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ÜST DODAQ VƏ DAMAĞIN ANADANGƏLMƏ İKİTƏRƏFLİ YARIĞI OLAN UŞAQLARDA VƏ NORMAL HALDA XIŞ SÜMÜYÜNÜN MORFOMETRİK GÖSTƏRİCİLƏRİ

L.N.Yakovenko[1], N.V.Kiselyova[1], S.O.Rebenkov[2]

[1]*A.A.Boqomolets adına Milli Tibb Universitetinin Uşaq cərrahi stomatologiyası və üz-çənə cərrahiyyəsi kafedrası, Kiyev, Ukrayna*

[2] *"OXMATDİT" İxtisaslaşdırılmış Milli Uşaq Xəstəxanasının Radiologiya Mərkəzi, Kiyev, Ukrayna*

Xülasə. *Məqalədə dodaq və damağın ikitərəfli bitişməməsi (DDİB) və çənəarası sümüyün (Premaxilla) protruziyası olan uşaqlarda xış və çənəarası sümüyün morfometrik parametrlərində yaşla əlaqəli dəyişikliklərin müəyyən edilməsinə yönəlmiş tədqiqatın nəticələri təqdim edilir.*

Kontrol qrupuna yaşı 6 günlükdən 14-ilə qədər olan 115 uşaq və 1 döl, əsas qrupa (DDİB qrupu) yaşı 6 günlükdən 8 yaşa qədər olan 20 uşaq daxil olmuşdur; retrospektiv olaraq kompüter-tomoqrafiya görüntüləri təhlil edilmişdir; xış sümüyünün uzunluğu, qalınlığı, optik sıxlığı və çənəarası sümüyün ölçüləri müəyyənləşdirilmişdir.

Kontrol qrupunda 1 yaşa qədər olan uşaqlarda xış sümüyünün morfometrik ölçüləri belə olmuşdur: uzunluğu – 19,6±1,8 mm, qalınlığı – 1,63±0,25 mm, sıxlığı – 383±98 mq/sm^3; DDİB olan uşaqlarda xış sümüyünün uzunluğu və qalınlığı kontrol qrupundakına nisbətən 1,6 dəfə, sıxlığı isə 2,4 dəfə artıq olmuşdur (p<0,001). Kontrol qrupuna daxil edilmiş yaşı 2-dən artıq olan uşaqlarda xış sümüyünün uzunluğu 28,0±5,5 mm, qalınlığı 1,62±0,35 mm, orta hissədə maksimum sıxlığı – 742±120 mq/sm^3 olmuşdur. Eyni yaş qrupundan olan DDİB-li uşaqlarda isə xış sümüyü kontrol qrupundakına nisbətən orta hesabla 1,2 dəfə uzun, 2,3 dəfə qalın (p<0,001), kaudal nahiyədə maksimum sıxlıq isə 1168±187 mq/sm^3 (p < 0,05) olmuşdur.

Açar sözlər: *çənəarası sümüyün protruziyası, xış sümüyünün optik sıxlığı, xış sümüyünün uzunluğu, üst çənə kompleksi, dodaq və damağın anadangəlmə bitişməməsi*

Ключевые слова: *протрузия межчелюстной кости, оптическая плотность сошника, длина сошника, верхнечелюстной колмплекс, врожденное несращение губы и неба*

Key words: *premaxillary protrusion, optical vomer density, vomer length, maxillary complex, congenital cleft lip and palate*

MORPHOMETRIC INDICES OF THE VOMER ARE WITHIN THE NORMAL RANGE AND IN CHILDREN WITH CONGENITAL BILATERAL CLEFT LIP AND PALATE – A COMPARATIVE STUDY

L.N.Iakovenko[1], N.V.Kiselyova[1], S.O.Rebenkov[2]

[1]*Surgical Dentistry and Maxillofacial Surgery of Childhood Department, Bogomolets National Medical University, Kyiv, Ukraine*

[2]*Radiology Center of the National Children's Specialized Hospital "OKHMATDYT", Kyiv, Ukraine*

The article presents the results of a study the aim was determination of the age-related changes in the morphometric indices of the vomer and the premaxilla in children with bilateral cleft lip and palate (BCLP) and premaxillary protrusion.

