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# EVALUATION OF ROOT DILACERATION AND TAURODONTISM IN CHILDREN WITH AND WITHOUT CLEFT LIP AND PALATE

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**Abstract:** Taurodontism and root dilaceration are developmental anomalies. Both taurodontism and dilaceration might be related with cleft lip and palate (CLP). This study aimed to investigate the prevalence of taurodontism and root dilaceration, in the children with CLP. Cone beam computed tomography images of 200 children (100 cleft 100 healthy) with CLP were evaluated retrospectively. Taurodontism level was divided into three subtypes as hypertaurodont, mesotaurodont and hypotaurodont. Root dilaceration was recorded if the tooth has completed apexification process. The frequency of taurodontism was found to be 30% in children with CLP and 12% in the control group. The frequency of root dilaceration was found to be 31% in children with CLP and 12% in children without CLP. Incidence of both root dilaceration and taurodontism was found higher in children with CLP ($P<0.05$). Left maxillary region was found to be the most common localization of both cleft side and root dilaceration ($P<0.05$). Children with CLP prone to develop dental anomalies such as pulp enlargement and root angulations. Taurodontism and dilaceration are both highly important for preoperative planning. Understanding the causative factors of dental anomalies may increase clinical success.

**Keywords:** Cleft lip, Cleft palate, Cone beam computed tomography, Root dilaceration, Taurodontism

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## 1. Introduction

Root development is a complex biological process, which includes epithelial-mesenchymal interactions. According to an alteration in this interaction may cause morphological changes such as taurodontism and root dilaceration (Ahmed and Dummer, 2018). Taurodontism is an entity that means the alteration of tooth shape due to the damage of Hertwig's epithelial sheath. A tooth with taurodontism can be observed with features such as an enlargement of the pulp chamber into the root area, apical displacement of the pulpal floor and no construction at the cementoenamel junction. This phenomenon is commonly an incidental radiographic finding, although the clinical importance of taurodontism is high for the endodontic and/or orthodontic treatment process (Jafarzadeh et al., 2008). According to previous studies, the prevalence of taurodontism was found between 0.04 % (Laganà et al., 2017) and 48% (Toure et al., 2000) of the normal population. It is possible to correlate varying incidence ratios with the study group's features, such as the age of the subjects or the stage of the dentition of the patients (deciduous, mixed, permanent). Additionally, there are also studies reporting that the incidence increases with some syndromes and anomalies such as amelogenesis imperfecta or cleft lip and palate (CLP) (MacDonald-Jankowski, 1991; Weckwerth et al., 2016).

Dilaceration is defined as a deviation in the axial inclination of the root or between the crown and the root of a tooth. It refers to angulation, or a sharp bend or curve, in the root or crown of a tooth. Crown dilaceration is a less common entity and mostly have been seen in maxillary permanent incisors (Ahmed and Dummer, 2018). Prevalence of tooth dilaceration was shown in various ranges in previous studies (Topouzelis et al., 2010; Melo Filho et al., 2015; Weckwerth et al., 2016; Cao et al., 2021). Abnormal angulation or sharp curvature has specific clinical importance for orthodontic and endodontic treatment procedures and tooth extraction. Additionally, tendency to impaction is high in these cases with a high risk of external resorption (Topouzelis et al., 2010; Chang et al., 2016; Cao et al., 2021). Although etiology of dilaceration remains uncertain, the trauma of deciduous teeth is a strong risk factor for primary teeth to dilacerate. Therefore, dilaceration may occur both in deciduous and permanent dentition, this theory is unlikely to account for all cases of dilaceration (Jafarzadeh and Abbott, 2007). Also, trauma mostly effects anterior dentition. Other probable factors are local effects such as insufficient space for development, an obstacle of maxillary cortical bone, nasal cavity or ankylosed or retentive deciduous tooth, and

supernumerary tooth (Chate, 2003; Turk and Elekdag-Turk, 2008; Hettiarachchi et al., 2017; Jafarzadeh and Abbott, 2007). Due to the high risk of impaction with CLP patients, dilaceration may also occur. Various surgical operations children with CLP have been through can be considered as local trauma which is an important risk factor for dilaceration (Ajami et al., 2017). However, current studies support the idea that dilaceration may be a true developmental anomaly and it might not be related to trauma. According to the results that these studies, most dilacerated teeth were found to be posterior teeth which are not prone to direct trauma. Additionally, it might also be related to the lack of space in the jaws which may clarify the high impaction rate in the anterior region of the jaws (Chadwick and Millett, 1995; Andreasen et al, 1997; Hamasha et al., 2002).

