Stomatologija. Baltic Dental and Maxillofacial Journal, 25: 3-10, 2023

Pilot study: Correlation between nasalance scores and cephalometric parameters in Estonian cleft palate children

Lagle Lehes[1], Carina Aria[2], Marika Padrik[2], Priit Kasenõmm[3], Triin Jagomägi[1]

SUMMARY

Background and objective. According to Klassen *et al.* (2012), the overall quality of life of CL/P children is most affected by appearance and quality of speech, as these differences are most noticeable to others. To what extent changes in craniofacial growth have an impact on speech quality has yet to be clarified. Therefore, we aimed to determine which cephalometric parameters differed between healthy and cleft palate groups.

Material and methods. 17 healthy and 11 children born with CL/P were included. We conducted a cross-sectional and comparative study. A combination of objective and subjective assessment methods was performed: nasalance scores were calculated, and lateral cephalograms were evaluated by indirect digitization using Dolphin Imaging Software.

Results. The analysis showed differences in the length of the hard (PNS-A) and soft palate (PNS-P), and in the width of the lower oropharyngeal airway (AW5-AW6). The mean length of the hard palate was 3.7 mm and the soft palate 3.0 mm shorter in the CL/P group compared to the healthy group. Hypernasal resonance was related to (1) the length of the hard palate, (2) the distance between the hyoid bone from the third cervical vertebra, and (3) the angle formed by the NA line and the NB line (ANB). Only 11 CL/P children met the inclusion criteria. Thus, the results may have been affected by the small sample size. The Control group consisted of children who visited ENT doctors or orthodontists.

Conclusion. The results showed differences in cephalometric parameters in the two groups. Still, we continue to collect data and plan to conduct the analysis on larger and more homogenous sample size.

Keywords: cleft palate speech, nasalance, cephalometric parameters, cephalometrics, cleft palate.

INTRODUCTION

Most children born with cleft palate (CP) or cleft lip and palate (CL/P) have speech disorders, e.g some degree of hypernasal resonance and articulation disorders. One of the primary treatment goals in cleft palate repair is to obtain successful speech outcomes. The latter is influenced by several pre- and postoperative factors, e.g., timing and techniques of surgical and orthodontic interventions, availability of speech therapy, craniofacial growth and proportional development, other morphological and physiological factors. According to literature, there is no concensus regarding preferable surgical protocols (Peterson Falzone *et al.*, 2010; Lohmander, 2011). Moreover, Scandcleft Project Trial 2, pointed out that poor speech outcomes could not be attributed to surgical protocol but found correlation between number of speech therapy visits and speech problems (1).

Determining the correlation between nasalance scores and cephalometric parameters may help to understand how craniofacial morphology impacts speech development in those patients. However, the pattern of craniofacial growth and malocclusions are complex, poorly predictable and incompletely understood (2). It is not clear which deficits in facial growth are due to genetic factors and which are caused by consequences of surgical interventions remains largely unclarified (3).

[1]*Institute of Dentistry, Faculty of Medicine, University of Tartu, Tartu, Estonia*
[2]*Institute of Education, Faculty of Social Sciences, University of Tartu, Tartu, Estonia*
[3]*Institute of Clinical Medicine, Faculty of Medicine, University of Tartu, Tartu, Estonia*

Address correspondence to Lagle Lehes, Institute of Dentistry, Faculty of Medicine, University of Tartu, Puusepa 1a, Tartu 50406, Estonia.
E-mail address: lagle.lehes@ut.ee

Like craniofacial growth, the degree of nasality in speech is influenced by a number of different factors including palatal cleft size, time and surgical technique of palatal repair, and various morphological and physiological factors, e.g., length and mobility of the soft palate (4–6). Normative nasalance scores are also language specific. Estonian nasalance scores were developed in 2018 (7).

According to Klassen *et al.* (2012), the overall quality of life of CL/P children is most affected by appearance and quality of speech, as these differences are most noticeable to others (8). To what extent changes in craniofacial growth have impact on speech quality has yet to be clarified. Therefore, we aimed to find out which cephalometric parameters were different between healthy and cleft palate groups. In addition, we described which cephalometric parameters were related to resonance disorders.

