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Odontological analysis of Polish children with unilateral cleft lip and palate

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Abstract: Tooth size, being the effect of interaction of genetic and prenatal factors, could be of importance in interpreting the multifactor causes of cleft lip/palate. Publications indicating decreased tooth parameters, no dental differences, or larger dimensions of teeth in cleft lip/palate patients. Researchers report mostly mesiodistal (MD) measurements of maxillary (affected) teeth. There is a lack of data for buccolingual (BL) diameters. Both MD and BL parameters have influence on the planning and performance of orthodontic treatment. The aim of this paper was to assess differences in mesiodistal and buccolingual tooth dimensions in Polish children with unilateral cleft lip and palate (UCLP) in comparison to patients without oral clefts. A total of 1883 permanent teeth, 1182 teeth of UCLP patients and 701 teeth of healthy participants were analyzed. Tooth diameters were performed using an orthodontic cast of dentition with a digital odontometer. The greatest anomalies were found in both maxillary canines and consisted of their reduced mesiodistal dimension and increased buccolingual dimension, resulting in a pathologically high crown shape index (BL/MD). Conclusion can be drawn that unilateral cleft lip and palate is a condition that causes morphological disturbances of varying severity in most mandibular and maxillary teeth both on the cleft and non-cleft sides.

Key words: teeth, odontometry, anthropometry, oral malformations

Abbreviations used in the text: MD – mesiodistal diameter, BL – buccolingual diameter, UCLP – unilateral cleft lip and palate, TEM – technical error of measurement, R – reliability index, I1– first incisor, I2 – second incisor, C – canine, P1 – first premolar, P2 – second premolar, M1 – first molar.

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Introduction

Unilateral cleft lip and palate is a malformation of complex etiology. According to the International Perinatal Database of Typical Oral Clefts (2011), the overall prevalence of cleft lip with or without cleft palate is 9.92 per 10,000 births. In turn, the prevalence of cleft lip is 3.28 per 10,000, and that of cleft lip and palate is 6.64 per 10,000 births. The group of risk factors for cleft appearance consists of both genetic and prenatal environmental factors. Several gene mutations associated with a risk or predisposition for nonsyndromic cleft lip/palate have been reported: *PAX7* – a neural crest enhancer downstream of *FGFR2*, variants near *NTN1* and *NOG* (Leslie et al. 2015), and mutations in *TP63* (Alves et al. 2015), *DLX4* (Wu et al. 2015), and *MSX1* (Gurramkonda et al. 2015). *MSX* and *DLX* homeobox genes share a key role in craniofacial development (Alappat et al. 2003) and tooth development in humans (Bei and Maas 1998, Zhao et al. 2000, Ruhin-Poncet et al. 2009). Additionally, according to Lézot and colleagues (2002) *Msx/Dlx* transcription factors modulate the impact of prenatal vitamin D on the tooth morphogenetic pathway. Among prenatal environmental factors which could trigger cleft formation are maternal use of corticosteroids during the first trimester of pregnancy (Skuladottir et al. 2014), maternal alcohol consumption (et al. 1996), and maternal coffee intake (Johansen et al. 2009). Medications used in epilepsy treatment also increase the likelihood of cleft lip/palate in the child (Margulis et al. 2012). Finally, the incidence of orofacial cleft is significantly inversely correlated with levels of sunshine in the first trimester and with the level of nitrogen oxides at around 8 weeks post conception (Chung et al. 2013).