Previous studies showed that there may be an association between dental anomalies and CLP which is essential for preoperative planning. Compared with individuals without cleft, CLP patients presented more common dental anomalies. Evaluation between with and without CLP subjects represented a high prevalence of taurodontism with CLP patients (Al Jamal et al., 2010). Studies aimed to compare the prevalence of dental anomalies between patients with and without cleft showed that CLP patients tend to develop dental anomalies such as taurodontism, root dilaceration dental agenesis, supernumerary teeth, microdontia, tooth fusion and ectopic tooth (Paranaiba et al., 2013; de Assis et al., 2021; Sobti et al., 2022). Additionally, root dilaceration was found to be one of the most frequent dental anomalies in CLP patients in previous studies (Raducanu et al., 2015; Fonseca Souza et al., 2022).

Our study was conducted to investigate the co-occurrence of taurodontism and root dilaceration in children with CLP with cone beam computed tomography (CBCT) retrospectively. The main objective of our study was to compare the prevalence of taurodontism and root dilaceration in children with and without CLP. Expected outcomes were a higher incidence of taurodontism and root dilaceration in children with CLP and the anterior maxillary region to be the most common area of the anomaly.

## 2. Materials and Methods

Cone beam computed tomography (CBCT) images of 100 children with CLP and 100 subjects without CLP were selected from the archive after the application of the inclusion and exclusion criteria. Control group subjects were compatible with the group of children with CLP in terms of age and gender.

Exclusion criteria:

- Absence of informed consent form which refers using images for research and scientific reasons,
- Poor qualified images (metal artifacts, motion artifacts),
- Images with an inadequate field of view,
- Individuals older than 18 years old,
- Patients with maxillofacial trauma, orthognathic surgery history,
- Subjects with any disorders which may affect bone metabolism,
- Presence of any other accompanying syndrome.

Imaging was performed with Planmeca® Promax 3D Mid (Planmeca Oy, Helsinki, Finland, 2012) CBCT with 16x9 cm field of view, 0.4 mm3 isotropic voxel size and 0.40 mm sectional thickness. Imaging was operated at 90 kVp and 10 mA and 36 seconds. Images were recorded in Digital Imaging and Communications in Medicine (DICOM) format. Romexis® software was used for viewing.

Morphological analyses of taurodontism were performed with the classification of Seow and Lai (Seow and Lai, 1989). The addition of crown length (C) and body length (B) were divided by root length (R). The linear measurements of the crown length and body length of taurodont tooth were analyzed with the cross-section of the CBCT using Romexis software. The severity of taurodontism can be classified objectively into three categories. If the (C+B):R ratio ranges from 1.10 to 1.29, taurodontism level was considered as hypotaurodont. If (C+B):R ratio ranges from 1.30 to 2.00, taurodontism level was considered as mesotaurodont. Hypertaurodont tooth was evaluated if the (C+B):R ratio is higher than 2.00. (Figure 1) One patient with 1.08 (C+B):R ratio was also considered a hypotaurodont (Figure 1a). Any root that angulated was considered as dilaceration (Figure 2).

Deciduous teeth that have not yet begun resorption and permanent teeth that have completed the apexification process were evaluated. The teeth with enlarged pulp chambers and root angulations were analyzed.

The collected data from all groups were imported to SPSS for Windows, version 22.0 (SPSS Inc., Chicago, IL, USA). The standard descriptive methods such as the mean, standard deviation, median, frequency, minimum and maximum were applied to determine the characteristics of the sample. The Chi-square test was used to compare the categorical demographic variables among the groups. The correlations between at least two continuous variables were examined using Pearson's correlation coefficient. The confidence interval was set to 95% and $P<0.05$ was considered statistically significant. Power was set to 95% and it was found that at least 22 children were needed in the study group and at least 22 children were needed in the control group (n=44) (25). Study group contained 100 children with CLP and 100 children without CLP in our study (n=200), according to the power analysis. To ensure efficient evaluation, two clinicians in the Department of Oral and Maxillofacial Radiology evaluated the images. During meetings for the pilot study, a specialist working in the Department of Oral and Maxillofacial Radiology, Faculty of Dentistry trained the oral and maxillofacial radiology specialists, and an agreement on the objective criteria for the qualitative evaluation of the images was forged among the evaluators.

