

Velar Motility, Velopharyngeal Closure, and Speech Proficiency in Cartilage Pharyngoplasty: The Effect of Age at Surgery

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This report is the second in a series of articles describing a program of research concerning the effectiveness of cartilage pharyngoplasty. In the first article (2) the research design was described and results regarding relative improvement in velar motility, velopharyngeal closure, and certain speech parameters, were reported on a longitudinal basis.

There was a general impression from the findings reported in the earlier report (2) that subjects who were operated on at an early age tended to exhibit greater benefits from the operation in terms of velopharyngeal closure than those who were older at the time of the operation. Moreover, they appeared to surpass the older subjects in the degree to which they could effect velopharyngeal valving prior to the operation. Without the benefit of statistical analysis, it appeared generally that the intervention of cartilage pharyngoplasty during or before the most dramatic downward, forward emergence of the maxillo-facial complex from the cranial base (presumably by growth) resulted in relatively better velopharyngeal restoration. In addition, the speech findings indicated that the subjects of younger operative age showed reduced nasality, better articulatory proficiency, and better intelligibility when compared to the subjects who had surgery at older ages.

Therefore, the purpose of the present report is to describe in some detail the preoperative and postoperative characteristics of two age groups of subjects with regard to degree of velar motility, degree of velopharyngeal closure, and degree of speech proficiency (nasal resonance, articulatory proficiency, and intelligibility).

Procedures

The details of the overall procedures and methods of analysis were outlined in a previous report (2) and are reviewed here only briefly.

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For 31 subjects who had undergone cartilage pharyngoplasty over a period of eight years, 181 upright sagittal laminographic cephalometric X rays were reviewed. For each of three evaluation periods (prepharyngoplasty, immediately postpharyngoplasty, and a most recent postpharyngoplasty evaluation, varying from one to eight years), two measures of velar motility (extent of vertical velar movement in reference to the nasal plane) and four measures of velopharyngeal closure (degree of velopharyngeal gap and extent of linear velopharyngeal contact) were obtained. For these same subjects, 157 speech recordings provided an assessable sample for seven evaluations; prepharyngoplasty, immediate post-, one year post-, two years post-, three years post-, four years post-, and five or more years postpharyngoplasty. These speech recordings were subjected to separate judgment sessions for degree of nasal resonance, degree of articulatory proficiency, and degree of intelligibility. Reliability of judgment of these speech parameters (.74, .90, .90, respectively) was judged to be sufficiently high for purposes of analysis, even though the r for degree of nasal resonance was not as high as might have been hoped (.74). The respective judgment-rejudgment data were also stable, since t tests did not yield ratios which are significant.

For purposes of this investigation, the subjects were arbitrarily divided into two groups based on the age at which they underwent cartilage pharyngoplasty: those who had pharyngoplasty before the age of 10 years (13 subjects), and those who had pharyngoplasty after the age of 10 years (18 subjects). The age range of the younger subjects varied from five years, ten months, to nine years, ten months. Their average age at surgery was 8.30 years. One subject had received autogenous cartilage; and the remainder, homogenous cartilage. Four of the 13 younger subjects were judged to demonstrate velopharyngeal incompetence without cleft palate, and nine with cleft palate. The older subjects ranged in age from 10 years, one month to 37 years, seven months, with a mean age at surgery of 17.49 years. Four of these subjects had received autogenous cartilage, and 14 had homogenous cartilage implants. One of the older subjects had velopharyngeal incompetence without cleft palate, and in the remainder the incompetence was secondary to cleft palate.

The first report (2) in this series described the use of the Wilcoxon signed-ranks test (T) for nonparametric assessment of significance of difference between matchable measures among the various evaluation periods (4, p. 373-375). This same mode of analysis was applicable in the present study also. However, the purpose of the present report is, primarily, to appraise the relative abilities of the two age-divided groups with regard to radiographic and speech parameters within each evaluation period. For this assessment, the Mann-Whitney U test (4, p. 368-371) was employed. This nonparametric test permits assess-

ment of significance of difference between two groups in terms of their relative rank in a combined distribution for any given parameter. As such, the test provides a crude comparison between observed distribution (by relative rank) and distribution expectable by chance.

