Original Article

3D Evaluation of Tooth Crown Size ın Unilateral Cleft Lip and Palate Patients

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Received: 04-Oct-2019;
Accepted: 20-Dec-2019;
Published: 04-May-2020.

ABSTRACT

Aim: The aim of this retrospective study is to evaluate and compare the 3-dimensional (3D) crown sizes of the left and right sides of upper and lower dental arches in patients with unilateral cleft lip and palate (UCLP). **Materials and Methods:** Dental casts of 94 patients all in permanent dentition were included in this study. Dental casts were divided into three groups as 36 casts with unilateral left cleft lip and palate (ULCLP), 18 casts with unilateral right cleft lip and palate (URCLP), and 40 casts without cleft (control). Mesiodistal (MD), buccolingual (BL), and gingiva incisal (GI) values of each tooth were measured by scanning the dental models with a high-precision optical 3D scanner. Paired *t*-test and independent *t*-test were used for statistical analysis. **Results:** U1 MD, U6 MD ($P = 0.001$) and BL ($P = 0.01$), L3 GI ($P = 0.05$) were greater in UCLP patients on the non-cleft side while U1 GI, L1 BL, L5 MD ($P = 0.001$), L4 MD, and BL ($P = 0.01$) values were found to be greater on the cleft side. Comparison of the cleft-sides and the control group showed that MD, BL, and GI dimensions of teeth on the cleft sides were generally found to be smaller, excluding the UR7 GI values for URCLP group ($P = 0.05$). **Conclusion:** In the measurements of teeth size, reliable and repeatable results were acquired through 3D software. Tooth size asymmetries can occur non-syndromic UCLP patients in both jaws. MD, BL, and GI dimensions of teeth are mostly found to be smaller in patients with CLP.

KEYWORDS: *3D, cleft lip and palate, crown size, tooth size*

INTRODUCTION

The treatment of cleft lip and palate (CLP) patients are quite complex and involves a range of craniofacial and dental treatment procedures beginning just after the birth and continuing to adulthood. All of these efforts become evident in the success of the "finishing stage" of orthodontic treatment of a CLP patient. The finishing stage is difficult and challenging due to discrepancies in tooth size or abnormal tooth anatomy.[1,2]

Dental abnormalities such as variations in tooth size, morphology, and position are commonly found in subjects with CLP.[2-6] One of the most common dental anomalies in CLP patients is congenital absence of the lateral incisor.[1,5]A previous study reported that the congenital absence of the cleft-side lateral incisor was observed in 49.8% of the sample while its antimere was congenitally missing in 10.9%.[5] Discrepancies in teeth dimension were also reported in several studies.[3,4,6-9] Walker *et al*.[8] claimed that tooth size in patients with cleft lip and palate was reduced in both jaws. Akçam *et al*.[4] also suggested that dental asymmetries can occur in non-syndromic CLP patients in the permanent dentition, and tooth size symmetry should be considered during treatment planning in individuals with a cleft.

Cleft lip and palate occurs in early fetal development. Thus, permanent teeth are considered to be unaffected. But, it was suggested that the postnatal environmental

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Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_537_19

How to cite this article: Kaplan M, Görgülü S, Cesur E, Arslan C, Altuğ AT. 3D evaluation of tooth crown size ın unilateral cleft lip and palate patients. Niger J Clin Pract 2020;23:596-602.

factors such as surgical operations, nutrition, and infections of CLP patients can affect the teeth both in the cleft and non-cleft side.[2,3,10] The occurrence of dental anomalies in CLP patients were also attributed not only to surgical operation but also to timing of the operation.[1]

Plaster models have been considered as a "gold standard" for diagnosis. However, they have some disadvantages such as sensitivity to damage, need of room for storage.[11] In this respect, several studies reported that 3-dimensional (3D) digital models can be alternative to plaster models as they are reliable and time saving.[12,13] As the studies regarding the tooth size and shape in individuals with CLP are generally made in two dimensions, their significance in the studies made using 3D software is fairly low. Additionally, in most of the previous studies the dental data of the cleft subjects were only compared with subjects without cleft lip and/or palate.[4,14]

Therefore, the aim of this retrospective study was to evaluate 3D mesiodistal (MD), buccolingual (BL), and gingivo incisal (GI) tooth dimensions in patients with unilateral CLP (UCLP) in detail in order to present viable guidelines for clinical treatment by comparing with the control group subjects with class I occlusion.