METHODS

Subjects

Control group consisted of 103 healthy children aged from 5 years and 1 month to 8 years and 7 months. Their lateral cephalograms had been taken in different reasons, e.g adenoid evaluation, teeth related problems. Study group included 52 children born with CL/P aged from 4 years and 3 months to 9 years and 1 month. We excluded 86 participants from control group and 41 from study group. CL/P children who had syndromic cleft, isolated cleft lip, delayed linguistic or psychomotor development and/or hearing loss were excluded. All included CL/P children received regular speech therapy sessions. Participants from control group were excluded if they had orthodontic or speech problems. Finally, 17 healthy children aged 5 years 2 months to 7years 11 months (mean age 6 years and 5 months) and 11 children (mean age 6 years and 3 months, SD 2.1) born with CL/P were included. All control group children were monitored in Unimed Medical Centre, and study group children had been treated by the cleft teams in Tartu University Hospital, Unimed Medical Centre and/or in the North Estonia Medical Centre. Both surgical protocols, one- and two-stages, are performed in Estonia. Taking into account the small sample size of the CL/P group, its heterogeneity, and previous findings, we did not divided the group into sub-groups based on the surgical protocol.

Materials and instruments

We conducted a cross-sectional and comparative study. Combination of objective and subjective assessment methods were performed by our multidisciplinary cleft teams. All included children were assessed by qualified SLP's for any possible articulation, resonance, and voice disorders in both groups. For this preliminary screening, Estonian Speech and Language Assessment Test for 5–6 years old (9), and non-standardized speech and language tests in Estonian were used. Nasometer II (model 6450) (PENTAX Medical, Montvale, NJ) hardware and software were used for recording the nasalance scores. Nasometer is an objective non-invasive measuring instrument that has been used worldwide in recent years, especially in the CL/P centres. Lateral cephalograms were evaluated by indirect digitization using Dolphin Imaging Software. This method have been found to be significantly reliable at the 95% level (method error) (10).

Procedure

First, an orthodontist screened all the lateral cephalograms that meet the criteria for age and sex. These cephalograms were selected from the archives of the Unimed Medical Centre, and from the archives of North Estonia medical Centre. All lateral cephalometric radiographs had been taken using standardized methods with the Frankfort horizontal plane positioned parallel to the floor. All participants, whose cephalograms did not meet the standard criteria, were excluded from the study.

Second, a qualified SLP tested all the participants for any possible exclusion criteria markers in speech and language. Prior to the SLP's assessment, parents of all included children and children older than seven years of age gave their written consent after receiving information about the research. Participation was voluntary and did not affect the subsequent therapy of children.

Third, nasalance scores were measured. Those CL/P children who fulfil the inclusion criteria, were recorded individually in a quiet room. The examiner introduced the procedure and then placed the Nasometer headset firmly on the child's head accordingly to the manufacturer's instructions. Once the headset was secured, the child repeated the speech stimuli after the examiner. Each speech sentence was given in a natural speech rate, loudness, and pitch. There was a 2–3 second pause between each sentence. The nasalance score was calculated for each repeated sentence by the Nasometer II software.

Based on the aims of this study, and previous researches of Ozge Uslu-Ackam (2017) and Van Thai Nguyen (2019), twelve different cephalometric landmarks were selected to identify skeletal morphology (11, 12). Reference landmarks and cepha-

lometric measurements are described in Figure and in Table 1.

Cephalometric parameters of all 28 included children were digitally measured twice by two independent, trained, and calibrated raters using Dolphin Imaging software. Inter-rater reliability was calculated. To assess the intra-rater reliability, the raters were asked to re-measure the parameters after three weeks. Intra-rater reliability was calculated.

Data analysis

Nasometer II software was used to calculate the nasalance scores for each child and for each sentence. Test-retest reliability was examined by calculating differences in the mean scores between the test and retest for each cephalometric parameter. The data was analysed using Statistical Package for the Social Science (SPSS) version 26.0 (SPSS Inc, Chicago, IL). Comparison between the groups was performed with Mann-Whitney U test. Linear regression analysis was used to estimate the relationship between the degree of hypernasal resonance and cephalometric parameters among CL/P children. Significance levels were set at the 5% (p=0.05) level. Cronbach alfa (α) was calculated for intra-rater and Cohen's Kappa (κ) for inter-rater reliability

RESULTS

Inter- and intrarater reliability

Cohen's Kappa (κ) was calculated for interrater reliability. Interrater reliability was considered sufficeient if κ>0.6. The results are shown at Table 2.

The raters performed repeated measurements on five parameters to obtain a consensus on the results.

Cephalometric parameters of three children in both groups underwent control measuring to ensure intrarater reliability. The results are shown in Table 3.

Internal consistency was considered sufficient if α>0.7.