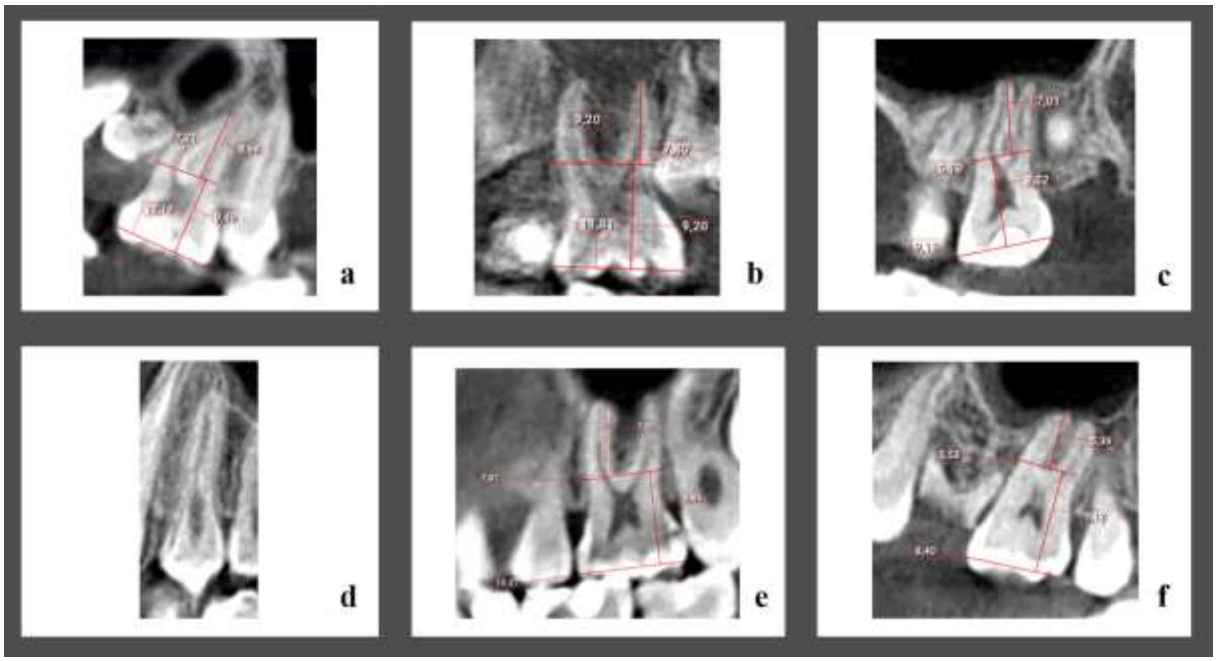


**Figure 1.** 1st molar with hypotaurontism in a patient with unilateral CLP (a) 1st molar with hypotaurodontism in a patient with bilateral CLP (b) 2nd molar with hypotaurodontism in a bilateral CLP patient (c) 1st premolar with taurodontism in a unilateral CLP patient (d) 1st molar with hypotaurodontism in a unilateral CLP patient (e) 1st molar with hypotaurodontism in a bilateral CLP patient (f).