Materials and Methods

Material selection

With institutional ethical board approval (approval date: 6/1/15), the dental casts of UCLP patients who were referred to the Health Sciences University University and Ankara University, faculty of dentistry, department of orthodontics were evaluated. The sample size was calculated using the G*power 3.0.10 program (Universität Düsseldorf, Germany). Considering an alpha significance level of 0.05 and a statistical power of 0.95, the study required at least 36 patients in each group. Thus, a total of 94 pretreatment orthodontic dental casts obtained from patients (UCLP group: 54 dental casts; control group: 40 dental casts) were included in this case-control study.

Three study groups were created: unilateral left CLP (ULCLP) (36 casts of patients with unilateral left cleft lip and palate; 20 male and 16 female), unilateral right CLP (URCLP) (18 casts of patients with unilateral right cleft lip and palate; 7 male and 11 female) and the control group (casts of 40 non-cleft patients; 18 male, 22 female).

Exclusion criteria were as follows:

1. Presence of any syndromic condition associated with UCLP,
2. Having bilateral CLP or isolated cleft palate,
3. Having dental structure abnormalities (such as amelogenesis imperfecta, microdontia, macrodontia),
4. History of orthodontic treatment/orthognathic surgery, and
5. Having reduced crown sizes due to excessive rotation, retrusion, or partial eruption.

The age of the patients wasn't taken into consideration as an inclusion criterion but all patients were in the permanent dentition stage with fully erupted crowns. Patients included in the control group were considered to have class I occlusion, well-aligned dental arches, no crowding/minor crowding. Crown dimensions of lateral incisors were not measured in the present study due to the common absence in both cleft and non-cleft sides.

Measurement method

3D models were scanned from the dental casts using the Smart Optics Activity 102 (smart optics, Bochum, Germany). The numerical model images obtained with the device were converted to digital media.STL file using the Dentoprogress software (smart optics, Bochum, Germany), and 3-Matic Research software (Materialise Haasrode, Belgium) was used for the measurements.

The landmarks were selected and measured by the same investigator (MK). To determine the crown size, three parameters were measured as 1. MD (the distance between mesial and distal contact points of the tooth); 2. BL (diameter of the tooth; perpendicular to the MD axis), and 3. GI (vertical length of the tooth from cusp tips or incisal edge to the gingival border, parallel to the axis of the tooth) [Figure 1].

Observer reliability and statistical analysis

SPSS version 24.0 (SPSS Inc., Chicago, USA) software package for Windows was used for statistical analyses. Descriptive statistics (means and standard deviations) were calculated. Levene's test was used for equality of variances. Paired t-tests and independent *t*-test were used to compare 3D tooth sizes among the study groups in both dental arches. Significance was accepted as $P \leq 0.05$. The measurements were repeated by the same investigator approximately 4 weeks after the initial measurement to determine the repeatability of the measurements. The correlation coefficients were calculated to assess the reliability of the method.

Results

The reliability of the measurements was high with the correlation coefficients ranging between 0.8962 and 0.9968. All measurements were found to be highly reproducible and there was no significant

difference between the two measurements of the observer ($P > 0.05$).

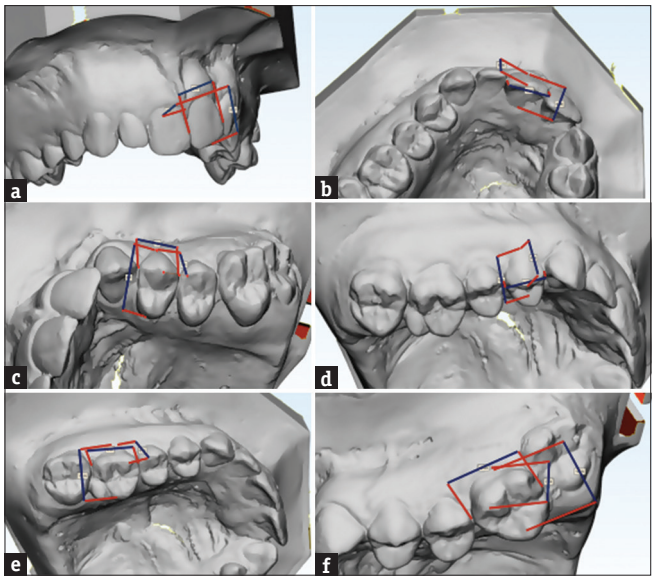

Figure 1: Mesiodistal, buccolingual, and gingiva incisal measurements with 3-Matic Research software (Materialise Haasrode, Belgium) a, b Measurements of incisor dimensions. c, d Measurements of premolar dimensions e, f Measurements of molar dimensions