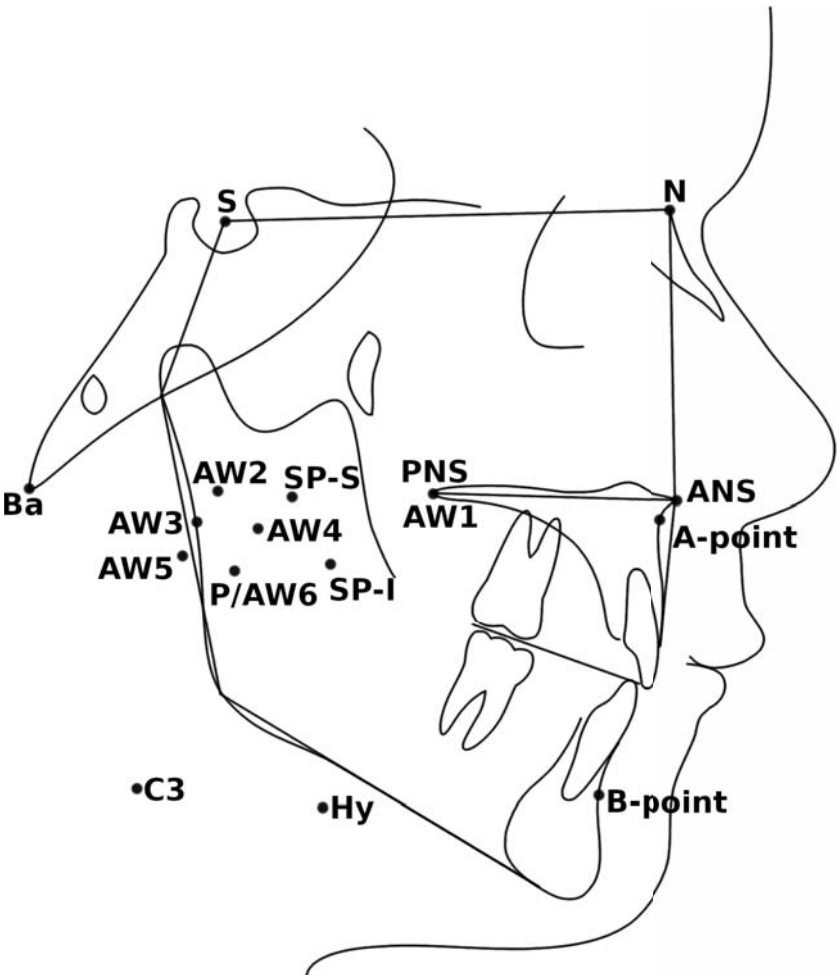

Fig. Cephalometric landmarks. Nasion (N): the intersection of the internasal suture with the nasofrontal suture in the midsagittal plane. Sella (S): the centre of the pituitary fossa of the sphenoid bone. Basion (Ba): the most inferior posterior point of the occipital bone at the anterior margin of the occipital foramen. Anterior nasal spine (ANS): the tip of the anterior nasal spine. Posterior nasal spine (PNS): the tip of the posterior nasal spine. A point: the deepest point on the curve of the maxilla. B point: the most posterior point in the concavity along the anterior border of the symphysis. Hyoid (Hy): the most superior and anterior point on the body of hyoid bone. C3: the most anterior and inferior point on the corpus of the third cervical vertebra. AW1 – airway anterior lower: AW2 – airway posterior lower: AW3 – middle posterior airway: AW4 – middle anterior airway; AW5 – inferior posterior airway AW6 – inferior anterior airway; P – tip of soft palate; SP-S – superior most point on the upper surface of the soft palate; SP-I – inferior most point on the lower surface of the soft palate

Table 1. Cephalometric measurements

Measurements	Description
SNA (º)	The angle between line SN and NA
SNB (º)	The angle between line SN and NB
ANB (º)	The angle between line NA and NB
BA-S-N (º)	Cranial base angle
PNS-A (mm)	The length from PNS to A
PNS-Ba (mm)	The length from PNS to Ba
Hy-C3 (mm)	The length from Hy to C3
PNS-P (mm)	The length of soft palate
SP-S-SP-I (mm)	The maximum thickness of soft palate
AW1-AW2 (mm)	The width of nasopharyngeal airway
AW3-AW4 (mm)	The width of upper oropharyngeal airway
AW5-AW6 (mm)	The width of lower oropharyngeal airway

Comparison of cephalometric parameters in two groups

Mann-Whitney U-test was used to calculate statistically significant differences between the cephalometric parameters in two groups. The results are given below in Table 4.

As shown in Table 4, statistical differences were found in PNS-A, PNS-P and AW5-AW6 between the two groups. The rest of the parameters did not reveal relevant differences.

