Prevalence and Characteristics of Taurodontism in Patients with Cleft Lip and Palate Compared to the Healthy Group: a CBCT Study

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Objective: *To investigate the prevalence and characteristics of taurodontism in patients with cleft lip and palate (CLP) and clarify the relationship between CLP and the frequency and severity of taurodontism.*

Methods: *CBCT scans of 30 patients with bilateral CLP (BCLP), 70 with unilateral CLP (UCLP) and 70 healthy individuals were taken for investigation. In each group, the first and second molars were assessed for the presence of taurodontism. In taurodontic teeth, the severity of taurodontism was measured and classified based on the taurodontic index (TI). The frequency and severity of taurodontism were compared between the three groups.*

Results: *Taurodontism was significantly higher in patients with CLP ($P < 0.001$), and its prevalence was significantly higher in patients with BCLP than those with UCLP ($P = 0.003$) and the control group ($P < 0.001$). There was no difference among the three groups regarding the severity of taurodontism. Additionally, the frequency of taurodontism in the second molars was significantly higher than that in the first molars in the control group ($P = 0.019$).*

Conclusion: *Based on this investigation, clinicians should be aware of the possible complications that may occur when performing dental procedures on patients with BCLP and UCLP due to the higher incidence of taurodontism in these patients.*

Keywords: *CBCT, cleft lip and palate, taurodontism*

Chin J Dent Res 2024;27(4):327–332; doi: 10.3290/j.cjdr.b5860295

Cleft lip and palate (CLP) is considered the most prevalent congenital anomaly developed in the craniofacial region, with a global frequency of 0.45 in every 1,000 newborns.[1] Patients suffer from several functional, psychological and aesthetic problems.[2,3] Dental anomalies are frequent in CLP patients, including missing, hypoplastic or supernumerary teeth, enamel hypoplasia and taurodontism.[4,5]

One of the most prominent dental anomalies that accompanies CLP is taurodontism, or bull-shaped teeth. Taurodontism is the apico-coronal enlargement of the pulp chamber with apical displacement of bifurcation or trifurcation areas of the root.[6] Taurodontic teeth, with their abnormal morphology, affect periodontal, surgical, prosthetic and endodontic treatment planning, as they are characterised by vertically elongated pulp chambers, apically displaced furcation areas, short roots and a lack of cervical constriction.[7,8] Taurodontism is classified based on a well-known radiographic index, the Taurodontic Index (TI), into three main groups: hypotaurodontism, mesotaurodontism and hypertaurodontism.[9] The least severe of these according to this scale is hypotaurotontism, whereas hypertaurodontism is considered the most severe type.[8]

Few studies have assessed the risk of incidence of taurodontism in patients with CLP compared to

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This study was supported by the School of Dentistry, Shiraz University of Medical Sciences (SUMS), Shiraz, Iran.

unaffected individuals in various populations.[4,10-13] According to the current literature,[4,12] the frequency of taurodontism in patients with CLP varies widely among different populations, ranging from 18.2% to 71.05%.

Moreover, the accuracy of radiographic techniques can greatly impact the outcomes and investigations, which should be considered carefully. Previously published research on the epidemiological characteristics of taurodontism is mostly based on panoramic[14,15] or other conventional radiographic examinations.[16] It has been observed that many taurodontic teeth go undiagnosed even after using conventional two-dimensional (2D) radiography because of its well-known disadvantage of superimposition, especially in maxillary teeth.[8] On the other hand, the application of CBCT, as a viable 3D modality, can be helpful in diagnosis, classification, accurate measurement and the planning of treatment of taurodontism.[4]

To the best of the present authors' knowledge, there are only two studies evaluating the frequency of taurodontism in patients with CLP using CBCT.[4,10] Therefore, the aim of the present study was to compare the frequency and severity of taurodontism in patients with bilateral CLP, unilateral CLP, and healthy individuals using CBCT imaging.

