperatively in Groups III

and IV showed peak increases to pressures more than four times as great as in the control group. The mean determination at two weeks postoperatively for Group IV was 8.5 cm of water higher than for Group III. The decrease in pressure for Group III was slower than for Group IV, but remained higher after the sixth week and through the end of the experiment. The lip pressure of Group IV showed a more rapid decrease, approached the level of the control group by the twelfth week, and remained nearly constant through the twentieth week.

Table 1 contains sample sizes, lip pressure means, and standard deviations for the four groups of rabbits studied. Sample size variations reflect the fact that two-week pressure determinations were missing for eight of the animals. Estimates of the missing data were obtained for analysis of variance statistics shown in Table 2 but were not incorporated into Table 1. The degree of freedom of residuals was adjusted for the missing data on Table 2.

Since our data resulted from repeated measurements, they were analyzed longitudinally to test for the significance of the observed profile differences over the period studied. A logarithm transformation, namely, log (measurement at x^{th} week) − log (preoperative measurements) was performed because the assumption of homogeneity of variances, based on the raw data, was violated. This assumption was checked again for the transformed data and showed no contradiction at $\alpha = 0.01$.

The analysis of variance was used to answer the question: Do the groups have significant dissimilar profiles over the period under study? The results obtained are presented on Table 2 and indicate that group profiles are significantly dissimilar ($F_{time} \times Group = 16.69 > F_{.01,15,137}$).

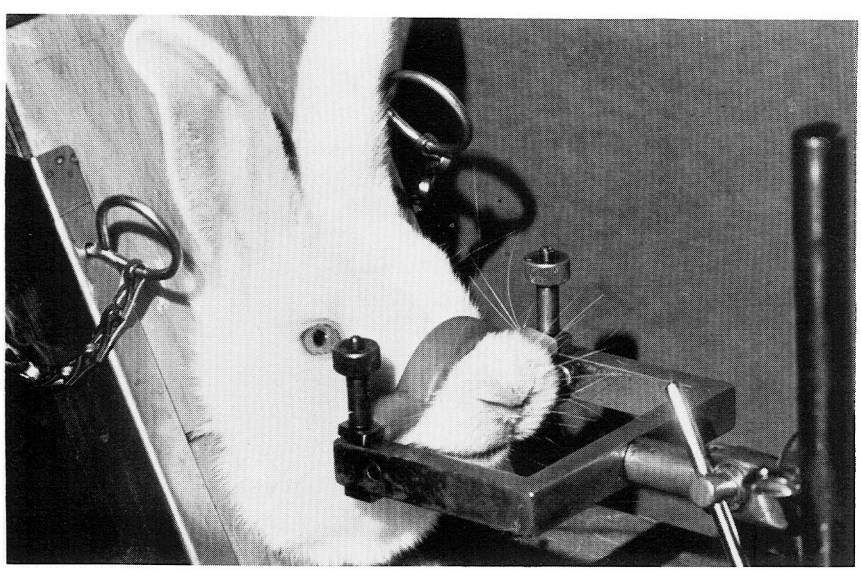

FIGURE 5. Rabbit headholder for the pressure determinations.

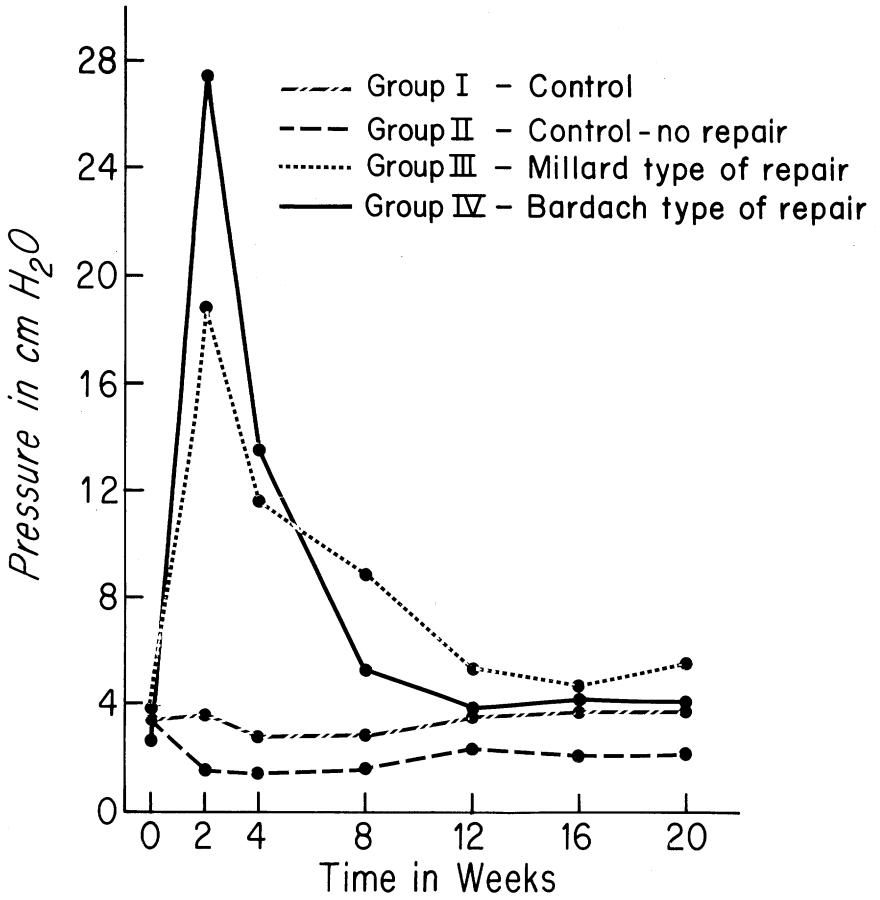

FIGURE 6. Lip pressure profiles.