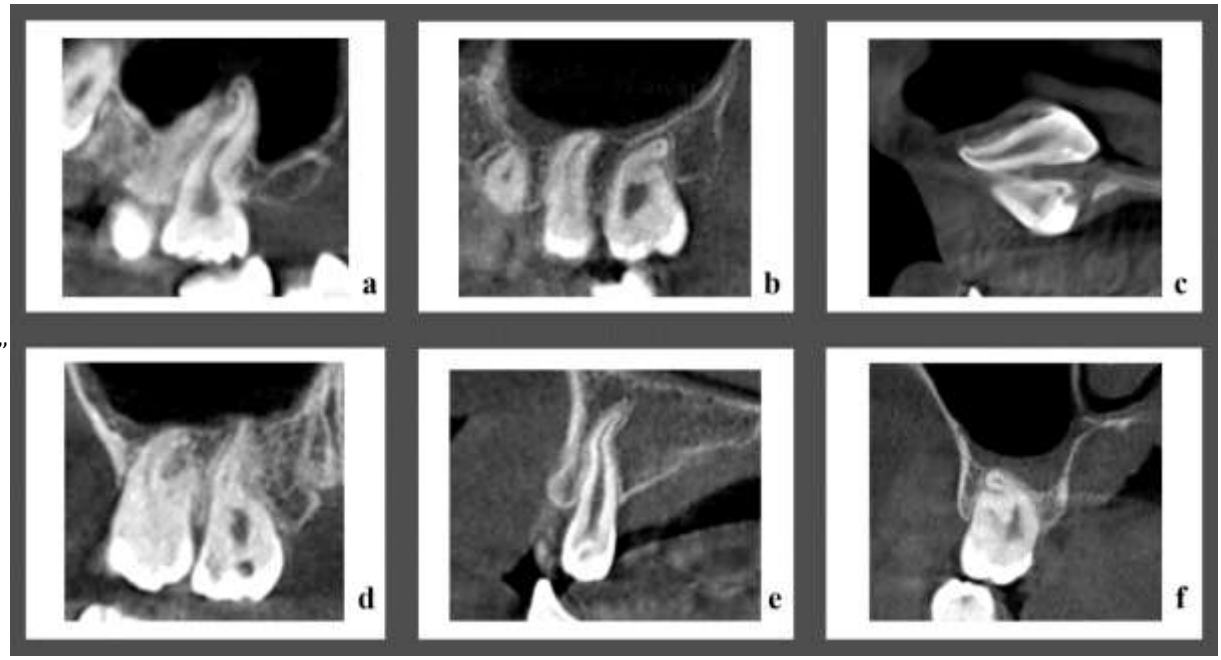


**Figure 2.** 2nd molar with root dilaceration in a patient with unilateral CLP (a) 1st and 2nd molars with root dilaceration in a patient with unilateral CLP (b) Canine root dilaceration in a bilateral CLP patient (c) 1st and 2nd molars with a bilateral CLP patient (d) 1st premolar with dilaceration in a unilateral CLP patient (e) 1st molar with root dilaceration in a unilateral CLP patient (f).

## 3. Results

A total of 200 patients, 102 male and 98 female patients were examined. The mean age was 12.28 and age range was between 5 and 19 years (Standard Deviation was 3.13). 54 male and 46 female patients were in the CLP group (n=100). There were 70 children with unilateral complete CLP and 30 children with bilateral complete CLP (Figure 3). As a control group, 100 CBCT images of healthy subjects (48 male and 52 female subjects) were also evaluated (n=100). In the analysis of children with CLP, there was a significant difference between the cleft type (unilateral - bilateral) and the frequency of taurodontism. A statistically significant difference was found between the cleft type (unilateral - bilateral) and dilaceration. Both root dilaceration and taurodontism was found higher in children with unilateral CLP.

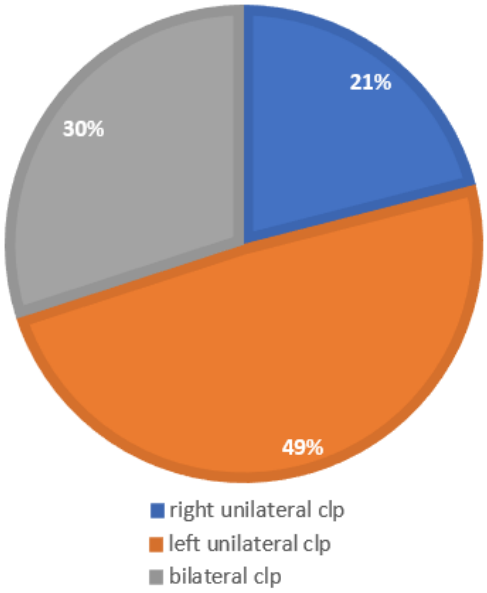


**Figure 3.** Distribution of study group in terms of cleft types.

The frequency of taurodontism was found to be 30% in children with CLP and 12% in the control group (Table 2). The incidence of taurodontism was statistically significantly higher in children with CLP. The most dilacerated tooth was in left maxilla. Most common type of taurodontism was hypotaurodontism (22%), following with mesotaurodontism (8%) (Table 3). 16 children with CLP had one or more tooth with taurodontism, although only 8 children without CLP had more than one tooth with taurodontism.

The frequency of root dilaceration was found to be 31% in children with CLP and 12% in children without CLP. The incidence of root dilaceration is significantly higher in patients with CLP. Additionally, 7 patients had one or more dilacerated tooth in children with CLP and there was not found any children in the control group with more than one tooth with root dilaceration. There were 31 children with root dilaceration in the CLP group. The 20 root dilaceration cases of a total of 31 children were observed in the left maxilla (Figure 4).

There was no statistically significant difference found in terms of gender and taurodontism or dilaceration.