Table 2. Interrater reliability

Cephalometric parameters	Group	N	Cohen's Kappa (κ)
PNS-A (mm)	SG	11	0.91
PNS-Ba (mm)	SG	11	0.84
Hy-C3 (mm)	SG	11	0.97
SNA (º)	SG	11	1
SNB (º)	SG	11	1
ANB (º)	SG	11	0.47*
Ba-S-N	SG	11	0.94
PNS-P	SG	11	0.69
SP-S-SP-I (mm)	SG	11	0.31*
AW1-AW2 (mm)	SG	11	0.53*
AW3-AW4 (mm)	SG	11	0.31*
AW5-AW6 (mm)	SG	11	0.41*

CG – Control group; * – κ<0.6.

Table 3. Intrarater reliability

Cephalometric parameters	Group	N	Rater 1 (α)	Rater 2 (α)
PNS-A (mm)	SG	3	0.99	0.9
	CG	3	0.99	0.98
PNS-Ba (mm)	SG	3	1	0.97
	CG	3	0.98	0.97
Hy-C3 (mm)	SG	3	0.82	0.99
	CG	3	0.95	0.99
SNA (º)	SG	3	1	0.99
	CG	3	1	1
SNB (º)	SG	3	1	0.99
	CG	3	1	1
ANB (º)	SG	3	1	1
	CG	3	1	1
Ba-S-N	SG	3	1	1
	CG	3	0.99	0.99
PNS-P	SG	3	0.99	1
	CG	3	0.98	0.97
SP-S-SP-I (mm)	SG	3	0.94	0.93
	CG	3	0.88	0.88
AW1-AW2 (mm)	SG	3	0.93	0.96
	CG	3	0.93	0.84
AW3-AW4 (mm)	SG	3	0.98	0.91
	CG	3	0.92	0.91
AW5-AW6 (mm)	SG	3	1	0.99
	CG	3	0.91	0.95

α – Cronbach's alpha.

Relationships between nasalance scores and cephalometric parameters

First, nasalance scores were measured in the study group. Estonian test material for nasalance scores consists of 24 speech stimuli. Based on the phoneme content, the stimuli were divided into three groups: (1) sentences that included oral and nasal phonemes and targeted the same phoneme distribution as in spontaneous speech in Estonian (10% of nasal phonemes), (2) sentences that included only oral phonemes, and (3) sentences that were loaded with nasal phonemes (30% of nasal phonemes). There are eight speech stimuli in each group. All sentences are at least six syllables in length. The results are given in Table 5.

Compared to the Estonian normative nasalance mean scores, the mean scores were higher in all sentence groups in CL/P group.

Regression analysis was used to determine the relationship between nasalance scores and cephalometric parameters.

As shown in Table 6, PNS-A, Hy-C3 and ANB were statistically significantly related to higher scores of resonance and hypernasality (p>0.05). In contrast, Ba-S-N was related to higher scores in nasal sentences.

Table 4. Cephalometric parameters in two groups

Cephalometric parameters	Group	N	U-statistic	p
PNS-A (mm)	SG	11	48.0	0.033*
	CG	17		
PNS-Ba (mm)	SG	11	78.0	0.487
	CG	17		
Hy-C3 (mm)	SG	11	86.5	0.746
	CG	17		
SNA (º)	SG	11	81.0	0.578
	CG	17		
SNB (º)	SG	11	67.0	0.225
	CG	17		
ANB (º)	SG	11	71.0	0.306
	CG	17		
Ba-S-N	SG	11	80.5	0.547
	CG	17		
PNS-P	SG	11	39.0	0.009*
	CG	17		
SP-S-SP-I (mm)	SG	11	67.5	0.225
	CG	17		
AW1-AW2 (mm)	SG	11	78.5	0.487
	CG	17		
AW3-AW4 (mm)	SG	11	84.0	0.677
	CG	17		
AW5-AW6 (mm)	SG	11	50.0	0.042*
	CG	17		

*p – statistical significance (>0.05).

DISCUSSION

First, we studied which cephalometric parameters are statistically different in two groups. The analysis showed statistically significant differences in the length of the hard (PNS-A) and soft palate (PNS-P), and in the width of lower oropharyngeal airway (AW5-AW6). Our findings are in accordance with several previous studies (Gohilot *et al.*, 2014; Wada *et al.*, 1997; Wermker *et al.*, 2012; Wu *et al.*, 1996; Orr *et al.*, 2016) that have highlighted the sagittal decrease of soft tissues and bone structures in cleft palate population because of the later and slower growth of the facial morphology complex due to early surgical interventions. In our study, we found that the mean length of hard palate was 3.7 mm and soft palate 3.0 mm shorter in CL/P group compared to healthy group (13-17). However, with a small sample size, caution must be applied, as the findings might not be applicable to wider CL/P group. Another interesting and controversial finding that stood out was wider lower oropharyngeal airway in CL/P group. The mean depth of it was 1.9 mm wider. However, the findings of the current study do not support the previous research. Nguyen (2019) and Tarawneh *et al.* (2019) showed that lower oropharyngeal airway in CL/P group was narrower (12, 19). Our finding might be opposite to the earlier findings because of the small study group. Two CL/P children had the depth of lower oropharyngeal airway wider than 14 mm. In case of small study sample, these results significantly affect the mean parameters of the group. Moreover, children had enlarged adenoids that might affect the width of oropharyngeal airway. Therefore, this result should be further validation on a larger sample.