They also indicate that there is significant difference among time means ($F_{time} = 33.58 > F_{.01,5,137}$). Since these groups are dissimilar, the comparison among group means is meaningless.

The results obtained in analysis of variance leads subsequently to the next question: Since group profiles are not similar, which groups are different from each other at given weeks after operation? To answer this question, pair-wise comparisons among groups were done using Tukey's test at each of the given weeks after operation. The results obtained are presented in Table 3. This table and Figure 6 were interpreted cross-sectionally and longitudinally.

A. *Cross-Sectional Interpretation*

1. The differences in mean lip pressure among the four groups were not significant before surgery. This indicates that all rabbits in the study were members of the same population in relation to lip pressure before any surgery was performed.

2. All pairs were significantly different from each other at two and four weeks after surgery except the pair composed of Groups III (Millard type of repair) and IV (Bardach type of repair).

3. Inspection of results at the end of the 20-week experiment showed that:

TABLE 1. Means and standard deviations of lip pressure in four groups

groups / *time after operation*	*control*			*control w/out repair*			*millard type of repair*			*bardach type of repair*		
	size	mean	sd	size	mean	sd	size	mean	sd	size	mean	sd
Pre-operation	6	3.43	0.69	9	3.44	0.59	9	3.74	1.16	9	2.79	0.63
2 weeks	3	3.93	0.55	7	1.71	0.54	6	18.90	7.64	9	27.41	11.98
8 weeks	6	2.87	0.44	9	1.60	0.84	9	11.57	4.51	9	13.51	7.14
12 weeks	6	2.97	0.58	9	1.74	0.72	9	8.93	5.12	9	5.09	2.03
16 weeks	6	3.52	0.35	9	2.36	0.74	9	5.18	1.70	9	3.86	2.66
20 weeks	6	3.75	0.60	9	2.06	0.61	9	4.82	2.32	9	4.12	2.90
	6	3.78	0.95	9	2.10	0.64	9	5.60	1.33	9	4.09	3.56

TABLE 2. Analysis of variances for lip pressure study

source of variation	*df*	*sum of squares*	*mean square*	*f ratio*
Group	3	73.5786	24.5262	27.05**
Subject/group	29	26.2940	.9067	7.90**
Subject/control	5	.8833		
Subject/control w/o repair	8	2.7219		
Subject/millard	8	5.2355		
Subject/bardach	8	17.4534		
Between subjects	32	99.8726		
Time	5	19.2763	3.8552	33.58**
Time × group	15	28.7485	1.9166	16.69**
Residuals	137	15.7354	.1148	
Within subjects	157	63.7602		
Total	189			

** indicates significant difference at 1% level.

TABLE 3. pair-wise comparison of lip pressure among groups

time after surgery	*group i vs group ii*	*group i vs group iii*	*group i vs group iv*	*group ii vs group iii*	*group ii vs group iv*	*group iii vs group iv*
2 weeks	*	**	**	**	**	
4 weeks	*	**	**	**	**	
8 weeks		*		**	**	
12 weeks						
16 weeks				*		
20 weeks				*		

* indicates significant difference at 5% level.
** indicates significant difference at 1% level.

(a) the mean lip pressure for Group II (control without repair) remained lower than that for Group I (control).

(b) the mean lip pressure for Group IV coincided with that of the control group, while;

(c) the lip pressure for Group III remained significantly higher than that for Group II.

B. *Longitudinal Interpretation*

1. The mean lip pressure for Group II remained consistently lower than that of Group I from the second week after surgery until the end of the experiment.

2. The mean lip pressure for Group III tended to be significantly higher than that for Groups I and II, beginning two weeks after surgery. The difference tended to level off at the 12th week after surgery. At the end of the 20-week experiment, the difference between Groups II and III again became significant. The reason for this deviation needs further investigation.

3. The mean lip pressures for Group IV tended to be significantly different from those of the control groups (I & II) starting two weeks after surgery. These differences tended to level off at twelve weeks after surgery until the end of the experiment.

4. The mean lip pressure profiles in Groups III and IV were consistently similar over the period studied.

Discussion

As far as we know, the results reported here represent the first attempt to collect and assess longitudinal data on the pressure exerted by the repaired cleft lip on maxillary segments. It is prudent to be cautious in the interpretation of early results such as these. We are inclined, nevertheless, to view them as reasonable, of considerable importance, and in support of our initial hypothesis on lip pressure after surgical repair. While our sample sizes were not large, they were sufficient to show a number of highly significant intergroup differences. Similarly, while the 20-week period of study was relatively brief, it was sufficient to indicate that the probability of further pressure fluctuations was low.

Several of the findings seem especially noteworthy. First, it is clear that lip pressure is less than normal in animals with unrepaired lips and that it becomes greater than normal in the early weeks after lip repair. Secondly, comparisons of the Group III and IV pressures are of interest both because of their differences and their similarities. Comparisons, for example, at any of the individual weekly intervals after lip repair revealed no significant intergroup differences in lip pressure. Comparison of the overall 20-week pressure profiles for the same two groups, however, showed clearly that the patterns of pressure change, over time, were quite different and that the difference was highly significant.

The next question, of course, is whether that difference is one which makes a difference in facial growth. The increased lip pressure after

operation and over the period of time studied has theoretical importance if we assume that the early period of life is very important in facial growth and development. In our study, we found that this increased pressure resulted in secondary maxillofacial deformities which will be presented with data in the next paper.

Summary

The results of this study indicate that lip pressure increased rapidly after lip repair was completed and was higher than in controls during the 20 postoperative weeks. The results of this study confirm that further research in this direction is necessary.

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