In recent years, in an effort to elucidate the causes of lip/palate clefts, many researchers have analyzed linear tooth diameters in the population compromised by this congenital defect (Rawashdeh and Bakir 2007, Lewis al at. 2008, Lai et al. 2009, Walker et al. 2009, Akcam et al. 2010). Permanent teeth begin to form at the end of the second trimester of pregnancy: in the 6th to 8th months of fetal life the tooth germs of incisors, canines and first molars start to develop, during the very last period in utero and around the time of labor the germs of premolars are initiated. Subsequently, the germs of the second molars develop between the 6th and 9th months of postconception life and the germs of third molars form at the age of 4–5 years (Nanci et al. 2008). Consequently, their volume and shape, being the effect of interaction of genetic factors and prenatal environmental factors, could be of importance in interpreting the multifactor causes of cleft lip/palate. The influence of genetic factors has been unambiguously shown, including the odontogenic transcription factor Msx1, which is associated with orofacial cleft and, amongst others, cue signaling BMP4 and its inhibitor (Kavanagh et al. 2007, Mammoto et al. 2011). However, biomechanical impact is of high significance. Experimental publications have reported different results for persons with orofacial cleft malformation, indicating decreased permanent and milk tooth parameters (Foster and Lavelle 1971, Werner and Harris 1989, Rawashdeh and Bakir 2007, Lewis et al. 2008, Lai et al. 2009, Akcam et al. 2010, Hermann et al. 2012), no dental differences (Peterka and Müllerová 1983), or significantly larger dimensions of selected teeth as compared to the control group (Akcam et al. 2008). Additionally, patients with unilateral clefts tend to have smaller teeth on the affected side than on the contralateral side (Walker et al. 2009). Meta-analysis by Antonarakis et al. (2013) indicates, however, larger dimensions of maxillary teeth in persons with CLP and significant differences in dental parameters between teeth in the upper jaw on the cleft and contralateral sides. The body of literature reviewed by Antonarakis and colleagues (2013) also revealed dissimilarities between maxillary and mandibular teeth. Different directions of changes in diameters were observed depending on whether analysis concerned the anterior region of the maxilla (incisors) or the posterior region (premolars and molars). Nevertheless, existing research only reports mesiodistal measurements of maxillary teeth. There is a lack of data for buccolingual diameters, which could stand for the proportion of crown sizes and massive shape and for the direction of distorted patterns of permanent tooth germs. Furthermore, odontometric canine analysis has been the subject of surprisingly few works. Only some researchers have provided data for the sizes of mandibular teeth, not affected by morphological defects. Both tooth parameters, MD and BL, have great influence on the planning and performance of orthodontic treatment, i.e., the choice of brackets or orthodontic wire, as well as the magnitude of and point of force application.

The aim of the presented study was to assess differences in mesiodistal and buccolingual permanent tooth dimensions in Polish children with unilateral cleft lip and palate in comparison to patients without oral clefts.

Material and Methods

The study was approved by the Ethical Committee of the Medical University of Łódź (RNN/155/10/KE). It involved 120 children: 69 individuals with UCLP (47 boys and 22 girls) and 51 patients without any orofacial malformations (21 boys and 30 girls) treated at the Department of Orthodontics, Medical University of Łódź. Both groups consisted of patients aged 9–14 years. In 43 of the UCLP children, the defect was located on the left side, and in 26 on the right side (Table 1).

Standard tooth crown measurements

MD and BL were performed by one researcher (PS) using an orthodontic cast of maxillary and mandibular dentition with a digital odontometer (accuracy of 0.03 mm). The second and third molars were not included in the study because most of them were not erupted in the UCLP patients at the time of orthodontic treatment. A total of 1182 permanent teeth (612 maxillary and 570 mandibular) of UCLP patients and a total of 701 teeth (319 maxillary and 382 mandibular) of healthy patients were analyzed (Table 2).

For each tooth, the crown shape index was calculated according to the formula:

Table 1. Characteristics of the examined children

Sex	UCLP	Right-sided cleft	Left-sided cleft	Control	Total
Males	47	19	28	21	68
Females	22	7	15	30	52
Total	69	26	43	51	120

UCLP – unilateral cleft lip and palate.

(BL/MD)*100. Tooth numbers for which the crown index was calculated are given in Table 3.

According to the procedure proposed by Ulijaszek and Lourie (1994), each measurement was performed twice to calculate the technical error of measurement (TEM) and for reliability index assessment (R). The mean R value was 0.95 (ranging from 0.91 for the right lateral mandibular incisor to 0.99 for the left central maxillary incisor). This means that 95% of variability in tooth crown diameters was caused by factors different from the calculated mean measurement error.

Statistical analysis

All statistical analyses were conducted based on *z-scores* of mesiodistal and buccolingual tooth diameters as well as *z-scores* of the crown shape index. Standardization was performed on respective data of non-cleft children: sex, jaw (maxilla, mandible) and jaw side (right, left) were considered. The obtained *z-score* values of relevant dental measurements and indices were categorized into three groups: 1) cleft children, the side of jaw with cleft; 2) cleft children, the side of jaw without cleft, and 3) non-cleft children (control group).