The second research question sought to determine which cephalometric parameters were most associated with hypernasal resonance in the CL/P paediatric population. In general, functional, and structural deviations, and dynamic disturbances are considered to cause velopharyngeal dysfunction and resonance problems, mainly hypernasality.

Table 5. Speech stimuli in Estonian

ONS	N	M (est_n)	M
Isal on pikk habe.	11	25.3	42.1
Lapsed mängivad palli.	11	27.9	42.8
Väike naine loeb lehte.	11	31.9	45.1
Tüdruk sööb punast õuna.	11	31.5	42.7
Saara ostis kommi.	11	33.8	45.4
Tige tikker karjub.	11	16.3	35.9
Epu valge tutimüts.	11	25.3	42.9
Ema punane mantel.	11	51.4	55.1
NS			
Emma mummuline kann.	11	61.9	65.9
Hani munes muna.	11	63.1	62.4
Mamma pani akna kinni.	11	60.7	62.7
Naine kõnnib tänaval.	11	48.4	54.5
Inga tahab linna minna.	11	56.1	64.4
Anna ei nuuska nina.	11	58.3	61.6
Ema annab homme kommi.	11	56.0	60.3
Inna pani nuku vanni.	11	57.7	64.3
OS			
Lõbus papa sööb suppi.	11	12.8	30.2
Kaja pugib kooki.	11	14.3	32.1
Tädi otsib uut potti.	11	16.9	38.1
Harri veeretab vurri.	11	16.8	35.5
Kalle läheb külla.	11	12.6	32.5
Valli vaatab pilve.	11	16.8	37.7
Juta kukkus ojja.	11	15.6	32.7
Sassi soojad sussid.	11	21.3	35.4

ONS – oronasal sentences; NS – nasal sentences; OS – oral sentences; M (est_n) – Estonian normative mean score; M – CL/P mean score.

Table 6. Speech stimuli in Estonian

		ONS	NS	OS		M (est_n)	M
Cephalometric parameters	**N**	**r**	**p**	**r**	**p**	**r**	**p**
PNS-A (mm)	11	-0.522	0.050*	-0.45	0.083	-0.584	0.030*
PNS-Ba (mm)	11	-0.315	0.172	-0.427	0.095	-0.193	0.285
Hy-C3 (mm)	11	-0.637	0.018*	-0.449	0.083	-0.59	0.028*
SNA (°)	11	-0.027	0.468	-0.044	0.449	-0.033	0.461
SNB (°)	11	0.24	0.238	0.297	0.187	0.256	0.223
ANB (°)	11	-0.496	0.061	-0.638	0.017*	-0.536	0.044*
Ba-S-N	11	-0.359	0.139	-0.574	0.032*	-0.274	0.207
PNS-P	11	-0.379	0.125	-0.388	0.119	-0.266	0.215
SP-S-SP-I (mm)	11	-0.103	0.381	-0.283	0.2	0.018	0.479
AW1-AW2 (mm)	11	-0.081	0.406	0.031	0.464	0.024	0.472
AW3-AW4 (mm)	11	0.168	0.311	0.064	0.426	0.195	0.283
AW5-AW6 (mm)	11	-0.039	0.454	0.062	0.429	-0.08	0.407

*r – correlation coefficient.

Our analysis showed that hypernasal resonance is significantly related to (1) the length of hard palate, (2) the distance between hyoid bone from the third cervical vertebra, and (3) angle formed by the NA line and the NB line (ANB). Interestingly, greater cranial base angle (Ba-S-N) was related to hyponasal resonance. There was no statistically significant association between cephalometric parameters and hypernasality.