A retrospective analysis of computed tomography scans included the control group -115 children from six days up to 14 years of age and an foetus, the group with BCLP - 20 children from six days to eight years of age. The dimensions comprised the length, thickness and the optical density of the vomer and the premaxilla process.

The morphometric data of the vomer in the control group up to the age of 1 year showed: length-19.6±1.8mm, thickness - 1.63±0.25mm, density - 383±98 mg/cm^3. The length and thickness vomer in children *with BCLP were exceeds the length measured in those without BCLP by 1.6 times, density by 2.4 times (p<0.001). The vomer data in children aged 2 years and older in the control group were established: length -28.0±5.5mm, thickness – 1.62±0.35mm, maximum density in the middle part 742±120 mg/cm*^{3}. *Children over 2 years old with BCLP possess a vomer that is 1.2 times longer and 2.3 times thicker on average in comparison with children without BCLP (p<0.001), maximum density in the caudal part 1168±187 mg/cm*^{3} *(p<0.05).*

In Ukraine, 450–500 children are born with cleft lip and cleft palate annually, 20.8% of whom exhibit bilateral pathology [1]. Among them, 30%–35% of children with premaxilla protrusion require correction of the maxillary median fragment position prior to labial and palatine repair surgery. The impairment of the integrity of the alveolar ridge and the orbicularis oris muscle create conditions for unrestricted growth of the nasal septum along with the premaxilla. Furthermore, the enlarged atonic tongue characteristic of individuals withbilateral cleft lip and palate (BCLP) brings extra pressure onto vomer, facilitating overgrowth within the premaxillary–vomerine junction of the nasal septum [2, 3]. As a result, the growth of the nasal septum begins to exceed the tissue growth of the middle facial area, becoming a particular speed regulator of the middle zone tissues and the anterior cranial section in the sagittal plane [4, 5, 6]. This contributes to protrusion of the premaxilla in children with BCLP that commonly shifts in three planes and complicates the treatment of such patients [7, 8].

The aim of the study was determination of the age-related changes in the morphometric indices of the length, thickness and density of the vomer and the premaxilla in children with BCLP and premaxillary protrusion.

Materials and Methods. ***Patient selection***. This case-control study includes a retrospective analysis of 127 computed tomography (CT) scans of the cephalic osseous structures and 8 diagnosis models of the maxilla from the database of the Clinical Department of Surgical Dentistry and Children's Maxillofacial Surgery obtained from January 2017 to June 2020 was performed. CT was performed using a Toshiba® Asteion Super 4 (1 mm native scans). The images were reconstructed applying the osseous reconstructtion filter of the middle stiffness series FC30, FC68 and analyzed on the adjacent areas of working stations using “HOROS” and “Radiant” software. Twenty children from 6 days to 8 years of age with BCLP and premaxillary protrusion (CT -12 and 8 diagnosis models of the maxilla) were includeed in the experimental group. The inclusion criteria were: all patients after 1 years old underwent staged labial and palatine repair surgery, according to age; all patients did not receive premaxillary osteotomy, gingivoperiosteoplasty or alveolar bone grafting, and all the alveolar clefts left open. The control group included 115 children from 6 days up to 14 years of age and an 11-week-old foetus in whom CT investigations were performed. The main criterion to be included in the control group was having a non-deformed middle zone of the facial bones. The study was approved by the local University Research Ethics Committee with approval number 0117U002263 of June 06, 2022 as a standard protocol. All procedures performed in the study were conducted in accordance with the ethics standards given in 1964 Declaration of Helsinki, as revised in 2013. CT examinations were according to standard protocol.