Table 2. Number of the measured teeth (MD and BL)

Tooth/measurement	Maxilla			Mandible		
	Cleft side	Non-cleft side	Control	Cleft side	Non-cleft side	Control
M1/MD	63	59	48	52	50	27
M1/BL	61	59	50	51	51	27
P2/MD	43	45	39	36	35	48
P2/BL	42	44	38	35	34	51
P1/MD	48	51	46	43	42	72
P1/BL	47	47	44	42	40	71
C/MD	48	53	65	48	48	81
C/BL	35	31	63	27	29	77
I2/MD	30	49	55	54	55	75
I2/BL	11	20	37	35	34	72
I1/MD	61	62	64	53	53	76
I1/BL	14	21	43	38	38	73

Note: The table does not include patients' sex and the affected side (R, L). Data normalization (transformation to *z-score* values) enabled to exclude these variables from statistical analysis.

Table 3. Number of teeth for which crown shape indices were calculated ([BL/MD]*100)

Tooth	Maxilla			Mandible		
	Cleft side	Non-cleft side	Control	Cleft side	Non-cleft side	Control
M1	60	57	48	50	48	25
P2	41	44	37	35	34	46
P1	46	47	44	42	40	71
C	35	31	63	27	28	76
I2	11	20	36	35	34	70
I1	14	21	41	38	37	71

Note: The table does not include patients' sex and the affected side (R, L). Data normalization (transformation to *z-score* values) enabled to exclude these variables from statistical analysis.

Differences in the range of respective dental measurements and indicators between the above groups were tested using univariate variance analysis (ANOVA) or its non-parametric analogue – the Kruskal-Wallis test. The choice of statistical test depended on variance homogeneity, which was evaluated using the Levene test. If significant differences were revealed, the post hoc test was performed (Tukey test for unequal numbers or multiple comparisons of mean ranks for all groups). All comparisons were conducted separately for the maxilla and mandible because morphological aberrations of the upper and lower teeth in children with UCLP were expected.

Results

The maxilla

A comparison of the maxillary tooth dimensions and crown shape index between UCLP children and the control group is given in Tables 4–5.

In individuals with UCLP, two upper tooth types (C, P1) showed differences in terms of both diameters (MD and BL) on both sides of the maxilla, while four other tooth types (I1, I2, P2, M1) differed in terms of one parameter only (MD or BL), on one side of the dental arch, in relation to non-UCLP children (Table 4, Figs 1, 2).

The group of children compromised by a lack of fusion between the two maxillary bones exhibited increased MD and BL parameters in the first premolars as well as a greater BL length of both canines in comparison to the controls. UCLP children also revealed lower MD values of both maxillary canines as indicated in Table 4 and Fig. 1 and 2.

Aside from bilateral changes, some unilateral tooth size abnormalities were also found. Second premolars on the ipsilateral side of the cleft exhibited a larger BL diameter in UCLP children than in healthy individuals. On the contralateral side, BL values were also higher in UCLP children, but the results failed to reach

Table 4. Results of maxillary teeth measurements comparison

Tooth/measurement (*z-score*)	*F*	*p*-value	Compared groups Post-hoc (*p*-value) Cleft side vs Control	Non-cleft side vs Control	Cleft side vs Non-cleft side
M1/MD	4.09	0.0185	0.0521	0.0385	0.9907
M1/BL	0.71	0.4941	–	–	–
P2/MD	2.24	0.1103	–	–	–
P2/BL	5.39	0.0057	0.0052	0.0618	0.6396
P1/MD	14.22	<0.0001	0.0007	<0.0001	0.3223
P1/BL	17.74	0.0001	0.0034	0.0002	1.0000
C/MD	33.09	<0.0001	<0.0001	<0.0001	1.0000
C/BL	18.32	0.0001	0.0069	0.0003	1.0000
I2/MD	13.17	0.0014	0.6709	0.0009	0.1827
I2/BL	4.07	0.0216	0.1517	0.7082	0.0420
I1/MD	3.46	0.0334	0.2399	0.0268	0.6123
I1/BL	7.48	0.0011	0.0096	0.1752	0.2734

Note: The table does not include patients' sex and the affected side (R, L). Data normalization (transformation to *z-score* values) enabled to exclude these variables from statistical analysis.

statistical significance by a small margin. Additionally, on the cleft side the first incisor was characterized by a lower average BL size, while on the contralateral side it did not differ statistically significantly from the control group (Table 4, Fig. 2).