Several research has suggested that resonance problems were due to the reduction in the sagittal dimensions of the soft tissue and bone in the nasopharyngeal complex (14, 16, 20–22). Our study supports these earlier findings. The analysis showed that the shortened length of the hard palate in the sagittal surface was significantly associated with hypernasality. Kummer (2014) and Impieri *et al.*, (2018) argue that velopharyngeal function is often disturbed because of the anatomically deviated hard and soft palate measurements (20, 23). Therefore, it is clinically important to objectively measure cephalometric parameters to determine if the VP closure can be achieved at all without surgical intervention. By combining different objective and subjective assessment tools, it is possible to plan the best possible treatment for CL/P children.

According to Kaduk *et al.* (2003) the hyoid bone is considered important for the openness of the upper respiratory tract (24). As noted earlier, the distance between hyoid bone from the third cervical vertebra is related to hypernasal resonance. We found that hyoid bone was placed more anteriorly compared to the healthy group. This finding is consistent with literature. Kaduk *et al.* (2003), Nguyen (2019) and Wermker *et al.* (2012) have also reported that CL/P children's hyoid bone might be dislocated to more anterior position (12, 15, 24). Kaduk *et al.* (2003) added that even a small change of the dislocation of hyoid bone may affect resonance and pronunciation. He clarified that the anterior position of hyoid bone might be conditioned from a compensation mechanism to facilitate swallowing and/or VPD (24). Laitinen *et al.* (2001) explained that the anterior position of hyoid bone and position of tongue had impact on normal development of bite that secondarily, in turn, might affect speech quality (25).

Third cephalometric parameter that was associated with hypernasal resonance was ANB. Study group showed higher ANB degree (3.5°) compared to healthy group (2.3°). In 1984, Hussels & Nanda (1984) observed that contrary to the common belief that ANB angle 2°±3° was considered normal (26), the calculated values of angle ANB will vary widely with changes in these four ANB-controlling factors. Therefore, the clinical application of this measurement must be cautiously considered. Still, our study showed that ANB degrees were in normal range in both groups according to the research of Holdaway (1956) (27). Therefore, we may assume that the skeletal growth is in normal range in CL/P group, and the hypernasal resonance is partly the result of soft tissues, e.g. decreased length of soft palate tissue. Still, as stated earlier, even the slightest changes in facial morphology may cause speech problems. Thus, we may assume that even if the ANB degree is in normal limits it may affect speech quality.

Last, we found that the parameters of cranial base angle (Ba-S-N) were related to resonance. Growth of the midface is generally impeded in CL/P group following surgical repair. Untreated CLP patients have midfacial growth without any obvious restriction, similar to non-cleft patients (28). In our study, BA-S-N angle was 3° greater in CL/P group compared to healthy children. This finding was also reported by Gopinath *et al.* (2017) (29). We may suggest that significantly higher BA-S-N angle is caused by surgical procedures that affect the anteroposterior growth and development of the maxilla CL/P children. In contrast, several studies do not support this finding and have not found differences in cranial base angle (30, 31). In our study, the higher the BA-S-N angle was related to the higher nasalance scores that were measured in nasal sentences group. It means higher Ba-S-N angle was related to hyponasal resonance. We may suggest that the posterior position of upper maxilla may (over)compensate the higher BA-s-N angle and wider upper nasopharyngeal airway. Sales *et al.* (2021) also concluded in their meta-analysis that the effect of maxillary advancement on speech and velopharyngeal function remains controversial in CL/P patients (32).

In contrast to Stellzig-Eisenhauer (2001), our study has been unable to demonstrate that the greater distance from the tip of the posterior nasal spine (PNS) to the most inferior posterior point of the occipital bone at the anterior margin of the occipital foramen (Ba) was related to resonance problems (22). It was not an unexpected outcome because this also accords with our earlier observations, which showed that there are no differences in PNS-Ba parameters between the two groups. In addition, our finding is supported by the work of Wu *et al.* (1996) who also stated that PNS-Ba parameters are not related to hypernasal resonance (16).

Soft palate function and length play an important role in balance of resonance in speech. According to the literature, soft palate thickness does not impact

resonance in contrast to soft palate length that has significant impact on resonance. Several authors have found a relationship between shorter soft palate and the presence of hypernasality in speech (16, 20–22). In contrast to these earlier findings, we did not find the correlation significant. Still, CL/P group had the mean length of soft palate 3 mm shorter compared to the control group, but this significant difference did not show up in resonance analysis. To explain this contradictory result, we analysed every CL/P child independently. We revealed that the length of soft palate for one CL/P child was 38.1 mm (mean length 25.2 mm). Thus, one significantly different measurement probably affected greatly the mean result of the group, and that's why we really cannot generalize these results to the whole CL/P group. Next time, we should exclude data that may significantly affect mean scores.