Measurement protocol. The dimensions comprised the length of the vomer starting from the basis of the premaxilla to the posterior edge of the hard palate in the control group and from the premaxillary basis to the projecttion of the vomer junction with the posterior edge of the horizontal plate of the palatine bones in cases of protrusion of the premaxilla in children with BCLP (Figure 1). The vomer thickness was measured behind the premaxillary–vomerine articulation. The average optical density of the vomer was measured in Hounsfield units (HU) in three regions: HU1, just behind the premaxillary–vomerine articulation; HU2, the middle area of the vomer; and HU3, the area of the caudal edge of the vomer (Figure 2). Additionally, optical density of the premaxillary process was gauged in children with premaxillary protrusion.

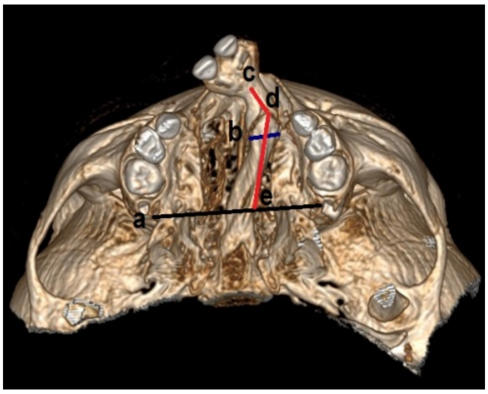

Figure 1: The measurement of the vomer morphometric indices in children with BCLP: a) the line projection of the vomer junction with the posterior edge of the horizontal plates of the palatine bones, b) the measurement of the vomer thickness, c-d) the measurement of the premaxillary process length, d-e) the measurement of the vomer length

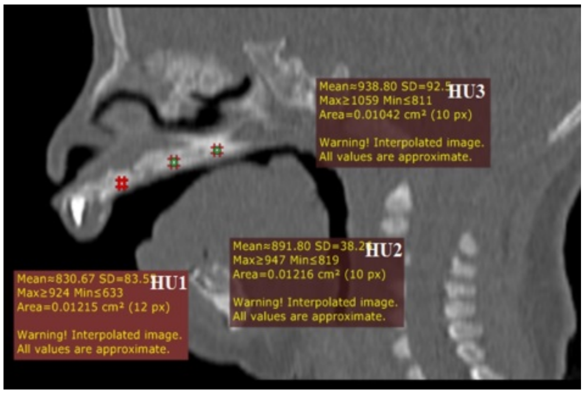

Figure 2: Definition of the average optical vomer density in Hounsfield units (HU).

Statistical analysis. To compare the indices of optical density, Kruskal–Wallis's and Friedman's criteria were applied; for post hoc comparison, Dunn's criteria were used. The Conover's criterion was used to compare variances between populations. The findings were considered to be statistically significant if $p<0.001$, $p<0.05$. To compare the indices of the length and thickness of the vomer, Wilcoxon's criterion was used, and the results were considered to be statistically significant if $p<0.001$. Spearman correlation test was conducted to investigate correlations. Statistical data processing was performed through IBM SPSS Statistics 29.0.1.0(171).

Results and discussion. The morphometric data of the vomer obtained for all investigated children in the control group made it possible to sort them into age groups in 6-month intervals up to the age of 1 year and 1 year intervals from 1 to 14 years of age that are marked by significant changes in the data indices.

Measurement of vomer length in the control group showed that its most intensive growth occurs up to the age of 1 year. The vomer grew an average 24% longer during this period, with the highest intensity during the first 6 months, during which the length increased by 15%. Furthermore, the annual growth gain is 4 mm up to the age of 4 years. Subsequent growth swings were observed at 5 and 7 years old, with increases of 13% and 20%, respectively. By the age of 8 years, the length increases by only 8%; subsequently, up to 14 years old, the growth is insignificant. Growth of thickness of the vomer are the most apparent by the age of 2 years, at which they vary by an average of 13%, and up to 8 years of age, the variation in the thickness is not statistically significant.

In analysing the indices of optical density of the normal vomer (HU1, HU2 and HU3), statistically significant differences ($p<0.001$) were found for various age groups (Figure 3). Using a paired comparison, it was established that the average value of the index for children from 1 to 6 months of age was lower ($p<0.05$ by Dunn's criterion) than in children from 2 to 14 years old. From birth to 6 months old, the vomer density along its total length increased by 6%, and up to 1 year old, it increased by 19%. No statistically significant differences in density at HU1, HU2 or HU3 were observed for children in groups up to 1 year old. The density leap occurs from the age of 1 to 2 years, increasing by 56% during this period, while the vomer density peaks at the age of 3 years. During the following 3 years, some stabilisation is seen, with a decreased density in the middle and caudal areas of the vomer over the age of 8 years.