Table 5. Results of maxillary teeth crown shape indices comparison

(BL/MD)*100 (*z-score*)	*F*	*p*-value	Compared groups Post-hoc (*p*-value) Cleft side vs Control	Non-cleft side vs Control	Cleft side vs Non-cleft side
M1	5.98	0.0031	0.0031	0.1114	0.3489
P2	2.15	0.1206	–	–	–
P1	0.06	0.9404	–	–	–
C	42.29	<0.0001	<0.0001	<0.0001	1.0000
I2	4.46	0.1077	–	–	–
I1	4.65	0.0126	0.0148	0.1676	0.4856

The table does not include patients' sex and the affected side (R, L). Data normalization (transformation to *z-score* values) enabled to exclude these variables from statistical analysis.

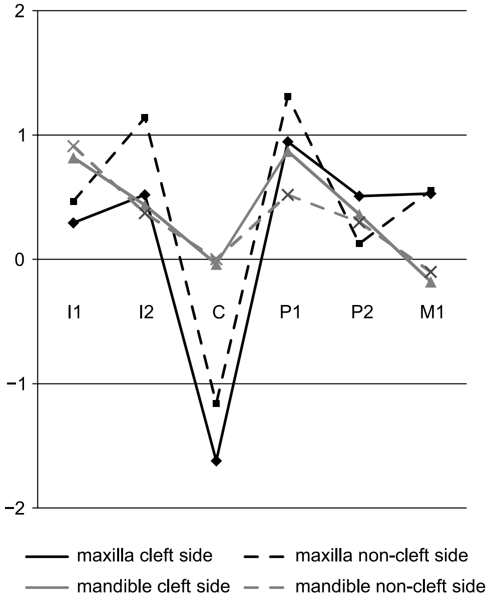

Fig 1. The mean values/medians of the standardised values (*z-score*) of mesiodistal (MD) dimension of mandibular and maxillary teeth in children with unilateral cleft lip and palate, related to healthy children (line "0")

Note: the mean values of *z-score* for: mandibular and maxillary I1, mandibular I2, mandibular C, maxillary P1, mandibular and maxillary P2, mandibular and maxillary M1; the medians of *z-score* for: maxillary I2, maxillary C, mandibular P1.

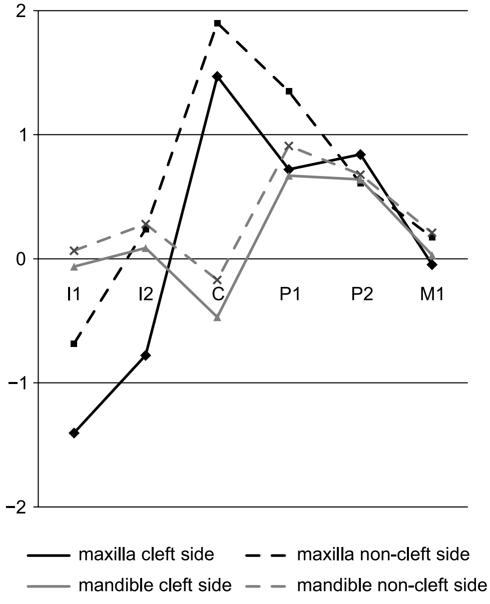

Fig 2. The mean values/medians of the standardised values (*z-score*) of buccolingual (BL) dimension of mandibular and maxillary teeth in children with unilateral cleft lip and palate, related to healthy children (line "0")

Note: the mean values of *z-score* for: mandibular and maxillary I1, mandibular and maxillary I2, mandibular and maxillary P2, mandibular and maxillary M1; the medians of *z-score* for: mandibular and maxillary C, mandibular and maxillary P1

