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# The 3D Evaluation of Central Incisors on the affected side of patients with Unilateral Cleft Lip and Palate: A Retrospective Study

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## ABSTRACT

**Aim:** The aim of this retrospective study was to determine whether there is a difference in shape between the Maxillary Central Incisors (MCIs) on the affected and nonaffected sides of subjects with Unilateral Cleft Lip and Palate (UCLP) using Three-Dimensional (3D) digital models.

**Subjects and Methods:** A total of 110 UCLP patients in late mixed and permanent dentition were included in the study (37 females, 73 males). Vestibular Surface Area (SA), Mesiodistal Diameter (MD) and Gingivoincisal Length (GI) of the MCIs on both sides were measured by scanning the dental models with a high-precision optical 3D scanner.

**Results:** There were no statistically significant sex differences in any of the variables measured. Mean MD values of MCIs on the cleft and non-cleft sides were 8.17±0.67 mm and 8.45±0.63 mm, respectively. Mean GI length was 9.45±1.17 mm on the cleft side and 8.77±1.15 mm on the non-cleft side. Similarly, mean SA was 85.03±12.96 $mm^2$ on the cleft side and 79.70±13.31 $mm^2$ on the non-cleft side. All differences between the measurements from the cleft and non-cleft sides were statistically significant.

**Conclusion:** Compared to conventional methods, current high-precision optical 3D scanners and software yield more reliable and reproducible results. Using this technology, we determined in the present study that the shape of the MCI on the cleft side differs significantly from the MCI on the non-cleft side in patients with UCLP.

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## Introduction

Cleft Lip and Palate (CLP) is one of the most common congenital anomalies in the head and neck region. Previous studies have reported that environmental and genetic factors influence tooth size, morphology, position, and shape during the prenatal and postnatal periods in patients with CLP [1,2].

The prevalance of dental anomalies is higher among individuals with CLP compared to the general population, and the prevalance of CLP is twice as high in males as in females [3]. Early surgical interventions can cause dental anomalies adjacent to the clefts. Those dental anomalies may include hypodontia, supernumerary teeth, abnormal shape or size, structural deformations, and displacement defects. It has been reported that the severity of the dental anomalies may increase with high numbers of surgical interventions. Moreover, these anomalies are commonly seen not only on the side ipsilateral to the cleft, but also on the contralateral side [4,5].

Several studies have focused on individuals with CLP, and evaluations were based on different measurements related to tooth size and shape, such as mesiodistical lengths, crown heights, and dental symmetry [6-10]. However, most of these studies conducted measurements using two-dimensional (2D) evaluation; the number of studies using three-dimensional (3D) software is fairly low [11-13]. In the present study, we aimed to evaluate the effect of the cleft area on the crown development of the central incisors in individuals with Unilateral CLP (UCLP) by comparing the vestibular crown area, mesiodistal and gingovoincisal measurements of both maxillary central incisors using 3D analysis.

## Materials and Methods

We evaluated the dental casts of UCLP patients who were referred to the University of Ankara and University of Health Sciences, Faculty of Dentistry, Department of Orthodontics. The inclusion and exclusion criteria for the study are shown in Table 1. We included patients with UCLP in order to form both a study (cleft) and control (non-cleft) groups among the same individuals. Only the maxillary central incisors (MCIs) were analyzed in our study because they are the closest teeth to the cleft area and are predicted to be the most affected by surgical interventions due to being the primary permanent teeth in the cleft area.

**Table 1: Inclusion and Exclusion Criteria for the Study**

| Inclusion criteria for the study | Exclusion criteria for the study |
|---|---|
| Unilateral cleft lip and palate | Cleft palate or bilateral cleft lip and palate |
| Not having undergone an orthodontic treatment and/or functional orthopedic treatment | Missing central maxillary incisor |
| Having undergone reconstructive lip and palate surgery | Having undergone or currently undergoing orthodontic treatment |
| Late mixed dentition or permanent dentition | Reduced crown size due to excessive rotation and/or partially erupted teeth |
| Erupted central incisors | Microdontia, macrodontia, or ectopic eruption of central incisors |
| | Extensive restoration of central incisors |
| | History of trauma, systemic disease, or neuromuscular deformation that may cause craniofacial anomaly or syndrome |

Three-dimensional digital models were scanned from the dental casts of a total of 110 patients (73 males and 37 females) using the Smart Optics Activity 102 (smart optics, Bochum, Germany) (Figure 1). The numerical model images obtained with the device were converted to digital media with .STL file using the Dentoprogress software (smart optics, Bochum, Germany), and 3-matic Research software (Materialise Haasrode, Belgium) was used for the measurements. The designated spots for the measurements were determined and measured by the same orthodontist. During the determination of vestibular crown surface area (SA), the anatomy and morphology of the tooth were evaluated (Figure 2). As the width between the mesial and distal contact points determines the mesiodistal diameter (MD) of the tooth, the highest point of gingival margin and incisal point on the exact opposite of this point determines the gingivoincisal length (GI) of the tooth (Figure 3).