Results

X-RAY FILM MEASURES. Table 1 presents data on velar motility, extent of velopharyngeal gap, and extent of linear velopharyngeal contact for the younger and older subject groups.

Despite slight differences between the younger and older subjects, particularly prepharyngoplasty and postpharyngoplasty, their differences in velar motility for either /a/ or /s/ were nonsignificant, as assessed by Mann-Whitney *U* test. This was true for all six possible comparisons.

One way of assessing velopharyngeal function is to consider it as broad continuum representing a possible range in velopharyngeal gap which may be continuous with a potential range of achieved linear velopharyngeal contact. This type of assessment need not require that

TABLE 1. Measures of velar motility, velopharyngeal gap, and linear velopharyngeal contact (for those with no velopharyngeal gap) for /a/ and /s/; for two groups of subjects, younger than 10 years and older than 10 years; and for three evaluations.

<i>x-ray measures</i>	<i>younger subjects</i>			<i>older subjects</i>		
	<i>pre-pharyng. (3.85 mos.)</i>	<i>post-pharyng. (3.69 mos.)</i>	<i>most recent (4.85 yrs.)</i>	<i>pre-pharyng. (5.56 mos.)</i>	<i>post-pharyng. (2.44 mos.)</i>	<i>most recent (4.87 yrs.)</i>
velar motility /a/ Mean mm	1.31	1.62	2.88	2.08	1.82	2.59
N	13	13	13	18	17	17
velar motility /s/ Mean mm	1.54	3.69	5.04	.79	2.53	5.03
N	13	13	13	17	18	16
v-p gap /a/ Mean mm	3.54	1.36	2.67	6.95	2.19	3.86
N	13	7†	7	18	13	14†
v-p gap /s/ Mean mm	5.09	—	1.50	7.54	4.83	6.17
N	6	—	2	13*	9	6*
lin. v-p contact /a/ Mean mm	—	9.09	9.15	—	5.84	7.37
N	—	7†	6	—	5	3†
lin. v-p contact /s/ Mean mm	8.81	11.81	11.72	5.15	9.20	9.51
N	7	13	11	4*	9	10*

* One x-ray film for /s/ was not available.

† One x-ray film showed touch closure and was regarded as showing 0 mm gap.

both velopharyngeal gap and velopharyngeal contact be present within the range of velopharyngeal achievement under consideration. It merely assumes a range of potential ability within which differences between subject groups may be evaluated. Tables 1 and 2 show such relative abilities in achieving velopharyngeal closure by the younger and older subjects.

One speech measure and its related radiographic measure for younger subjects may be taken as an example. In the prepharyngoplasty period, six of the younger subjects exhibited velopharyngeal gap on /s/, while seven of these subjects had linear velopharyngeal contact on this sound (see Table 1). Table 2 reveals the total range for the 13 younger subjects for production of /s/ to be 16 mm gap to a 15.7 mm contact. Therefore, through Table 1 it is possible to determine the number of subjects who exhibited gap and contact, respectively, whereas Table 2 provides information on the total range of performance of subjects. Other measures may be evaluated in like manner.

Table 2 reveals results of the Mann-Whitney *U* test for assessing comparative range of velopharyngeal closure between the younger and older subjects. In all such comparisons for /a/ and /s/ during prepharyngoplasty, postpharyngoplasty, and the most recent evaluation, significant differences were found in favor of the younger subjects' ability to achieve velopharyngeal closure. All *U* values were significant at the 5% level or better. Table 1 reveals the major reasons for this finding. A smaller percentage of younger subjects tended to exhibit

TABLE 2. Data for size of velopharyngeal gap and, if no gap is shown, extent of linear velopharyngeal contact for the two age groups and for /a/ and /s/ at each of three evaluations. All *U* values are significant at the 5% level.