Comparison of the cleft and non-cleft sides in individuals with CLP [Table 1]

U1 MD and U6 MD values were significantly greater in UCLP patients on the non-cleft side ($P < 0.001$) while L4 MD ($P < 0.01$) and L5 MD ($P < 0.001$) values were found to be greater on the cleft side. BL measurements of U6, L1, and L4 were also significantly different between the cleft and non-cleft sides. U6 BL value was greater on the non-cleft side (non-cleft: 10.92 mm, cleft: 10.77 mm; $P < 0.01$). When mandibular teeth were evaluated, L1 BL ($P < 0.001$) and L4 BL ($P < 0.01$) values were greater on the cleft side. The comparison of GI values showed that U1 was greater on the cleft side (non-cleft: 9.32 mm, cleft: 9.91 mm; $P < 0.001$) Meanwhile, L3 value was found to be greater on the non-cleft side (non-cleft: 9.45 mm, cleft: 9.13 mm; $P < 0.05$) in the GI dimension [Table 1].

Comparison of the cleft side of URCLP group and the right side of the control group [Table 2]

When MD dimensions of teeth were compared, mean values of UR1 ($P < 0.001$), UR3 ($P < 0.01$) and LR2 ($P < 0.05$) were significantly smaller in URCLP group. According to BL measurements, UR1 ($P < 0.001$), UR4 ($P < 0.05$), UR5 ($P < 0.05$), UR6

Table 1: The comparison of the cleft and non-cleft sides in individuals with cleft lip and palate (CLP) with paired *t*-test

		n	Mesiodistal			Buccolingual			Gingivoincisal		
			Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*
U1	Non-cleft side	54	8.43	0.58	0.000***	7.00	0.73	0.103	9.32	1.00	0.000***
	Cleft side		8.14	0.60		6.88	0.69		9.91	1.15	
U3	Non-cleft side	54	7.51	0.51	0.994	7.99	0.70	0.273	8.91	1.09	0.960
	Cleft side		7.51	0.57		7.90	0.73		8.90	1.26	
U4	Non-cleft side	54	6.90	0.42	0.087	8.87	0.53	0.743	7.29	0.97	0.625
	Cleft side		6.97	0.40		8.84	0.70		7.23	0.97	
U5	Non-cleft side	54	6.64	0.62	0.187	8.99	0.58	0.189	6.30	0.91	0.473
	Cleft side		6.54	0.48		8.90	0.67		6.37	0.89	
U6	Non-cleft side	54	10.39	0.62	0.000***	10.92	0.70	0.002**	6.02	0.89	0.710
	Cleft side		10.24	0.60		10.77	0.73		6.00	0.83	
U7	Non-cleft side	54	9.63	0.75	0.834	10.37	0.68	0.910	5.76	0.93	0.657
	Cleft side		9.62	0.76		10.38	0.74		5.71	0.85	
L1	Non-cleft side	54	5.49	0.69	0.290	5.96	0.42	0.001***	8.57	1.08	0.062
	Cleft side		5.51	0.68		6.05	0.41		8.69	1.04	
L2	Non-cleft side	54	5.93	0.68	0.306	6.24	0.49	0.325	8.52	1.02	0.844
	Cleft side		5.94	0.73		6.28	0.42		8.53	1.10	
L3	Non-cleft side	54	6.86	0.43	0.121	7.39	0.73	0.510	9.45	1.42	0.029*
	Cleft side		6.81	0.43		7.34	0.85		9.13	1.61	
L4	Non-cleft side	54	6.87	0.43	0.002**	7.48	0.51	0.002**	7.80	0.82	0.114
	Cleft side		6.98	0.39		7.62	0.50		7.66	0.88	
L5	Non-cleft side	54	6.98	0.47	0.000***	8.16	0.61	0.354	6.81	0.77	0.663
	Cleft side		7.09	0.52		8.21	0.62		6.77	0.97	
L6	Non-cleft side	54	10.96	0.41	0.797	10.11	0.73	0.405	6.21	0.78	0.198
	Cleft side		10.97	0.40		10.07	0.77		6.36	0.90	
L7	Non-cleft side	54	10.07	0.05	0.818	9.60	0.73	0.925	6.05	0.70	0.669
	Cleft side		10.06	0.05		9.59	0.72		6.09	0.86	