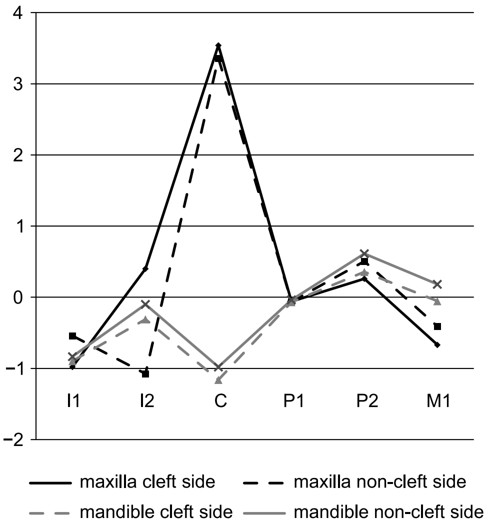

Fig 3. The mean values/medians of the standardised values (*z-score*) of crown shape index of mandibular and maxillary teeth in children with unilateral cleft lip and palate, related to healthy children (line "0")

Note: the mean values of *z-score* for: mandibular and maxillary I1, mandibular and maxillary I2, mandibular and maxillary P1 and P2, mandibular and maxillary M1; the medians of *z-score* for: mandibular and maxillary C.

Besides the distinct bilateral features described in this paper, tooth size analysis on the non-cleft side in UCLP children additionally revealed increased mesiodistal distances in three tooth types (I1, I2, and M1). On the contralateral (malformed) side of the maxilla, the MD diameter of the I1 and I2 teeth did not differentiate UCLP from non-UCLP patients, while in the case of M1, case-control differences bordered on statistical significance (Table 4, Fig. 1).

The BL dimension of the second incisor did not differ significantly between UCLP patients and healthy individuals; however, in UCLP children it was smaller on the cleft side (Table 4, Fig. 2).

The crown shape index confirmed an increased BL diameter relative to MD in both maxillary canines in UCLP children as compared to healthy individuals. In the case of the central incisors and the first upper molars, the BL to MD ratio on the cleft side was lower than in non-UCLP children (Table 5, Fig. 3).

The mandible

A comparison of mandibular tooth dimensions and the crown shape index between UCLP children and the control group is presented in Tables 6–7.

In UCLP children, both dimensions of the mandibular P1 were abnormal, on both sides of the dental arch. Other minor but statistically significant departures from normal were found in UCLP cases in the central incisor and second premolar (I1 and P2). The differences affected just one parameter (MD or BL), but in both quadrants. Moreover, two types of teeth (I2, C) showed differences in one metrical trait (MD or BL) only on the cleft side in comparison to normative values obtained from non-UCLP individuals (Table 6).

In UCLP children, the first premolars on both sides of the mandible were characterized by larger MD and BL values than the controls. The same differences were found for MD in the second mandibular premolars in UCLP children. The UCLP group exhibited larger average values of MD measurements for both lower first incisors (Table 6, Figs. 1, 2).

Apart from the above bilateral morphological differences, on the cleft side the mandibular canine had a shorter BL diameter and the second mandibular incisor had a longer MD diameter than healthy persons (Table 6, Figs. 1, 2).

The crown shape index indicated a lower BL to MD ratio for both mandibular canines and the first mandibular incisors in UCLP children in comparison to healthy individuals (Table 7, Fig. 3).

A summary of differences in the dimensions and crown shape index of maxillary and mandibular teeth is presented in Table 8.

Discussion

All teeth in the UCLP group differed from the teeth of patients from the control group at least in terms of one diameter (except for the first mandibular molar), with slightly higher MD and/or BL deviations in the maxilla as compared to the mandible. In this regard, our results seem to be in accordance with other studies (Antonarakis et al. 2013). However, the direction of differences presented herein diverges from most literature reports indicating reduced tooth size in UCLP cases (Werner and Harris 1989, Rawashdeh

Table 6. Results of mandibular teeth measurements comparison

Tooth/measurement (*z-score*)	*F*	*p*-value	Compared groups Post-hoc (*p*-value)		
			Cleft side vs Control	Non-cleft side vs Control	Cleft side vs Non-cleft side
M1/MD	0.21	0.8099	–	–	–
M1/BL	0.51	0.6017	–	–	–
P2/MD	0.26	0.8794	–	–	–
P2/BL	4.56	0.0124	0.0404	0.0287	0.9890
P1/MD	12.26	0.0022	0.0043	0.0340	1.0000
P1/BL	7.81	0.0202	0.0300	0.0233	1.0000
C/MD	0.02	0.9815	–	–	–
C/BL	6.32	0.0424	0.0490	0.2462	1.0000
I2/MD	4.12	0.0178	0.0433	0.0976	0.9326
I2/BL	1.34	0.5121	–	–	–
I1/MD	21.86	0.0001	<0.0001	<0.0001	0.8500
I1/BL	0.12	0.8909	–	–	–