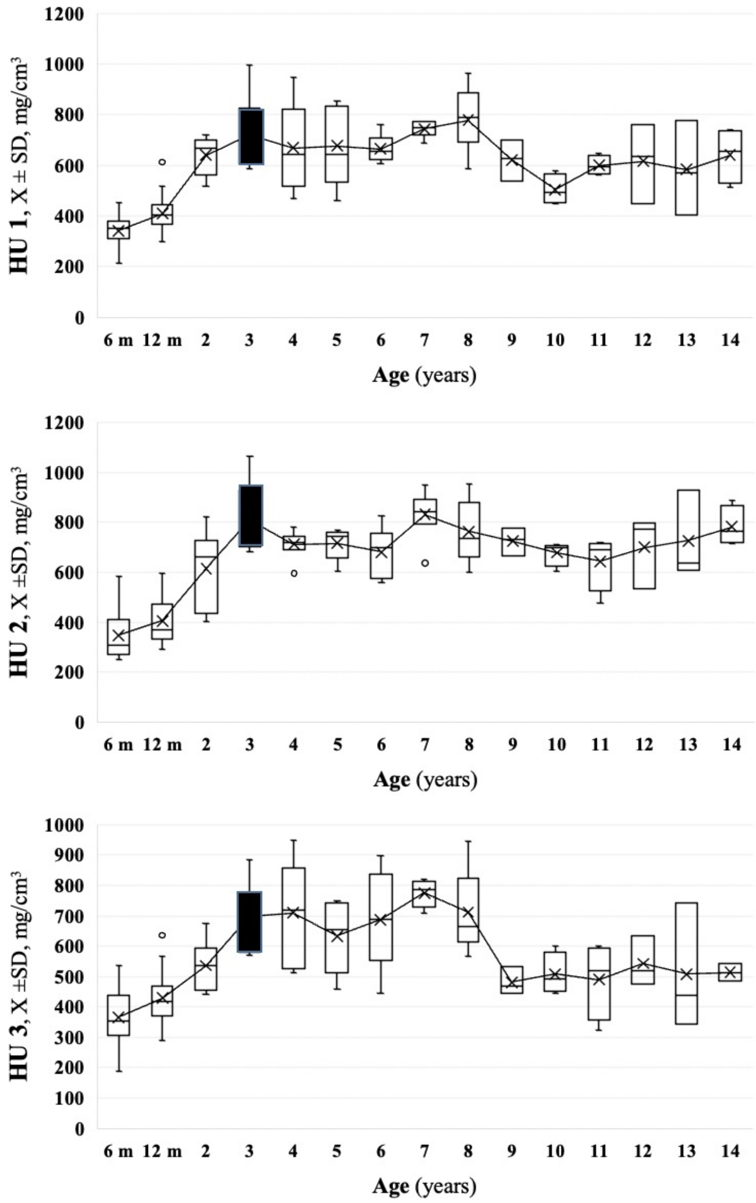

Figure 3: The indices of optical vomer density in three regions in the control group for various age groups. *Note*: Kruskal–Wallis's were applied; for post hoc comparison, Dunn's criteria were used (95% CI).

A statistically significant value of the index in the same points HU1, HU2, HU3 was observed between the groups of children aged 1years old and from 2 to 14 years old ($p<0.05$ by Dunn's criterion) while making a doubled comparison. No statistically significant differences in HU1, HU2 or HU3 index values were detected in any of the age groups of children from 2 to 14 years old. Notably, in children without BCLP, the vomer density doubles from 6 months to 3 years old; the rise density process slows down within the period of 3 to 8 years old, and from 8 to 14 years old, it becomes stabilised. No statistically significant differences in density were identified among various measurement points up to the age of 1 year. However, differences were established in children aged 2 years and older ($p=0.004$, parabolic trend detected); moreover, the difference in the value of density indices at the middle point (HU2 = 742±120 mg/cm^3) is statistically more significant ($p<0.05$) than at HU1 and HU3 (Table 1). Therefore, the density to be highest in the middle part of the vomer in control group over the age of 1 year.