*P<0.05, **P<0.01, ***P<0.001. U: upper, L: lower; 1: central, 2: lateral, 3: canine, 4: first premolar, 5: second premolar, 6: first molar, 7: second molar

Table 2: The comparison of the cleft side in patients with URCLP and right side of the control group by independent *t*-test

URCLP		*n*	Mesiodistal			Buccolingual			Gingivoincisal		
			Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*
UR1	Cleft side	18	8.09	0.66	0.000***	6.77	0.83	0.001***	9.86	1.17	0.862
	Control	40	8.84	0.63		7.41	0.51		9.81	0.96	
UR3	Cleft side	18	7.54	0.59	0.004**	7.78	0.74	0.056	9.12	1.49	0.913
	Control	40	8.07	0.61		8.16	0.64		9.09	0.85	
UR4	Cleft side	18	6.93	0.41	0.062	8.91	0.52	0.027*	7.02	0.75	0.073
	Control	40	7.10	0.44		9.30	0.62		7.40	0.72	
UR5	Cleft side	18	6.59	0.51	0.465	9.06	0.53	0.017*	6.26	0.79	0.589
	Control	40	6.65	0.49		9.47	0.61		6.39	0.86	
UR6	Cleft side	18	10.21	0.63	0.387	10.73	0.71	0.018*	5.95	0.88	0.756
	Control	40	10.33	0.53		11.23	0.71		6.02	0.83	
UR7	Cleft side	18	9.65	0.85	0.960	10.40	0.57	0.006**	5.94	0.97	0.026*
	Control	40	9.66	0.68		10.95	0.72		5.41	0.73	
LR1	Cleft side	18	5.53	0.38	0.137	6.14	0.45	0.429	8.61	0.91	0.212
	Control	40	5.68	0.34		6.25	0.51		8.29	0.86	
LR 2	Cleft side	18	5.93	0.34	0.019*	6.41	0.37	0.473	8.46	1.09	0.599
	Control	40	6.15	0.35		6.50	0.49		8.31	0.94	
LR 3	Cleft side	18	6.96	0.55	0.614	7.33	1.03	0.383	9.19	1.74	0.272
	Control	40	6.99	0.44		7.52	0.60		9.45	1.14	
LR 4	Cleft side	18	7.11	0.47	0.980	7.49	0.45	0.003**	7.84	0.95	0.336
	Control	40	7.10	0.57		8.01	0.64		8.05	0.68	
LR 5	Cleft side	18	7.12	0.52	0.840	8.28	0.55	0.054	6.82	0.83	0.868
	Control	40	7.08	0.56		8.57	0.49		6.79	0.74	
LR 6	Cleft side	18	10.97	0.74	0.439	10.21	0.62	0.046*	6.28	0.89	0.578
	Control	40	10.75	0.67		10.51	0.46		6.40	0.71	
LR 7	Cleft side	18	10.08	0.61	0.246	9.59	0.66	0.004**	6.27	0.73	0.186
	Control	40	9.89	0.64		10.10	0.57		5.98	0.80	

*P<0.05, **P<0.01, ***P<0.001. UR: upper right, LR: lower right; 1: central, 2: lateral, 3: canine, 4: first premolar, 5: second premolar, 6: first molar, 7: second molar; Cleft side: URCLP, Control: Right side

Table 3: The comparison of the cleft side in patients with ULCLP and left side of the control group by independent *t*-test

ULCLP		*n*	Mesiodistal			Buccolingual			Gingivoincisal		
			Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*
UL1	Cleft side	36	8.15	0.57	0.000***	6.92	0.61	0.000***	9.92	1.14	0.558
	Control	40	8.82	0.61		7.44	0.47		9.78	0.90	
UL 3	Cleft side	36	7.48	0.56	0.000***	7.96	0.72	0.168	8.78	1.12	0.156
	Control	40	8.01	0.56		8.17	0.62		9.10	0.78	
UL 4	Cleft side	36	6.99	0.40	0.198	8.80	0.78	0.004**	7.33	1.06	0.927
	Control	40	7.12	0.46		9.29	0.64		7.35	0.74	
UL5	Cleft side	36	6.51	0.47	0.146	8.82	0.72	0.000***	6.42	0.93	0.346
	Control	40	6.66	0.46		9.45	0.60		6.65	0.711	
UL6	Cleft side	36	10.25	0.59	0.547	10.77	0.75	0.003**	6.01	0.81	0.986
	Control	40	10.33	0.57		11.26	0.63		6.01	0.78	
UL7	Cleft side	36	9.59	0.72	0.668	10.36	0.81	0.001***	5.60	0.76	0.818
	Control	40	9.66	0.67		10.97	0.71		5.65	1.09	
LL1	Cleft side	36	5.50	0.31	0.081	6.00	0.38	0.057	8.73	1.11	0.076
	Control	40	5.64	0.35		6.20	0.52		8.32	0.84	
LL 2	Cleft side	36	5.94	0.42	0.038*	6.21	0.43	0.031*	8.56	1.1	0.347
	Control	40	6.13	0.36		6.44	0.49		8.35	0.83	
LL 3	Cleft side	36	6.73	0.49	0.043*	7.33	0.76	0.308	9.09	1.56	0.108
	Control	40	6.95	0.43		7.51	0.70		9.57	0.95	
LL 4	Cleft side	36	6.91	0.33	0.060	7.67	0.50	0.023*	7.56	0.83	0.002**
	Control	40	7.10	0.52		7.98	0.62		8.11	0.66	