Materials and methods

Study design

This retrospective study was performed on CBCT images of 170 subjects (87 women, 83 men), including 70 with UCLP (37 women, 33 men) and 30 with BCLP (17 women, 13 men), as well as 70 control subjects (33 women, 37 men) who met the eligibility criteria. The sample size was calculated according to the following formula:

$$n = \frac{\left(Z_{1-\alpha/2} + Z_{1-\beta}\right)^2 [P_1(1-P_1) + P_2(1-P_2)]}{(P_1 - P_2)^2}$$

Assuming α = 0.05 and power = 80%, with the use of the above formula, the sample size was calculated as 70 subjects per group. The age range of the participants was between 18 to 67 years. This study was approved by the institutional research committee (IR.SUMS.DENTAL.REC.1401.100). The criterion for inclusion of patients in the CLP and control groups was the presence of fully developed permanent molars. The high-quality images that showed both arches were included. Patients with extensive caries, restorations or crowns and who had undergone endodontic treatment of first and/or second permanent molars were excluded from the study. Finally, the patients were categorised into the UCLP, BCLP and control groups. All participants signed an informed consent so that their anonymous data could be used in further research.

Radiographic assessment of taurodontism

CBCT images were taken using the VGi EVO NNT imaging system (NewTom, Imola, Italy) at 0.3 mm voxel size, 110 kVp, 7.56 mAS, and a standard field of view. To assess the intergroup observer reliability, a dentistry student and an oral and maxillofacial radiologist measured the variables of every CBCT scan separately. Two weeks later, 20% of the studied images were randomly chosen for reassessment to evaluate the intragroup observer reliability of the measurements. To quantitatively assess the inter- and intragroup observer reliability of the outcomes, the Kappa coefficient was estimated for each variable. The diagnosis of taurodontism was based on the TI, which was proposed by Shifman and Chananel.[17] To determine TI, the present authors measured two variables. Variable 1 was the distance from the lowest point of the roof of the pulp chamber to the highest point of the floor of the pulp chamber, whereas variable 2 was the distance from the lowest point of the roof of the pulp chamber to the apex of the longest root. Then variable 1 was divided by variable 2 and multiplied by 100.

The teeth were categorised as being affected by hypotaurodontism if TI was 20% to 30%, mesotaurodontism if it was 30% to 40% and hypertaurodontism if it was 40% to 75% (Fig 1). All measurements and calibrations were performed using the digital scale provided by NewTom NNT software. The presence and severity of taurodontism in eight molar teeth of each subject were assessed in the BCLP, UCLP and control groups.

Statistical analysis

All the obtained values were restored and measured in SPSS (version 26; IBM, Armonk, NY, USA). A chi-square test was used to compare the frequency and severity of taurodontism in the three studied groups. The prevalence of taurodontism between the three groups regarding laterality, tooth number and arch was evaluated. The confidence interval (CI) of 95% and $P < 0.05$ were considered as the level of statistical significance.

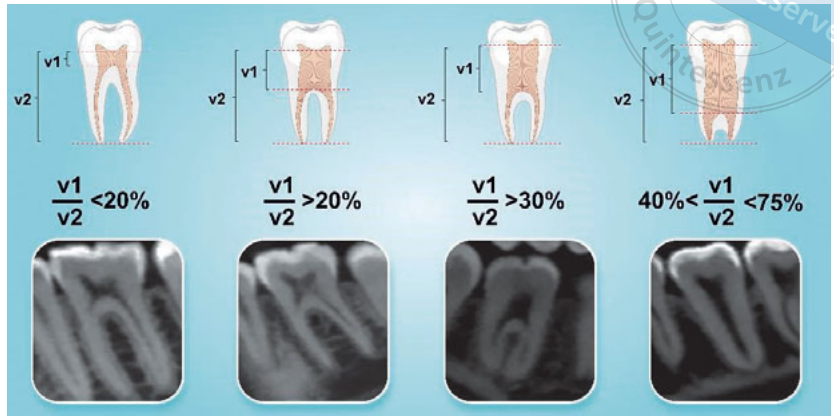

Fig 1 Classification of taurodontism in the CBCT images.

Table 1 Comparison of the frequency of taurodontism in different subtypes of CLP.