Surprisingly, there were not correlations between the width upper and lower nasopharyngeal nor the oropharyngeal airways to hypernasality in speech. In 1996 Wu *et al.*, and in 2001 Stellzig-Eisenhauer described the relationship between oropharyngeal and nasopharyngeal width (16, 22). Stellzig-Eisenhauer (2001) added that even if the nasopharyngeal airway was deeper, then the length and mobility of soft palate could compensate the deficiency and hypernasality did not appear (22). Thus, the problem is much more complicated and complex than just the measurements.

CONCLUSION

Changes in craniofacial morphology characteristics may have an enormous impact on speech quality. Determination of these cephalometric parameters is essential for applying the results in clinical practise. In conclusion, we determined the craniofacial characteristics that may affect resonance in speech in CL/P children. We may suggest that changes in the length of hard palate, the distance between hyoid bone from the third cervical vertebra, and angle formed by the NA line and the NB line (ANB) are more sensitive. The length of soft palate was significantly shorter in CL/P group, and this plays crucial role in achieving balanced resonance.

LIMITATIONS OF THE STUDY

First, the major limitation of the study was the sample size. In Estonia, about 20 CL/P children are born every year. Only 11 CL/P children met the inclusion criteria. Thus, the results may have been affected by the small sample size. Control group consisted of children who were visited ENT-doctors or orthodontists; therefore, the intra-group variability might be quite high. We continue to collect data and plan to carry on the study on a larger and more homogenous sample size. In addition, it would be interesting to identify the articulation errors that are more associated with cephalometric parameters in Estonian language.

REFERENCES

1. Hammarström IL, Nyberg J, Alaluusua S, Rautio J, Neovius E, Berggren A, *et al.* Scandcleft project trial 2—comparison of speech outcome in 1- and 2-stage palatal closure in 5-year-olds with UCLP. *Cleft Palate Craniofac J* 2020;57 (4):458-69.
2. Long RE, McNamara JA. Facial growth following pharyngeal flap surgery: skeletal assessment on serial lateral cephalometric radiographs. *Am J Orthod* 1985;87 (3):187-96.
3. Dahl E, Kreiborg S, Jensen BL, Fogh-Andersen P. Comparison of craniofacial morphology in infants with incomplete cleft lip and infants with isolated cleft palate. *Cleft Palate J* 1982;19 (4):258-66.
4. Hardin-Jones MA, Jones DL. Speech production of preschoolers with cleft palate. *Cleft Palate-Craniofacial J* 2005;42 (1):7-13.
5. Karnell MP. Nasometric discrimination of hypernasality and turbulent nasal airflow. *Cleft Palate-Craniofacial J* 1995;32 (2):145-8.
6. Lam E, Hundert S, Wilkes G. Lateral pharyngeal wall and velar movement and tailoring velopharyngeal surgery: determinants of velopharyngeal incompetence resolution in patients with cleft palate. *Plast Reconstr Surg* 2007;120 (2):495-505.
7. Lehes L, Horn R, Lippus P, Padrik M, Kasenõmm P, Jagomägi T. Normative nasalance scores for Estonian children. *Clin Linguist Phon* 2018;32 (11):1054-66.
8. Klassen AF, Tsangaris E, Forrest CR, Wong KWY, Pusic AL, Cano SJ, *et al.* Quality of life of children treated for cleft lip and/or palate: a systematic review. *J Plast Reconstr Aesthetic Surg* 2012;65 (5):547-57.
9. Padrik M, Hallap M, Aid M, Mäll R, Helekivi T, Aavik-Vadi V, *et al.* Toimetajad. 5-6-aastaste laste kõne test. Tartu: Studium; 2013. 75 lk.
10. Power G, Breckon J, Sherriff M, McDonald F. Dolphin Imaging Software: An analysis of the accuracy of cephalometric digitization and orthognathic prediction. *Int J Oral Maxillofac Surg* 2005;34 (6):619-26.
11. Uslu-Akcam O. Pharyngeal airway dimensions in skeletal class II: A cephalometric growth study. *Imaging Dent* Sci 2017;47 (1):1-9.
12. Nguyen VT. The first study of the treatment outcomes of patients with cleft lip and palate in Central Vietnam [Internet] [Thesis]. 2019 [tsiteeritud 21. november 2021]. Available from: URL: https://dspace.ut.ee/handle/10062/64820
13. Gohilot A, Pradhan T, Keluskar KM. Cephalometric evaluation of adenoids, upper airway, maxilla, velum length, need ratio for determining velopharyngeal incompetency in subjects with unilateral cleft lip and palate. *J Indian Soc Pedod Prev Dent* 2014;32 (4):297-303.
14. Wada T, Satoh K, Tachimura T, Tatsuta U. Comparison of nasopharyngeal growth between patients with clefts and