The table does not include patients' sex and the affected side (R, L). Data normalization (transformation to *z-score* values) enabled to exclude these variables from statistical analysis.

Table 7. Results of mandibular teeth crown shape indices comparison

(BL/MD)*100 (*z-score*)	*F*	*p*-value	Compared groups Post-hoc (*p*-value)		
			Cleft side vs Control	Non-cleft side vs Control	Cleft side vs Non-cleft side
M1	0.51	0.5993	–	–	–
P2	3.42	0.1806	–	–	–
P1	0.06	0.9393	–	–	–
C	20.14	<0.0001	0.0009	0.0013	1.0000
I2	1.09	0.3394	–	–	–
I1	13.44	<0.0001	0.0003	0.0011	0.9616

The table does not include patients' sex and the affected side (R, L). Data normalization (transformation to *z-score* values) enabled to exclude these variables from statistical analysis.

Table 8. Differences in teeth measurements/indices

		Maxilla			Mandible		
		Cleft side(1) vs Control(2)	Non-cleft side(1) vs Control(2)	Cleft side(1) vs Non-cleft side(2)	Cleft side(1) vs Control(2)	Non-cleft side(1) vs Control(2)	Cleft side(1) vs Non-cleft side(2)
Teeth measurements	M1/MD		>				
	M1/BL						
	P2/MD						
	P2/BL	>			>	>	
	P1/MD	>	>		>	>	
	P1/BL	>	>		>	>	
	C/MD	<	<				
	C/BL	>	>		<		
	I2/MD		>		>		
	I2/BL			<			
	I1/MD		>		>	>	
	I1/BL	<					
(BL/MD)*100	M1	<					
	P2						
	P1						
	C	>	>		<	<	
	I2						
	I1	<			<	<	

> Measurement/index higher in group (1) than in group (2)
< Measurement/index lower in group (1) than in group (2).

and Bakir 2007, Lewis et al. 2008, Walker et al. 2009, Akcam et al. 2010, Hermann et al. 2012). In individuals with UCLP, the smaller segment of the maxilla is not connected to the vomer, with the latter being largely responsible for splanchnocranial growth (if one assumes that cartilage is the main growth-determining factor). Despite the large size of the maxilla, in the transverse plane the space for dental development is limited due to the relatively extensive area of the cleft region. On the other hand, the lip does not constrain growth in the anteroposterior direction, which may explain the increased MD to BL ratio.

We conjecture that larger MD to BL measurements of the incisors on the non-cleft side could be attributable to lost soft tissue and musculature after a flap from that side of the oral cavity was surgically transposed to the other side to repair a unilateral cleft lip or palate by covering the fissure at around 6 months of postnatal life. Thus, diminished pressure is exerted on the non-cleft side in contrast to increased pressure on the non-fused segment (Fisher 2005).

In the mandible, all significant differences between patients with UCLP and the control group (both on the cleft and non-cleft sides) indicate larger tooth diameters in individuals with UCLP, except for the canine BL diameter. Similarly, in the maxilla all significant differences in indicate larger tooth dimensions in UCLP patients, the only exceptions being the canine MD diameter and the incisor BL diameter.