	BCLP, n (%)	UCLP, n (%)	Control group, n (%)	*P* value
Taurodontism	48 (41.88%)[a,b]	91 (26%)[a,c]	51 (12.57%)[b,c]	< 0.001*
Normal teeth	69 (58.11%)	259 (74%)	345 (87.12%)	

*Statistically significant.
a, statistically significant difference between the BCLP and UCLP groups ($P = 0.003$); b, statistically significant differences between the BCLP and control groups ($P < 0.001$); c, statistically significant differences between the UCLP and control groups ($P < 0.001$)

Table 2 Comparison of the frequency of occurrence different types of taurodontism among groups

Type of taurodontism	BCLP, n (%)	UCLP, n (%)	Control group, n (%)	*P* value
Hypotaurodontism	117 (81.25%)	78 (85.71%)	45 (88.23%)	0.879
Mesotaurodontism	7 (14.58%)	11 (12.08%)	5 (9.80%)	
Hypertaurodontism	2 (4.16%)	2 (2.19%)	1 (1.96%)	

Table 3 Comparison of the frequency of taurodontism between first and second molars in the CLP and control groups

	BCLP group		UCLP group		Control group	
	1st molar (%)	2nd molar (%)	1st molar (%)	2nd molar (%)	1st molar (%)	2nd molar (%)
Taurodontism	30	18	49	42	17 (8.99%)	34 (16.42%)
P value	0.274		0.115		0.019*	

*Statistically significant.

Results

The prevalence of taurodontism was 139 (12.87%) and 51 (29.76%) in the participants with CLP and healthy individuals, respectively. The analysis of the present results indicated that the presence of CLP was significantly associated with a higher prevalence of taurodontism ($P < 0.001$). Table 1 shows the frequency of taurodontism among the three groups. The frequency of taurodontism was significantly correlated with the type of CLP ($P < 0.001$). In this regard, it was found that taurodontism was significantly higher in the BCLP group than the UCLP ($P = 0.003$) and control groups ($P < 0.001$).

The different classifications of taurodontism (hypo-, meso- and hypertaurodontism) were assessed among patients with BCLP and UCLP and the control group. The results indicated that there was no difference between the three groups regarding the severity of taurodontism (Table 2).

The frequency of taurodontism in second molars in the control group was significantly higher than in first molars ($P = 0.019$); however, this difference was not significant among patients with BCLP and UCLP (Table 3).

The results in Table 4 indicate that in both CLP and control groups, taurodontism was significantly more prevalent in the maxilla compared to the mandible. The estimated *P* value in the BCLP and UCLP groups was < 0.001. The same outcome was obtained in the control group ($P < 0.001$). In both the CLP group and the control group, no statistically significant correlation

Table 4 Association of taurodontism with the arch in both the BCLP and UCLP groups and the control group

	BCLP group		UCLP group		Control group	
	Maxilla, n (%)	Mandible, n (%)	Maxilla, n (%)	Mandible, n (%)	Maxilla, n (%)	Mandible, n (%)
Taurodontism	42 (87.5 %)	6 (12.5%)	72 (79.12 %)	19 (20.88 %)	44 (86.27%)	7 (13.72%)
P value	< 0.001*		< 0.001*		< 0.001*	

*Statistically significant

was observed between the two sides. The *P* value in the BCLP, UCLP and control groups was estimated as 0.233, 0.429 and 0.469, respectively.

Discussion

Taurodontism is one of the dental anomalies commonly observed in molars, and its prevalence varies among different populations. Several systemic disorders have been demonstrated to be associated with taurodontism, including amelogenesis imperfecta, osteogenesis imperfecta, Down syndrome, ectodermal dysplasia, hypophosphatasia and tricho-dento-osseous syndrome.[18] Among the different systemic disorders associated with a higher risk of taurodontism, CLP, being the most common developmental craniofacial anomaly, has been suggested to have possible associations with taurodontism. Taurodontism is a developmental anomaly that can affect several clinical procedures, including endodontic procedures,[16,19] prosthetic treatment[20] and tooth extraction.[16] The large and elongated pulp chamber, as well as the shortened root canals and high proximity of dilated roots, create specific challenges for clinicians to achieve acceptable outcomes in the treatment of teeth with taurodontism.[16,21-23]

The present study indicated that the frequency of taurodontism in patients with CLP was significantly higher than in healthy individuals. This finding is confirmed by previous studies that assessed the frequency of taurodontism in patients with CLP compared with healthy individuals.[10,11,13,24] Moreover, the type of CLP also played a role in this regard, since BCLP was associated with a higher incidence of taurodontism compared to UCLP. One of the possible mechanisms through which CLP can be correlated with taurodontism is through the role of DLX genes. Since these genes are involved in the pathogenesis of both CLP and taurodontism, it can be speculated that the enhanced frequency of teeth affected by taurodontism can be associated with possible genetic factors, including DLX genes.[25,26]