**Table 2.** Evaluation of taurodontism and root dilaceration (n=200)

| | | CLP | Control | P |
|---|---|---|---|---|
| | | n (%) | n (%) | |
| Taurodontism | Yes | 30 (30%) | 12 (12%) | 0.002* |
| | No | 70 (70%) | 88 (88%) | |
| Dilaceration | Yes | 31 (31%) | 12 (12%) | 0.001* |
| | No | 69 (69%) | 88 (88%) | |

Chi-square test, *=P<0.05.

**Table 3.** Distribution of taurodontism types in children with and without CLP

| | CLP | Control | P |
|---|---|---|---|
| Taurodontism | n (%) | n (%) | |
| No | 70 (70%) | 89 (89%) | 0,003* |
| Hypo | 22 (22%) | 9 (9%) | |
| Meso | 8 (8%) | 2 (2%) | |
| Hyper | 0 | 0 | |

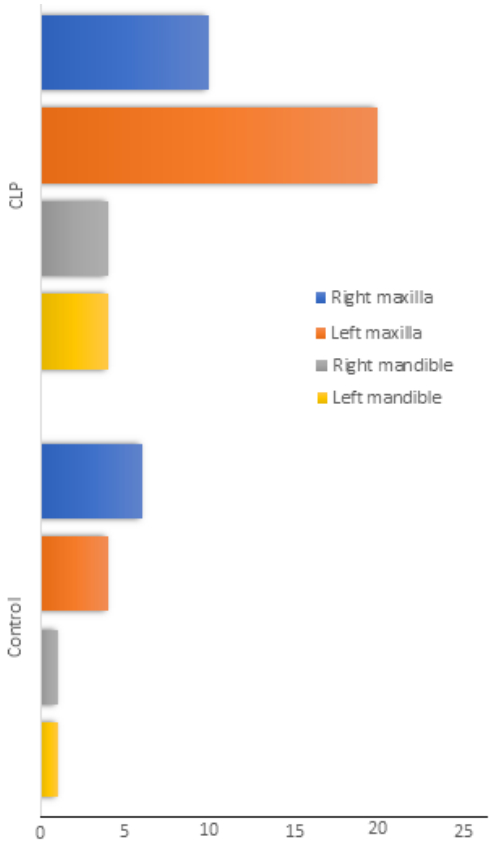


**Figure 4.** Location of tooth with root dilaceration.

## 4. Discussion

Identifying the frequency of dental anomalies is important in order to evaluate the possibility of requiring treatment, the methods of treatment, and the potential complications. We evaluated these problems in non-syndromic CLP children because we know that they will have dental problems that they have to deal with it for years and will need many surgical and orthodontic operations. It is critical to know the frequency of dilaceration and taurodontism in this group in order to prevent possible complications. As some studies have reported that the etiology of dilaceration might be related to trauma and in addition to that (Tewari et al., 2018; Gibbison et al., 2019; La Monaca et al., 2019), some studies have reported the relation of taurodontism (Nawa et al., 2008; Awadh et al., 2021; Chetty et al., 2021) and dilaceration (Jena and Kharbanda, 2005; Yassin and Rihani, 2006; Tomona et al., 2006) in certain syndromes, we excluded these patients in our study. Considering that we can only evaluate a limited number of teeth in the

mixed dentition, the incidence that found in our study is quite high.

Beyond clinical effects, according to Topouzelis et al. (2010), tooth with dilaceration have higher risk of impaction. Also in a study of Chang et al. (2016), root dilaceration was found to be a risk factor for external resorption. According to a cone beam computed tomography study (CBCT) with 44 patients and 59 impacted maxillary canines of Hettiarachchi et al. (2017) impaction was considered as a risk factor for dilaceration. They observed palatally impacted maxillary canines and compared them with normal subjects and claimed that impacted maxillary canines have a tendency to develop an apical hook (MacDonald-Jankowski, 1991). In addition to this study, few case reports presented impacted tooth having a higher risk for dilaceration (Chate, 2003; Turk and Elekdag-Turk, 2008; Hettiarachchi et al., 2017).

In a retrospective study of Weckwerth *et al.* examined 974 panoramic radiographies (PR) of non-syndromic CLP patients. According to this study, the teeth most affected by taurodontism were found to be 2nd molars (tooth numbers: 17 and 27). In addition root dilacerations were most common in teeth 38 and 48. Nonetheless, 3rd molars are excluded from our study due to the incomplete apexification process. The prevalence of taurodontism was found between 42.8-67.0%, while the prevalence of root dilaceration was found between 26.3-31.2% (Weckwerth et al., 2016).