Table 1. **The difference in the value of vomer density indices in children in the control group**

Age	The control group ($\overline{X}$ ±SD, mg/cm^3)			Significance level, p*
	HU_1	HU_2	HU_3	
Foetus (n=1)	223	269	344	–
≤ 1 year (n=50)	381±69	383±98	404±87	0.06
≥ 2 years (n=64)	704±124	742±120	683±133	0.004

* The Friedman test was conducted when comparing indicators, Conover test was used for pairwise comparisons (95% CI).

A positive correlation between the density and length of the vomer, particularly in its caudal area (0.888, p<0.01), was established based on morphometric indices of the vomer in children in the control group. The sequence of vomer growth and density increase was determined: up to the age of 1 year, an intensive elongation of the vomer is accompanied by a slow elevation of the density. After its growth stabilisation from 1 to 4 years old, the density enhancement is marked, with the maximum value at the age of 3 years. Subsequently, the vomer growth becomes activated from 4 to 7 years old; however, density indices become stabilised, with the increase in density subsequently decelerating.

After processing the morphometric data of the vomer of 20 patients with BCLP based on CT findings (n=12) and diagnosis models of the maxilla (n=8), it was established that the median fragment of the upper jaw comprises the premaxillary body and its palatine process. The most active growth resulting in lengthening of the vomer occurs prenatally. A 1-month-old infant with BCLP has a vomer and premaxillary process with a total length that exceeds the length measured in those without BCLP by 1.6 times, as evidenced by their protrusion position. The growth of the vomer itself from birth to 1 year is slow, increasing in length by a total of 18%, with some preference within the period from 3 to 8 months. Moreover, the palatine process of the premaxilla progresses more actively and becomes 33% longer during this time period. Its stabilisation is marked during the period from 1 to 4 years old; however, it starts growing again from 4 to 8 years of age (Figure 4).

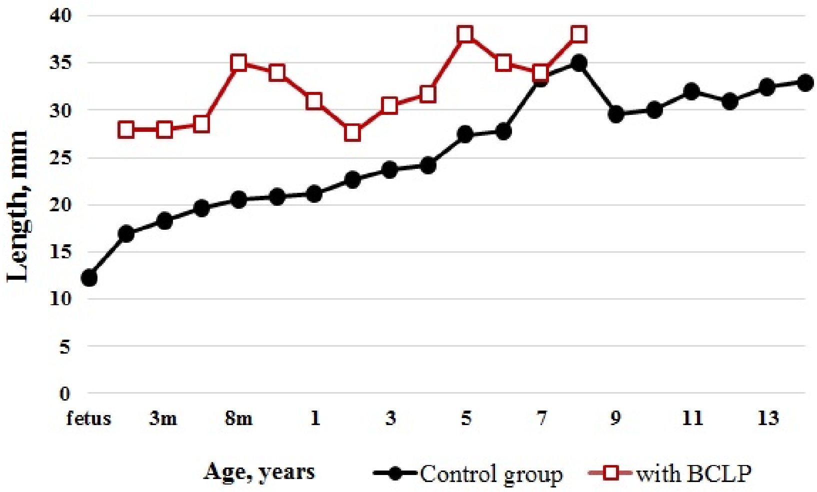

Figure 4: The indices of vomer length in children in the control group and with BCLP for various age groups.
Note: Wilcoxon's criterion was used when comparing indicators, the level of significance was set at $p < 0.001$.