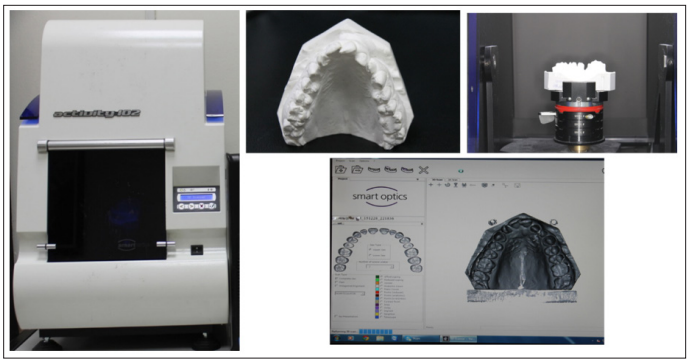


**Figure 1:** Obtaining 3D models from Dental Casts

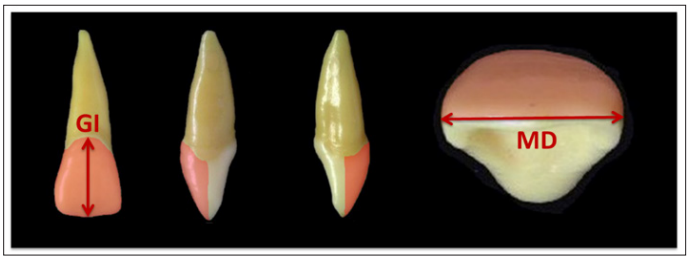


**Figure 2:** Borders of Vestibular Crown Area

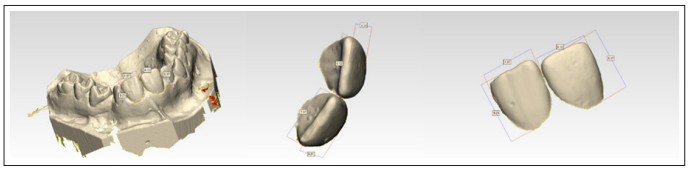

**Figure 3:** The Mesiodistal Lengths and Gingioincisal Heights of Central Incisors

SPSS version 20.0 (SPSS Inc., Chicago, USA) software package for Windows was used for statistical analyses. Normality of the parameters was evaluated using the Kolmogorov-Smirnov test. Differences between the two matched groups were statistically evaluated using paired-samples t-test because the SA, MD, and GI values were normally distributed. Independent samples t-test was performed to evaluate differences in tooth size according to gender. Data are expressed as mean ± SD unless otherwise specified. Significance was accepted as $p<0.05$.

## Results

The SA, MD, and GI values were compared to evaluate the differences between the MCIs on the cleft and non-cleft sides of patients with UCLP.

Mean MD length was significantly greater on the non-cleft side (8.45±0.63 mm) compared to the cleft side (8.17±0.67 mm) ($p<0.001$). In contrast, mean GI height of the cleft-side MCI (9.45±1.17 mm) was significantly higher than that of the MCI on the non-cleft side (8.77±1.15 mm)($p<0.001$) and vestibular SA was also larger on the cleft side (85.03±12.96 mm²) compared to the non-cleft side (79.70±13.31 mm²)($p<0.001$) (Table 2).

**Table 2: Standard and average deviation rates of the studied parameters; *p<0.05; **p<0.01; ***p<0.001**

| | Cleft side | | | | Non-cleft side | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD± | Min | Max | Mean | SD± | Min | Max | p |
| Surface Area (mm²) | 85.03 | 12.96 | 49.76 | 123.93 | 79.70 | 13.31 | 39.19 | 108.84 | <0.001*** |
| Mesiodistal (mm) | 8.17 | 0.67 | 6.71 | 10.05 | 8.45 | 0.63 | 6.95 | 10.19 | <0.001*** |
| Gingivoincisal (mm) | 9.45 | 1.17 | 6.40 | 12.79 | 8.77 | 1.15 | 5.27 | 11.63 | <0.001*** |

SD: Standard deviation

Furthermore, there were significant within-subject differences between measurements of MD, GI, and vestibular SA taken from the cleft and non-cleft sides (pMD<0.001, pGI<0.001, pSA<0.001) (Table 3).

**Table 3: Standard and average deviation rates of within-subject differences (cleft vs non-cleft side) in the studied parameters; *p<0.05; **p<0.01; ***p<0.001**

| Differences Between Cleftside – Non-cleftside | Mean | SD± | Min. | Max. | P |
|---|---|---|---|---|---|
| Surface Area(mm²) | 5.33 | 8.09 | 3.80 | 6.86 | .000*** |
| Mesiodistal (mm) | -.28 | .47 | -.37 | -.19 | .000*** |
| Gingivoincisal (mm) | .68 | 1.07 | .47 | .88 | .000*** |

No significant sex differences emerged between groups for MD, GI, and vestibular SA measurements (Table 4).