	<i>range in velopharyngeal gap or in linear contact</i>		<i>Mann-Whitney U</i>
	<i>younger subjects</i>	<i>older subjects</i>	
prepharyngoplasty			
/a/	11 mm gap to 1 mm gap	11 mm gap to 1.5 mm gap	50.0
/s/	16 mm gap to 15.7 mm contact	12 mm gap to 8 mm contact	53.0
postpharyngoplasty			
/a/	4 mm gap to 17.4 mm contact	7 mm gap to 12.7 mm contact	51.5
/s/	2.8 mm contact to 20.7 contact	8.5 mm gap to 16.4 mm contact	41.0
latest evaluation			
/a/	5 mm gap to 16.7 mm contact	9 mm gap to 12.4 mm contact	50.5
/s/	1.5 mm gap to 18.9 mm contact	9 mm gap to 13.5 mm contact	48.5

velopharyngeal gap than of older subjects for any given speech measure at any given evaluation period (the one exception being /a/ in the prepharyngoplasty period, where all younger and older subjects showed gap). By the same token, a larger percentage of younger subjects than of older subjects had velopharyngeal contact for these speech measures in the three evaluation periods. In general, gap measurements for younger subjects were smaller than for older subjects, and contact measurements for younger subjects were larger than for older subjects.

SPEECH MEASURES. Figures 1, 2, and 3 provide graphic portrayal of changes in degree of nasal resonance, degree of articulatory proficiency, and degree of intelligibility before and after the operation. Changes in proficiency for each of the parameters are shown for the two age groups. In Figure 1, more dramatic improvement in reduction of nasality appears to have been effected by the younger subjects than by the older subjects, and the younger subjects continued to improve to the point of approximating normal nasal resonance two to five years after the operation. The improvement in the older subjects was not extensive initially, and they tended to have slight regression within the first year. Following this period there was very slight further

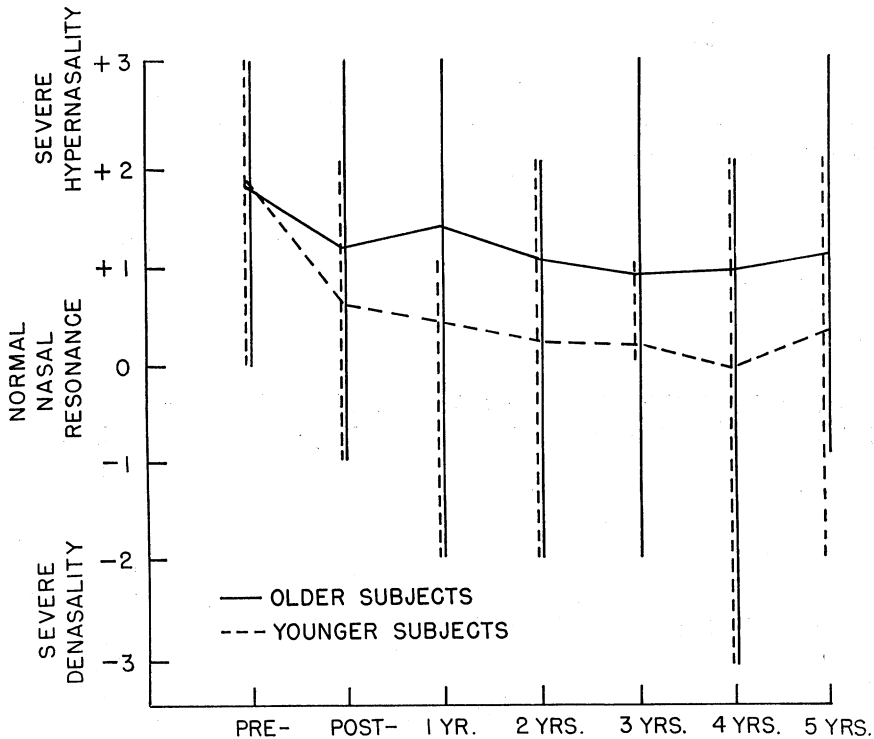


FIGURE 1. Range in judgments and mean judgments of nasal resonance for subjects of younger operative age and older operative age at seven evaluations.