Table 2. **Vomer morphometric indices in children in the control group and with BCLP**

Age	**The control group (n=115)**	**BCLP (n=20)**	**Signifi-cance level, p***
	Vomer length ($\overline{X}$ ±SD, mm)		
foetus	12.4	–	–
≤ 1 year	19.6±1.8	30.9±3.5	<0.001
≥ 2 years	28.0±5.5	33.8±4.3	0.004
	Vomer thickness ($\overline{X}$ ±SD, mm)		
foetus	1.5	–	–
≤ 1 year	1.63±0.25	2.68±0.27	<0.001
≥ 2 years	1.62±0.35	3.79±0.74	<0.001

*Wilcoxon's criterion was used when comparing indicators.

The vomer thickness at birth in children with BCLP is 78% greater than in children without BCLP, and the vomer thickens by 20% up to the age of 1 year in children with BCLP. Children over 2 years old with BCLP possess a vomer that is 2.3 times thicker on average in comparison with children without BCLP ($p<0.001$). Vomer length and width in various age groups were found to be statistically significantly greater in children with BCLP than in children without BCLP ($p=0.004$ and $p<0.001$, respectively) (Table 2).

Upon analysis of the optical density of the vomer in children with BCLP, it was determined that it remarkably exceeded the values measured in children without BCLP (Figure 5) in each of the age groups: by 2.4 times up to the age of 1 year and by 1.3–1.7 times at 2 years and older ($p\leq 0.001$). The density of the premaxillary process correspon-ded to the density at HU1. A statistically significant value of vomer optical density was established at different points of measurement ($p<0.001$, linear trend was revealed) in children 2 years and older (Table 3). Augmen-tation of the index value from HU1 (952±120 mg/cm^3) to HU3 (1168±187 mg/cm^3) ($p<0.05$, for all pairs of comparison points) was noted, indicating a density increase in the proximal–distal direction with maximal va-lues of density in the caudal part of the vomer. A correlation between vomer growth and vomer density has not been established in children with BCLP.

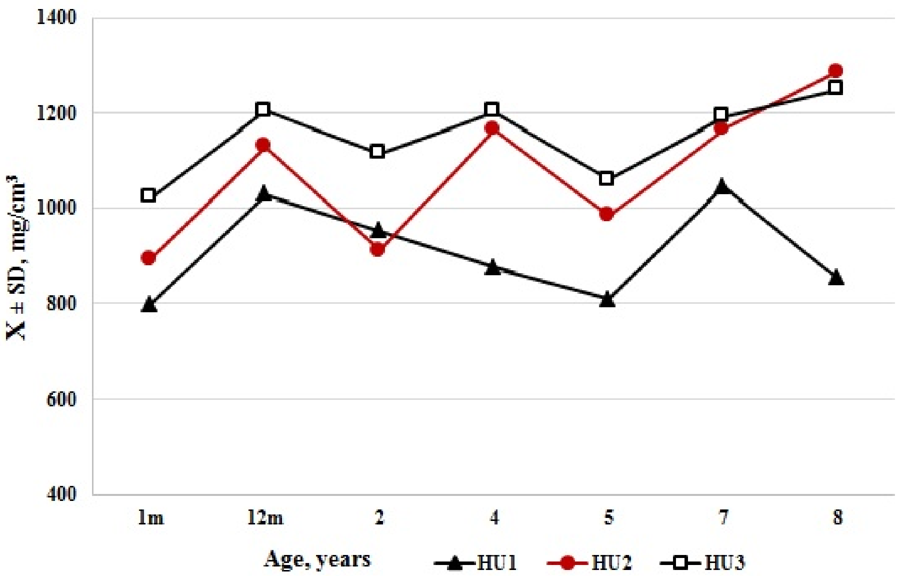

Figure 5: The indices of optical vomer density in three regions in children with BCLP.
Note: Kruskal–Wallis's were applied; for post hoc comparison, Dunn's criteria were used (95% CI).

***Table 3.* The difference in the value of vomer density indices in children with BCLP**

Age	BCLP ($\overline{X}$ ±SD, mg/cm^3)			Significance level, p*
	HU_1	HU_2	HU_3	
≤1 year (n=1)	800	895	1023	–
1 year (n=1)	1031	1130	1205	–
≥ 2 years (n=10)	952±120	1152±253	1168±187	<0.001

* The Friedman test was conducted when comparing indicators, Conover test was used for pairwise comparisons (95% CI).