Contd...

Table 3: Contd...

ULCLP		*n*	Mesiodistal			Buccolingual			Gingivoincisal		
			Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*
LL 5	Cleft side	36	7.06	0.37	0.591	8.17	0.65	0.001***	6.74	1.03	0.424
	Control	40	7.12	0.55		8.63	0.48		6.91	0.81	
LL6	Cleft side	36	10.97	0.72	0.209	9.99	0.82	0.001***	6.39	0.90	0.469
	Control	40	10.76	0.68		10.50	0.49		6.53	0.73	
LL7	Cleft side	36	10.04	0.72	0.413	9.59	0.75	0.002**	6.00	0.90	0.768
	Control	40	9.91	0.60		10.10	0.63		6.06	0.83	

*P=0.05, **P=0.01, ***P=0.01. UL: upper left, LL: lower left; 1: central, 2: lateral, 3: canine, 4: first premolar, 5: second premolar, 6: first molar, 7: second molar; Cleft side: ULCLP, Control: Left side

($P < 0.05$), UR7 ($P < 0.01$), LR4 ($P < 0.01$), LR6 ($P < 0.05$) and LR 7 ($P < 0.01$) were also smaller in URCLP group. A comparison of GI values revealed that only the UR7 value was significantly higher in the URCLP group ($P < 0.05$) [Table 2].

Comparison of the cleft side of ULCLP group and the left side of the control group [Table 3]

According to MD measurements, the mean values of UL1 ($P < 0.001$), UL3 ($P < 0.001$), and LL2 and LL3 ($P < 0.05$) were greater in control group compared to ULCLP group. When BL dimensions of teeth were compared, UL1 ($P < 0.001$), UL4 ($P < 0.01$), UL5 ($P < 0.001$), UL6 ($P < 0.01$), UL7 ($P < 0.001$), LL2 ($P < 0.05$), LL4 ($P < 0.05$), LL5 ($P < 0.001$), LL6 ($P < 0.001$), and LL7 ($P < 0.01$) were observed to be smaller in ULCLP group. GI value of LL4 ($P < 0.01$) was also smaller in the ULCLP group compared to the control group [Table 3].

Discussion

The measurements of tooth sizes are a necessary consideration when planning orthodontic treatment to ensure the result is both permanent and well-aligned. In previous studies, sizes and shapes of teeth were evaluated with manual and 2D measurements of diameter and/or length of dental casts, as well as panoramic and periapical radiographs. However, these evaluation methods have some inherent limitations. For example, due to distortion and/or magnification of x-rays, radiographic imaging can often lead to misleading measurements and unsatisfactory results.[15,16]

Calipers or digital calipers can also be difficult to use where the teeth are in close contact. Additionally, dental casts may deteriorate or break depending on the storage conditions. All of these issues could lead to inaccurate measurements.[3,4] Archiving the jaws as 3D models in computer media provides faster, reliable, and precise measurements and also allows evaluation with other computer software.[12,13,17] In light of the disadvantages of conventional methods, we preferred using 3D dental casts in our study in order to perform measurements from more accurate and detailed data. Maxillary lateral incisors with abnormal morphology have been reported in up to 94% of patients with CLP on the cleft side.[2,18] Maxillary lateral teeth were not measured in our study due to the frequent occurrence of congenital lateral missing, peg lateral teeth and abnormal morphology in individuals with CLP.[2,18]

Akcam *et al*.[4] reported that asymmetries in teeth dimensions can be found in non-syndromic CLP patients.They found that maxillary central and lateral incisors were larger on the non-cleft side in the MD dimension compared with the cleft side. Lewis *et al*.[6] claimed that anterior teeth are smaller mesiodistally in individuals with UCLP. According to the results of the present study, we also found that upper central incisors and first molars were significantly larger mesiodistally on the non-cleft side.