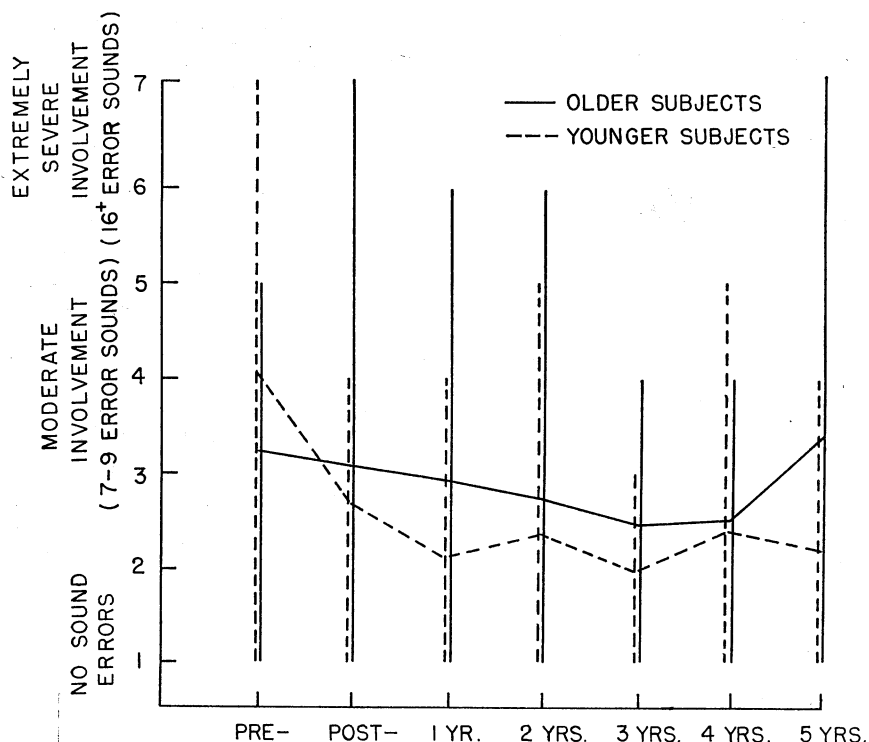


FIGURE 2. Range in judgments and mean judgments of articulatory proficiency for subjects of younger operative and older operative age at seven evaluations.

improvement and, in general, they were judged to demonstrate a mild degree of hypernasality between the two- and five-year postoperative evaluations.

The data were analyzed by the Wilcoxon *T* test. For the younger subjects the differences between degree of nasal resonance for the preoperative and each of the first five postoperative evaluations were found to be significant at the 5% level. The lack of significance of difference in nasal resonance between prepharyngoplasty and the fifth postoperative year may be due to the small number of subjects. On the other hand, for the older subjects, only the difference between prepharyngoplasty and the fifth postoperative year was significant. Despite this discernible trend favoring the younger subjects, intergroup comparisons within each evaluation period failed to yield significant differences by the Mann-Whitney *U* test.

Figure 2 shows the graphed means for degree of articulatory proficiency for the two age groups at seven evaluations. Again, dramatic improvement in articulatory proficiency was shown by the younger subjects immediately following the operation; subsequently, one year through five years, they were judged to demonstrate mild articulatory