The premaxilla builds up a vertical osseous column which contacts the base of the skull that is composed of the premaxilla (crista nasalis) and the vomer dorso-cranially. The premaxilla has been compared to a cornerstone in the Roman arch whose removal will result in alveolar arch collapse [9].

Experimentally induced growth decrease of the maxillary bone (of domestic Sus scrofa) leads to the normal growth of the nasal septum as well as compensatory elongation of the premaxilla, demonstrating the developmental interrelation between the nasal septum and the premaxilla as one of the growth components of the middle facial zone [10]. The growth speed of the nasal septal is the highest during in the newborn and the cartilaginous part exhibits maximal acceleration by the age of 2 years. Later growth of general septum occurs due to the development of a perpendicular plate via prolongating ossification of the septal cartilage in the septo-ethmoid junction [4]. The morphometric findings of the vomer that we obtained have shown that in children without BCLP, its most active period of growth occurs by the age of 1 year; subsequent growth swings take place at 5 and 7 years old [11], but by the age of 14, growth activity diminishes. The increase in the width of the vomer occurs up to the age of 2 years, but the width continues to increase up to the age of 8 (although this change is not statistically significant). The sequence of vomer growth and density increase was determined which is probably characteristic of all skull structures [12].

On-time closure of sutures in the embryonic and postpartum period along with the progression of the entire maxillary complex, comprising correlation of all growth zones among themselves and the muscular complex, facilitate the harmonious growth of the middle facial zone [9, 13]. Children with BCLP are observed to have a deviation of the total maxillary complex in the germinal period that creates natural conditions for unrestricted growth of the median fragment in the sagittal plane [14].

In studying growth interconnection of the nasal septum with premaxillary protrusion in children with BCLP, we point out the notion of the osseous–cartilaginous complex of the median fragment of the maxilla, which is represented by the premaxilla with the palatine process as well as the vomer that comprises both a bony constituent of the nasal septum with the perpendicular lamina of ethmoid and a four-angled cartilage. The continuity disturbance of the alveolar crest and the palatine processes of the maxilla, along with muscular imbalance (labial–buccal–pharyngeal ring), lead to a failure to restrain the growth of the osseous–cartilaginous complex in individuals with BCLP. An enlarged atonic tongue, which is often observed in individuals with BCLP, exerts extra pressure onto the premaxilla, contributing to overgrowth in the area of the premaxillary–vomerine junction of the nasal septum [15]. In such conditions, the growth of the nasal septum in combination with the premaxilla and the vomer begins to exceed the growth of the tissues of the middle facial zone antenatally. By comparing histological sections vomers from foetuses 8 to 21 weeks of gestation in children without and with cleft lip and palate (CLP), Kimes *et al.* detected that in individuals with CLP, the growth tendencies of the vomer are compatible with those of the nasal septum [3]. In these individuals, vomer growth was more accelerated than in those without CLP. The speed of volume growth along the total length of the vomer is also more rapid in individuals with CLP [3]. This corresponds to our indices of the vomer at birth in individuals with BCLP. Perhaps the increased thickness and density of the vomer are induced by extra pressure from the enlarged tongue on the vomer. In children with BCLP, the tongue is more massive in its posterior third than in children without BCLP, in whom thickening is closer to the anterior third of the tongue. The majority of the pressure of the tongue at rest and during sucking is laid on the vomer, which reaches a density 2.4 times greater in children with BCLP than in children without BCLP at birth. Most of the pressure is exerted onto the posterior part of the vomer, which is evident in its density increase in the proximal–distal direction. The functional activity of the premaxillary–vomerine junction also promotes the growth of the vomer as well as the premaxillary process [5]. According to our data, the growth speed of the premaxillary process exceeds the actively of the vomer in 1.8 times in children with BCLP by the age of 1 year. In Trevizan's *et al.* investigations of children's crania, 52.42% of children from 0 to 3 years of age and 20% from 3 to 6 years of age were revealed to have 100% opening of the premaxillary–maxillary suture. Premaxillary–maxillary suture closure is estimated to occur at a rate of 3.72% per year from birth up to the age of 12 years [16, 17]. Consequently, the more time spent on the osseous suture closure, the longer the growth potential. The growth within the premaxillary–maxillary suture area is also promoted by the morphological difference in the palatine suture and the incisal canal, where the vomer forms a junction with the premaxilla process. Where the nasal epithelium penetrates into the incisal canal, there is an abundance of vessels on the lateral walls, as well as paramedian pearls that do not allow it to be closed [18]. A strip of lucidity within the junction area of the premaxilla with the vomer is apparent on CT scans of children with BCLP.