Moreover, the present study demonstrated that the severity of CLP can also be associated with a higher incidence of taurodontism since the frequency of taurodontism in patients with BCLP was significantly higher than the group with UCLP. Thus, the dental care and treatment planning for these patients should be conducted with more caution. In this regard, Küchler et al[12] failed to determine the possible correlation of severity of CLP with taurodontism. This difference could be ascribed to the fact that this study included only patients with the highest severity of taurodontism (hypertaurodontism),[12] whereas the present authors included patients regardless of their level of severity of taurodontism. Furthermore, to obtain the highest precision in our study, we utilised CBCT scans to avoid possible inaccuracies and imprecisions in the diagnosis and measurement of the identified values, whereas the cases evaluated by Küchler et al[12] were examined using conventional techniques.

Concerning the severity of taurodontism, it was found that hypotaurodontism was more commonly detected, followed by mesotaurodontism and hypertaurodontism. The results of the present study are in line with previous studies.[4,11] In this regard, Weckwerth et al[11] stated that in patients with CLP, the frequency of hypotaurodontism, mesotaurodontism and hypertaurodontism was 83.70%, 10.67% and 5.61%, respectively. Similarly to the studies by Sobti et al[4] and Weckwerth et al,[11] we can assume that the frequency of taurodontism subtypes was not affected by the presence of CLP.

Also, we investigated whether the number of taurodontic teeth can also be affected by CLP. The present study demonstrated that in patients with CLP, taurodontism does not exhibit any tendency towards the first or the second molar; however, in participants without CLP, it was more frequently observed in the second molar compared to the first molar. This is in line with the study by Jamshidi et al,[27] which found that taurodontism is more commonly diagnosed in second molars compared to first molars in healthy individuals. Besides, in another study conducted by Aydin and Mobaraki,[7] in healthy individuals, the incidence of taurodontism suggests a predilection towards the second molars.

Concerning the impact of tooth laterality, it was also demonstrated that there was no significant predilection towards the left or the right side in either the control group or the CLP groups. This is in line with previous

studies that reported no significant difference in the frequency of taurodontism on the left or right side in patients without CLP.[22,27,28]

Concerning the impact of the arch on the incidence of taurodontism, the present authors found that in all three groups, the frequency of taurodontism in the maxilla was significantly higher than in the mandible. This is in line with the studies conducted by by Jamshidi et al[27] and Li et al,[29] who reported that taurodontism was more common in the maxilla compared to the mandible in a normal population. In another study, Bharti et al[30] found that taurodontism is much more frequent in the maxilla than the mandible by evaluating the full-mouth periapical radiographs of 1,000 patients. These results are further confirmed by several other studies that assessed the frequency of taurodontism through various radiographic techniques.[7,31,32] The present authors hypothesise that it could be possible that, due to the higher vascularisation of the maxilla compared to the mandible,[33] the genetic background of teeth with taurodontism may have a higher chance of incidence, and therefore the probability of formation of taurodontism may be enhanced in the tooth formation process.

The differences in root and canal morphologies in taurodont molars in the BCLP, UCLP and control group were not evaluated. Therefore, further studies are recommended to examine this topic in taurodont teeth in CLP patients.

Conclusion

The present study showed that the presence of CLP increased the incidence of taurodontism. Moreover, the type of CLP is also a factor that can further increase this phenomenon. The authors also found that the incidence of taurodontism in the maxilla is much higher than in the mandible in all groups. It is important to note that the severity of taurodontism was not affected by the presence or even the type of CLP. Thus, based on the current outcomes, clinicians should be aware of the possible complications in endodontic, prosthodontic and surgical procedures in patients with BCLP and UCLP due to the higher incidence of taurodontism in these patients.

Conflicts of interest

The authors declare no conflicts of interest related to this study.

Author contribution

Drs Maryam Paknahad, Mohammad Pordel and Fatemeh Akbarizadeh contributed to the design and implementation of the research, the analysis of the results and the writing of the manuscript.

(Received Feb 05, 2024; accepted Aug 13, 2024)

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