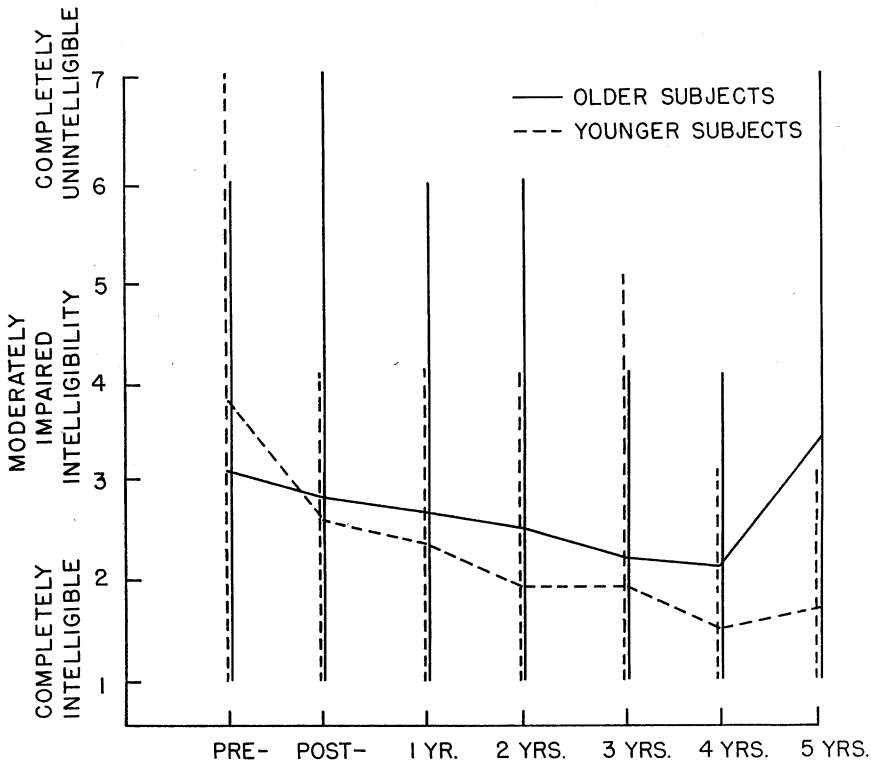


FIGURE 3. Range in judgments and mean judgments of intelligibility for subjects of younger operative age and older operative age at seven evaluations.

involvement (one to three error sounds). However, the improvement in the older subjects was quite gradual through three years after the operation; there appears to be a plateau between the third and fourth years, with considerable regression at five years or more. By the Wilcoxon T test, the younger subjects showed significant improvement from their preoperative articulatory proficiency through each of the following four evaluation periods. Failure to achieve significance of difference at four and five years again may be due to the small number of subjects under study. The older subjects, by similar analysis, were significantly different in comparisons made between prepharyngoplasty and the periods of one through four years. Until the fifth year following the operation, the mean judgment of their articulatory proficiency approximated a value of *three*, which is described as mild-to-moderate articulatory involvement (four to six error sounds). Despite these trends, which tend to favor the younger subjects, intergroup comparisons within each evaluation period by the Mann-Whitney U test failed to reveal significant differences.

Figure 3, showing changes in intelligibility for the two age groups,

rather closely mirrors the relative changes in articulatory proficiency that were described above. (Further consideration of these two parameters will be provided in later reports.) The results of assessment within each of the two groups of subjects by the Wilcoxon *T* test were almost identical with those for articulatory proficiency. The younger subjects improved significantly in intelligibility immediately following the operation, and this improvement over prepharyngoplasty intelligibility was demonstrated in a significant fashion through three years following the operation. Further improvement in the fourth and fifth years appeared to occur, although this was not demonstrable statistically, probably because of a limited *N*. The older subjects showed significant improvement over preoperative intelligibility at two through four years following the operation. Their regression at five years was not found to be significant in comparison to the prepharyngoplasty period or any other period of evaluation. Intergroup comparisons by Mann-Whitney *U* test did not show any significant differences between the two groups at any evaluation period.

Discussion

Two findings are clearly evident. First, the younger and older subjects did not differ from each other in amount of velar motility, either before or after cartilage pharyngoplasty, yet as a combined group they did show significant improvement in this respect for /s/ production immediately postoperatively, and continued on the average to effect further improvement on this sound as late as five years after the operation (2). Second, the younger subjects tended to have smaller velopharyngeal openings or larger linear velopharyngeal contact than the older subjects at all evaluation periods, both preoperatively and postoperatively, for /ɑ/ and /s/.

These results suggest that the differences in velopharyngeal adequacy which favored the younger subjects are not attributable to differences in palatal motility, since there are no such demonstrable differences between the younger and older subjects. The X rays for all 31 subjects, considered collectively, show very few subjects who did not substantially improve in palatal lifting ability following the operation. Where poor palatal mobility appeared to be evident prior to pharyngoplasty, it was usually accompanied by poor palatal length. It generally appears, therefore, that poor palatal movement before the operation represented more functional surrender than true inadequacy for movement. In this respect, the present findings, as well as the findings of the previous report (2), suggest that poor palatal mobility prior to cartilage pharyngoplasty cannot be considered an important factor for predicting successful velopharyngeal restoration resulting from the operation, contrary to what had previously been maintained (1, 3).