The results of our study do not indicate an explicit tooth size reduction in UCLP patients; just on the contrary, they suggest a lack of odontometric shifts, which is in agreement with other studies, such as by Peterka and Müllerová (1983), with a tendency for larger diameters of certain (mostly posterior) teeth reported by Akcam et al. (2008) and Antonarakis et al. (2013). In their meta-analysis, Antonarakis et al. (2013) compared only mesiodistal tooth dimensions in nonsyndromic UCLP patients from four different populations (Turkey, United Kingdom, Czechoslovakia, and Jordan) and found UCLP patients to have larger posterior teeth both on the cleft and non-cleft sides, but smaller anterior teeth compared with the general population. In our studies of anterior teeth, MD and BL measurements seem to react differently to UCLP. Apparently, the effect is pronounced in measurements of the maxillary canine. This tooth is significantly smaller in the MD dimension and concomitantly increased in the BL dimension in comparison to the control group canine. The crown shape of this tooth is thus effectively different from that in non-UCLP children, being elongated in the BL plane (a high crown shape index). Canine shape modification in UCLP patients has not been reported to date. Instead, researchers have indicated the absence of significant differences in this tooth measurement, which is associated with the commonly known hypothesis of canine developmental stability (Dahlberg 1945). In the majority of publications, canine size analyses rely on MD measurements only, precluding inter-population comparisons of shape variability of this tooth in UCLP patients. The only exception is the publication by Walker et al. (2009), which indicates lower MD and BL tooth measurements (on average by 0.3–0.2 mm) in Britons with UCLP, with significant differences found exclusively for the upper central and lateral incisors.

On the cleft side, teeth are smaller than those on the non-cleft side, though statistically significant differences were shown only concerning the BL parameter of the upper lateral incisor. This difference was also significant for the crown shape index. This result is in accord with earlier studies, which indicated reduced tooth sizes on the malformation side (e.g., Foster et al. 1971, Sofaer 1979, Werner and Harris 1989), to the greatest degree in the upper lateral incisors. Walker et al. (2009) also observed that in UCLP patients from the UK the upper lateral incisors on the cleft side showed not only the greatest reduction in size but also the highest frequency of abnormal (hypoplastic or peg-shaped) morphology. This has been corroborated by other researchers (Ranta 1986, Vichi and Franchi 1995, Ribeiro et al. 2003, Dewinter et al. 2009). Walker et al. (2009) also reported a significantly higher frequency of shovelling of the upper incisors in unilateral and bilateral CLP patients, which, according to them, may support the hypothesis of a genetic link between clefting and incisor shoveling. The second left upper incisor had almost the same diameter as the central incisor despite the fact that the supernumerary tooth obstructed the availability of formation space and the eruption path for the right central incisor.

The changes in the crown shape index of incisors and maxillary canines observed in this paper may also imply a direct local effect on the developing anterior tooth germs if the cleft involves an alveolus.

In conclusion, the anterior teeth of Polish subjects with UCLP are characterized by a significant diameter reduction in comparison to the control group – the upper canines both on the cleft and non-cleft sides exhibit lower mesiodistal values and the upper central incisor and lower canine on the cleft side reveal a lower buccolingual diameter. The upper lateral incisor was found to be significantly smaller on the cleft side as compared to its contralateral counterpart. Characteristically, a larger distance was observed between the mesial and distal contact points (MD) both on the cleft and non-cleft sides for the upper and lower first premolars. The mesiodistal crown dimensions of the upper first molars and upper central and lateral incisors were greater only on the non-cleft side and a larger MD dimension was found for the lower incisors. A longer BL diameter was noted for the upper and lower premolars and upper canines, while the lower canines exhibited a smaller BL. The upper canines on both sides of the maxilla exhibited a higher crown shape index (larger BL in relation to MD). Conversely, the upper first molars and central incisors on the malformation side, as well as the lower canines and central incisors on both sides revealed a smaller crown shape index.

Study Limitations

Not always both measurements of tooth crown could have been made. This limitation was the result of tooth abrasion or poor quality of the model at the measuring point. In case of any doubts concerning the correct positioning of the measuring point, the measurement was abandoned.

Conclusions

Unilateral cleft lip and palate is a condition that causes morphological disturbances of varying severity in most mandibular and maxillary teeth both on the cleft and non-cleft sides.

The upper teeth are characterized by more severe abnormalities than the lower teeth.

The greatest anomalies are found in maxillary canines and consist of their reduced mesiodistal dimension and increased buccolingual dimension resulting in a pathologically high crown shape index (BL/MD).

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Authors' contributions

PS conceived the concept, served as principal investigator for the research; EŻ, EP were co-investigators of the project; AS performed statistical analysis, interpreted the results; BA was the head of the research team. All authors were involved in drafting the manuscript and approved the final manuscript.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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