Dos Santos *et al*.[19] reported that cleft and non-cleft sides demonstrated similar maxillary tooth sizes except for the lateral incisor. When we compare cleft patients with non-cleft individuals, we showed that upper central incisors and canines were significantly larger. Reduction in the dimension of the upper incisor could be attributed to their origin that the medial nasal spine is alleged to be smaller than normal in cleft patients.[9] According to Sofaer,[20] tooth-size asymmetry in CL/P patients results from a generally high level of developmental instability throughout cleft lip/palate dentitions. This generalized developmental instability may be to some extent under genetic control, as cases with positive family histories showed some signs of greater asymmetry than those with negative family histories.

Upper premolars and molars were also significantly bigger in the buccolingual dimension in cleft subjects compared to control subjects in this study. Peterka and Müllerova[21] reported that females with clefts had reduced buccolingual dimensions of the permanent teeth, in both jaws, although no significant difference was observed in males with clefts. Walker *et al*.[8] investigated the incisor and first molar morphology in cleft patients

based on the hypothesis that the clefting process may have a greater effect on the morphology of teeth adjacent to the cleft than on those distant from the cleft. They concluded that although a reduction in size was seen for all teeth, in both jaws was observed compared to control groups, there was no relationship between clefting and molar morphology. We also observed a GI dimension of the upper second molar was bigger in the URCLP group in comparison with control subjects. Although all teeth fully erupted in study models, we think over-eruption of upper second molars due to the lack of proper occlusion and contact between upper and lower teeth could be the reason for this increase.

Interestingly, we observed an increase in MD and BL dimensions of lower first premolar on the cleft side and MD dimension of the lower second premolar. Some previous studies reported that mandibular incisors and premolars could be larger in the cleft side inline with our results.[4,7] However, it should also be noted that MD dimension of lower second incisor, and BL dimensions of lower first premolar and second molar in URCLP patients; and MD dimensions of lower second incisor and canine, BL dimensions of all lower teeth except first incisor and canine in ULCLP patients were also smaller compared to control group. de Sabóia *et al*.[22] observed a strong association between the smaller second premolar and oral clefts. According to their study, smaller premolars could be a phenotypic variability of premolar agenesis. Akçam *et al*.[3,4] also concluded that mandibular first premolar and molars were bigger in the occluso-gingival dimension on the non-cleft side.

According to Ranta,[2] the size of the permanent teeth is smaller in children with cleft lips in both jaws. Enamel defects in shape and size of the teeth in both jaws are more apparent in children and fetuses affected with a cleft. A previous study reported similar results to our study but they evaluated the genders independently. They suggested all the non-cleft-mandibular teeth except the second molar in male patients were smaller compared to the control group. In female patients, mandibular cleft-side teeth, with the exception of the second molar, and non-cleft side teeth, with the exception of the molars, were smaller than in the controls.[9] Teeth size differences were also shown between male and female cleft patients in another study. The authors attributed the results of their study to the influence of sex-linked genes on enamel and dentin contributions to crown size.[22,23] Comparisons between the genders were not done in this study to avoid a reduction in the number of subjects. However, care was taken to ensure that the genders were similar in each group to avoid confounding (ULCLP: 20 male and 16 female; URCLP: 7 male and 11 female; control group: 18 male, 22 female). So, we suggest that further studies should be done with larger samples considering gender differences.

Conclusion

Tooth size asymmetries can occur non-syndromic UCLP patients in both jaws. MD, BL, and GI dimensions of teeth are found to be smaller in patients with CLP, excluding the maxillary second molar (URCLP; $P < 0.05$) and first premolar GI dimensions (ULCLP; ns). In the measurements of teeth size, reliable and repeatable results were acquired through 3D software. 3D tooth size determination is important in orthodontic treatment planning in order to achieve a stable, functional, esthetic, and well-balanced posttreatment occlusion in cleft lip and palate patients.

Authors' contributions

MK collected patients and analyzed the data and prepared the final manuscript. CA helped to collect the data. SG and ATA contributed to the conception of the work and supervised the whole study. EC contributed to collect the data and preparation of the manuscript. All authors read and approved the final manuscript.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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