On the other hand, palatal length is an important determinant of

success in the operation. The x-ray films for the subjects generally show that those subjects with good preoperative palatal length tend to have good velopharyngeal closure at most recent evaluation, whereas poor palatal length before pharyngoplasty invariably was associated with poor velopharyngeal closure at most recent evaluation. Superior palatal length prior to pharyngoplasty was shown by the younger subjects in this study, as compared with the older subjects. Over half of the younger subjects, and only a little more than one-fourth of the older subjects, exhibited good palatal length for the demands of the nasopharyngeal dimensions. Although approximately one-fourth of the older subjects had poor preoperative palatal length, none of the younger subjects did. Thus, an important reason for the superiority of the younger subjects over the older subjects in velopharyngeal closure following cartilage pharyngoplasty is that the younger subjects exhibited relatively better palatal length than did the older subjects.

Cartilage retention appeared to be another factor affecting postoperative velopharyngeal closure. X-ray films of 28 patients were available for most recent evaluation. Of 22 cases exhibiting fair-to-good cartilage retention postoperatively, 19 showed fair-to-good velopharyngeal closure. In this regard, the younger subjects also had an edge on the older subjects. Over 60% of the younger subjects showed good cartilage retention, as compared to 40% of the older subjects. This is countered by the fact that three subjects from each group exhibited poor retention of their implants. These six cases generally had poor velopharyngeal closure at most recent evaluation.

Whereas location of the cartilage implant is felt to have an important bearing on the outcome of the operation, in the two cases where cartilage was placed or was retained slightly below the level of the Atlas bone, there was fair to good velopharyngeal closure. In all other cases available for most recent evaluation, the cartilage was placed higher. Thus, it would appear that, while correct implantation of cartilage is probably important to success in cartilage pharyngoplasty, rare mislocations of cartilage did not affect velopharyngeal closure. This factor, then, could not account for the better valving seen among the younger subjects than was observed in the older subjects.

In summary, it appears that the better postoperative velopharyngeal function among the younger subjects in this study may be accounted for principally by the fact that such subjects tended to have better preoperative palatal length and better postoperative retention of cartilage.

The consistent trend favoring younger subjects over older subjects for improvement in all speech parameters following cartilage pharyngoplasty was not supported by demonstrably significant differences. However, this is probably due to the limited N in the two groups of subjects. Undoubtedly the better speech improvement among the younger

subjects is attributable to their superior velopharyngeal closure. Another factor of influence was speech therapy, offered postoperatively. Of 10 subjects who received speech therapy following the operation, eight were younger subjects and only two were older subjects. One of the younger subjects who received speech therapy exhibited normal speech eight years after cartilage pharyngoplasty despite complete resorption of cartilage and lack of velopharyngeal contact at her most recent evaluation. This was Subject 33, shown in Figure 1 of the first report (2). One might infer then that cartilage pharyngoplasty exerts its maximum benefit when carried out with younger patients (under 10 years of age) who are followed up with intensive speech therapy.

Summary

From radiographic and listener-judgment data employed in an evaluation of the results of cartilage pharyngoplasty over an eight year period, the effect of age at time of surgery was studied. For purposes of comparison, subjects were arbitrarily divided into younger subjects (under 10 years of age) and older subjects (10 years of age or older). Results show that younger and older subjects are not differentiable in velar motility either preoperatively or postoperatively. However, the younger subjects excelled the older subjects in degree of velopharyngeal closure shown before the operation, immediately after the operation, and at the time of their most recent evaluation (about five postoperative years on the average). This advantage among the younger subjects is attributable to better relative preoperative palatal length and to better postoperative retention of cartilage. There is a discernible trend indicating greater postoperative speech improvement and better maintenance of improved speech among the younger subjects than among the older subjects. This trend may be explained by effects of the operation and by speech therapy which was offered in greater measure to the younger subjects following the operation.

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