In a retrospective study of Al Jamal et al., 78 CLP patients' PR were evaluated. Taurodontism was seen in 70.5% of all CLP patients. Additionally, dilaceration was seen in 19.2% of all (2010). Sobti et al. evaluated 67 CLP patients and 80 patients in control groups with cone beam computed tomography (CBCT) retrospectively. Taurodontism was seen in 71.05% of CLP patients and 45% of control group. Prevalence of taurodontism is higher in CLP patients (2022). Also, pulp enlargement was found to be more common in the maxilla, in CLP patients (de Assis et al., 2021). In a retrospective PR study of de Assis et al., enlarged pulp chamber was seen in 74 out of 90 CLP patients. Presence of CLP increased the possibility of having enlarged pulp chamber 1.5 times, as they reclaimed in their study (de Assis et al., 2021).

A meta-analysis of Fonseca-Souza et al. found a significant relation between taurodontism with CLP. Various studies with different results were evaluated in this meta-analysis. They also claimed that the variety of results may be caused by the heterogeneity of the sample. Additionally, an association was not found between root dilaceration and CLP in the study of Fonseca-Souza et al. root dilaceration remained a dental anomaly that is related to local trauma, not to CLP (Fonseca-Souza et al., 2022).

Răducanu et al. examined 48 patients with CLP and evaluated dental anomalies. In the comparison of the prevalence of root dilaceration between with and without CLP was found to be significantly different. The prevalence of dilaceration was found 1.2% in healthy subjects, while in CLP patients it was found 45.1%. Additionally, they claimed that dilaceration was found to be the most common dental anomaly in CLP patients. In their study, 23 out of 48 patients had dilaceration (Răducanu et al., 2015).

Low frequency of both taurodontism and root dilaceration in our study compared to other studies may be related with our inclusion criteria. Our case group had both deciduous and permanent tooth, which led us to evaluate only tooth with completed apexification. Some researchers report a delay in dental development or tooth eruption in CLP patients compared to non-CLP patients (Van Dyck et al., 2019). Considering our inclusion criteria, the delay of tooth development is important for our study. Although it has the same age distribution as the control group, it means less number of teeth were evaluated in the CLP group.

Common localization of dilaceration in children with CLP may be correlated with the cleft side. In our study, the left maxillary region was found to be the most common localization of both cleft and root dilaceration, contrary to the expected outcome. Although genetic studies have reported common genes associated with these root anomalies and clefts, current findings are still insufficient to explain the same localization (Küchler et al., 2022).

On the other hand, Hereman et al. (2018) reported that there is a great risk for canine impaction at the cleft side in unilateral CLP patients. Manfio et al. (2022) reported that more acute angulation and more apical position of the cleft side maxillary canine may be associated with an increased risk of its impaction. Similar studies commonly showed that the cleft side is related to tooth impaction (Celikoglu et al., 2015; Hereman et al., 2018; Manfio et al., 2022). In this point, the complex etiology of impacted teeth should be considered with developmental problems, maxillary deficiency, and dilacerations. To understand the role of dilaceration, the rate of these anomalies in impacted teeth on the cleft side should be examined in a larger CLP group.

In conclusion, understanding the etiology and presence of dental anomalies such as taurodontism and root dilaceration is essential in preoperative planning. Even though the association between CLP and dental anomalies is still not clear, we found that taurodontism and root dilaceration was significantly higher in children with CLP.

**Author Contributions**

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

| | M.Ö. | B.D.A. | M.O.B. | A.D. |
|---|---|---|---|---|
| C | | 100 | | |
| D | 40 | 40 | 10 | 10 |
| S | | | 50 | 50 |
| DCP | 50 | 50 | | |
| DAI | 50 | 50 | | |
| L | 20 | 60 | 20 | |
| W | 50 | 40 | 10 | |
| CR | | 10 | 20 | 70 |
| SR | 70 | 10 | 10 | 10 |
| PM | | | 40 | 60 |
| FA | | | | |

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

**Conflict of Interest**

The author declared that there is no conflict of interest.

**Ethical Approval/Informed Consent**

Ethical approval for this retrospective study was granted by the Marmara University, Faculty of Medicine, Non-invasive Clinical Research Ethics Committee with the following project no: 09.2021.1247.

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