**Table 4: Average and standard deviation values of the parameters in regards to sex**

| | | Sex | Number | Mean | SD± | p |
|---|---|---|---|---|---|---|
| Vestibular surface area (mm²) | Cleftside | F | 37 | 82.15 | 10.44 | 0.111 |
| | | M | 73 | 86.38 | 13.84 | |
| | Non-cleftside | F | 37 | 78.05 | 10.97 | 0.379 |
| | | M | 73 | 80.47 | 14.28 | |
| Mesiodistal length (mm) | Cleftside | F | 37 | 8.09 | 0.70 | 0.442 |
| | | M | 73 | 8.20 | 0.65 | |
| | Non-cleftside | F | 37 | 8.32 | 0.70 | 0.163 |
| | | M | 73 | 8.51 | 0.59 | |
| Gingivoincisal height (mm) | Cleftside | F | 37 | 9.29 | 1.06 | 0.335 |
| | | M | 73 | 9.52 | 1.22 | |
| | Non-cleftside | F | 37 | 8.61 | 1.07 | 0.343 |
| | | M | 73 | 8.84 | 1.19 | |

F: Female, M: Male

## Discussion

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 [14-16]. 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 [6,17,18]. Archiving the jaws as 3D models in computer media provides faster, more reliable and precise measurements and also allows evaluation with other computer software [19-22]. 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.

Our evaluation of the vestibular SA enabled us to analyze the effects of the cleft on dental symmetry. Previous studies have reported that the formation of permanent teeth is generally symmetrical, and that CLP often negatively affects the development of central incisors and causes asymmetrical dental development [6,7,9,10,22,23]. Akçam et al. reported that asymmetry was present in individuals with CLP on both the cleft and non-cleft sides and was not limited only to the maxillary dental arc, but was also evident in the mandibular dental arc [6]. Consistent with these reports, we also determined the presence of dental asymmetry in the MCIs of patients with UCLP. Vestibular SA value on the cleft side was 5.33 mm² greater on average than on the non-cleft side.

In previous studies, it has been reported that MD length is greater in the central incisor on the non-cleft side compared to the cleft side [17,24,25]. The observed deviations in tooth size in patients with CLP are also observed not only in the maxilla but in the mandibula as well.17 Antonarakis et al. reported that the central incisor was risen higher on the non-cleft side of the maxilla in nonsyndromic CLP patients [24]. Akçam et al. reported that the mesiodistal, labiolingual, and occlusogingival dimensions are smaller in maxillary incisors on the cleft side in individuals with CLP and that the size of their teeth is smaller in comparison to individuals with Class I occlusion [17]. In our study, the MD deviation between the MCI on the cleft and non-cleft sides revealed slightly longer MD (average 0.28 mm) on the non-cleft side.

There are numerous studies in the literature evaluating crown height, tooth/root length ratio and root lengths in patients with CLP. These studies generally argue that surgical interventions performed in the cleft area and the subsequent scar tissue cause congestion, thus negatively affecting cell proliferation and especially root dentin development, and the authors usually cite this as the cause of reduced crown height and root length. Because the central incisor is the first permanent tooth and is closest to cleft area, the development of root dentin is reported to be affected more in comparison to other teeth [14,26-28].

Al-Jamal et al. investigated and compared the crown-to-root (C/R) ratios in cleft lip and palate patients and controls by panoramic radiographs and reported that most CLP patients have unfavorable C/R ratios due to shorter root lengths [14]. Although this study was based primarily on C/R ratio, they also measured the crown heights of the MCIs. However, in their study, they pooled both UCLP and bilateral CLP (BCLP) patients together and compared them with the controls. This approach could significantly affect their results, as the possible unfavorable etiological factor may affect all incisors in the BCLP group, thus obscuring any possible impact of the cleft area on MCI crown height. In another recent study, Zhou et al. employed a split-mouth study design similar to that of the present study in order to test the null hypothesis that the teeth on the cleft side are affected by same etiological factors responsible for clefting, whereas the teeth on the non-cleft side are not [28]. They evaluated the crown and root dimensions of MCIs in patients with CLP using computed tomography and reported that maxillary incisors in nonsyndromic CLP patients were underdeveloped, with the root affected more severely than the crown. They also reported that the incisors proximal to the cleft showed more developmental deficiency and that BCLP patients showed more deficiency than the UCLP patients. In terms of crown height in UCLP patients, they reported a nonsignificant difference with MCIs on the cleft side smaller than the antimeres (-0.1 mm) [28]. In our study, the average GI deviation value between the MCIs on the cleft and non-cleft side was 0.68 mm longer in the cleft side.

In many studies, there were no statistically significant results regarding the effect of sex on tooth size [13,29,30]. Some researchers have reported larger teeth in males than females.31,32 However, Foster and Lavelle reported that most teeth in females are significantly larger compared to those of males [25]. In our study, the tooth measurements of males were greater than in the females but the differences were not statistically significant.

## Conclusion

Patients with nonsyndromic UCLP may exhibit ectopic eruption, deformed teeth, microformed teeth, and dental asymmetry regardless of unerupted and partially erupted teeth. Variations in size, shape, and form have been observed in the central incisor on the cleft side in CLP patients. Our results show that while MCIs on the cleft side have larger vestibular SA and GI height, MD length is lower.

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