At birth, the length, thickness and density of the premaxilla and the vomer in children with BCLP significantly surpasses the values of these morphometric indices in children without BCLP; thus, the sequence of growth and density becomes impaired in children with BCLP. These parameters will affect the indication and terms as well as the techniques for orthodontic and surgical stages of treatment of children with BCLP and premaxillary protrusion.

Conclusions. The sequence of vomer growth and density increase was determined in children in the control group, any correlations has been established in children with BCLP.

The protrusion of the median osseous–cartilaginous complex of the maxilla becomes enlarged due to growth of the premaxillary process in children with BCLP. Initially, the density of the vomer is 2.4 times higher in children with BCLP, and it becomes enlarged in the proximal–distal direction in all age groups.

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МОРФОМЕТРИЧЕСКИЕ ПОКАЗАТЕЛИ СОШНИКА В НОРМЕ И У ДЕТЕЙ С ВРОЖДЁННЫМ ДВУСТОРОННИМ НЕСРАЩЕНИЕМ ВЕРХНЕЙ ГУБЫ И НЁБА - СРАВНИТЕЛЬНОЕ ИССЛЕДОВАНИЕ

Л.Н.Яковенко[1], Н.В.Киселёва[1], С.О.Ребенков[2]

[1]Кафедра хирургической стоматологии и челюстно-лицевой хирургии детского возраста, Национальный медицинский университет имени О.О.Богомольца, Киев, Украина;
[2]Радиологический центр Национальной детской специализированной больницы «ОХМАТДИТ» Киев, Украина

Резюме. В статье представлены результаты исследования, целью которого было определение возрастных изменений морфометрических показателей сошника и межчелюстной кости у детей с двусторонним несращением губы и неба (ДНГН) и протрузией межчелюстной кости.

Ретроспективный анализ компьютерно-томографических изображений включал в себя контрольную группу – 115 детей в возрасте от 6 дней до 14 лет и плод, группу с ДНГН – 20 детей в возрасте от 6 дней до 8 лет. Измерения включали длину, толщину и оптическую плотность сошника и отростка межчелюстной кости.

Морфометрические данные сошника в контрольной группе в возрасте до 1 года показали: длина – 19,6±1.8 мм, толщина – 1,63±0,25 мм, плотность – 383±98 мг/см^3. Длина и толщина сошника у детей с ДНГН превышала длину, измеренную у детей без ДНГН, в 1.6 раза, плотность — в 2,4 раза (p<0,001). Установлены данные сошника у детей в возрасте 2 лет и старше в контрольной группе: длина – 28,0±5,5 мм, толщина – 1,62±0,35 мм, максимальная плотность в средней части – 742±120 мг/см^3. У детей старше 2 лет с ДНГН сошник в среднем в 1,2 раза длиннее и в 2,3 раза толще по сравнению с детьми без ДНГН (p<0.001), максимальная плотность в каудальном отделе 1168±187 мг/см^3 (p<0.05).

Возрастные изменения морфометрических параметров сошника и межчелюстной кости будут влиять на показания и сроки, а также на методику ортодонтического и хирургического этапов лечения детей с ДНГН и протрузией межчелюстной кости.

Correspondence to:
Natalia Kiselyova, Surgical Dentistry and Maxillofacial Surgery of Childhood Department, Bogomolets National Medical University, Kyiv, Ukraine.
e-mail: kiseleva.nv03@gmail.com
ORCID iD: https://orcid.org/0000-0002-1587-0215