noncleft controls. *Cleft Palate-Craniofacial J* 1997;34 (5):405-9.
15. Wermker K, Jung S, Joos U, Kleinheinz J. Nasopharyngeal development in patients with cleft lip and palate: a retrospective case-control study. *Int J Otolaryngol* 2012;2012:458507.
16. Wu JT, Huang GF, Huang CS, Noordhoff MS. Nasopharyngoscopic evaluation and cephalometric analysis of velopharynx in normal and cleft palate patients. *Ann Plast Surg* 1996;36 (2):117-22.
17. Orr DJA, Teeling EC, Puechmaille SJ, Finarelli JA. Patterns of orofacial clefting in the facial morphology of bats: a possible naturally occurring model of cleft palate. *J Anat* 2016;229 (5):657-72.
18. Vaivads M, Balode E, Pilmane M. Factors affecting facial development and formation of cleft lip and palate: a literature review. *Pap Anthropol* 2020;29 (2):22-35.
19. Tarawneh A, Ali AA, Alazm KF. Evaluation of Pharyngeal Airway Dimensions in a Sample of Jordanian Preadolescent Cleft Lip and Palate Patients before Orthognathic Surgery [Internet]. 2019 [tsiteeritud 11. detsember 2021]. Available from: URL: https://www.semanticscholar.org/paper/Evaluation-of-Pharyngeal-Airway-Dimensions-in-a-of-Tarawneh-Ali/d1267193dd3e0dcf113d1264e34cdcac10532cf3
20. Impieri D, Tønseth KA, Hide Ø, Brinck EL, Høgevold HE, Filip C. Impact of orthognathic surgery on velopharyngeal function by evaluating speech and cephalometric radiographs. *J Plast Reconstr Aesthetic Surg* 2018;71 (12):1786-95.
21. Jakhi SA, Karjodkar FR. Use of cephalometry in diagnosing resonance disorders. *Am J Orthod Dentofacial Orthop* 1990;98 (4):323-32.
22. Stellzig-Eisenhauer A. The influence of cephalometric parameters on resonance of speech in cleft lip and palate patients. An interdisciplinary study. *J Orofac Orthop* 2001;62 (3):202-23.
23. Kummer AW. Speech and resonance disorders related to cleft palate and velopharyngeal dysfunction: a guide to evaluation and treatment. *Perspect Sch-Based Issues* 2014;15 (2):57.
24. Kaduk WMH, Grabowski R, Gundlach KKH. Position of the hyoid bone in cleft lip, alveolus, and palate: variation of normal anatomy or sign accompanying the malformation? *Cleft Palate-Craniofacial J* 2003;40 (1):1-5.
25. Laitinen J, Hurmerinta K, Ranta R, Sarmas R, Haapanen ML. Comparisons of speech aerodynamics and lateral craniofacial cephalometrics in cleft lip and palate patients with and without Finnish /r/-sound distortion. *Folia Phoniatr Logop* 2001;53 (2):85-92.
26. Hussels W, Nanda RS. Analysis of factors affecting angle ANB. *Am J Orthod* 1984;85 (5):411-23.
27. Holdaway RA. Changes in relationship of points A and B during orthodontic treatment. *Am J Orthod* 1956;42 (3):176-93.
28. Khanna R, Tikku T, Verma S, Verma G, Dwivedi S. Comparison of maxillofacial growth characteristics in patients with and without cleft lip and palate. *J Cleft Lip Palate Craniofacial Anom* 2020;7 (1):30-42.
29. Gopinath VK, Samsudin AR, Noor SNFM, Sharab HYM. Facial profile and maxillary arch dimensions in unilateral cleft lip and palate children in the mixed dentition stage. *Eur J Dent* 2017;11 (1):76-82.
30. Liu X, Chen Z. Effects of palate repair on cranial base and maxillary morphology in patients with unilateral complete cleft lip and palate. *Cleft Palate-Craniofacial J* 2018;55 (10):1367-74.
31. Tinano MM, Martins MATS, Bendo CB, Mazzieiro Ê. Base of the skull morphology and Class III malocclusion in patients with unilateral cleft lip and palate. *Dent Press J Orthod* 2015;20 (1):79-84.
32. Sales PHH, Costa FWG, Cetira Filho EL, Silva PGB, Albuquerque AFM, Leão JC. Effect of maxillary advancement on speech and velopharyngeal function of patients with cleft palate: Systematic Review and Meta-Analysis. *Int J Oral Maxillofac Surg* 2021;50 (1):64-74.

Received: 11 03 2022
Accepted for publishing: 24 03 2023