

Taurodontism in maxillary and mandibular molars using cone beam computed tomography in a dental center in Saudi Arabia

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BACKGROUND: Taurodontism is a dental anomaly characterized by altered crown root ratio that is often diagnosed by radiographic evaluation. A three-dimensional cone beam computed tomography (CBCT) can aid in the diagnosis and treatment of taurodontic teeth. Only one study has reported the prevalence of taurodontism in a Saudi population.

OBJECTIVE: Determine prevalence and other characteristics of taurodontism in permanent maxillary and mandibular molars, by CBCT in a dental center in Saudi Arabia.

DESIGN: Cross-sectional.

SETTING: College of dentistry.

SUBJECTS AND METHODS: The first and second molars, maxillary and mandibular, from study participants of Saudi origin from Jazan region of Saudi Arabia were evaluated for taurodontism based on the criteria of Shifman and Chanannel. The degree of taurodontism was determined by the taurodontism index. Results were tabulated for analysis and the chi-square test was applied for the differences between age groups, genders, and maxillary and mandibular teeth.

MAIN OUTCOME MEASURES: Characteristics of taurodontism.

SAMPLE SIZE: 1839 teeth in 300 individuals.

RESULTS: Taurodontism was seen in 24 (8%) of the study participants and in 71 teeth (3.9%). Taurodontism was significantly more prevalent in individuals between 21 and 40 years of age. Hypotaurodontism (67.6%, n=48) was most prevalent, followed by mesotaurodontism (23.9%, n=17) and hypertaurodontism (8.5%, n=6). The maxillary molars were more commonly involved than mandibular, but the results were not statistically significant. No significant differences in gender were observed.

CONCLUSIONS: Dental clinicians should be familiar with the condition due to the clinical implications in oral surgery, endodontics and prosthodontics. The possibilities of a complex root canal system, an additional canal, difficulties in canal negotiation, instrumentation and subsequent obturation can be challenging for the clinician.

LIMITATIONS: Conducted in a single dental center hence future studies with larger sample sizes in different regions of Saudi Arabia should be conducted to more accurately measure the prevalence.

CONFLICT OF INTEREST: None.

Dental anomalies are described as imperfections in the natural process of tooth formation (odontogenesis).¹ Taurodontism is a common dental anomaly and has an array of clinical implications. The term is derived from the Greek word 'tauros' which means bull and 'odontos' which means teeth.² Hence the literal meaning of this term is "bull-shaped teeth". This condition is clinically characterized by an apico-coronal elongation of the pulp chamber of a tooth with apical displacement of bifurcation or trifurcation areas of the root.³ In other words, the crown of the tooth elongates at the expense of the roots deregulating the crown-root ratio. In the year 1913, Sir Arthur Keith was the first to introduce the term taurodontism to describe molar teeth resembling bulls.⁴ The etiopathogenesis of taurodontism is attributed to a failure of invagination of the Hertwig epithelial root sheath at a proper horizontal level thereby enlarging the tooth body and pulp chamber and shortening the roots. Despite an unclear etiology, there is a genetic basis described as an X-linked, familial or autosomal dominant trait, making taurodontism an oral-cavity component of syndromes such as Klinefelter syndrome and Down syndrome.^{5,6} However, recently taurodontism has been described as only an anatomic variation occurring in normal individuals.⁷

The condition affects both primary and permanent teeth with the mandibular molar most often affected by taurodontism.^{8,9} The incidence of taurodontism was greater in primitive man (3%) compared to modern man (1%).^{6,10} Taurodontism has been subclassified by Shaw into hypotaurodontism, mesotaurodontism and hypertaurodontism based on the amount of displacement of the floor of the pulp chamber.¹¹ Shifman and Chanannel used clinical criteria to diagnose the degree of taurodontism.⁷

Endodontic treatment of taurodontic teeth has been described as a complex procedure, especially in terms of canal identification, cleaning and shaping, and obturation. Jafarzadeh et al¹² mentioned that clinicians may encounter complex root canal systems with the possibility of additional root canals, which needs careful exploration under magnification. Previously published research on the prevalence of taurodontism are mostly based on panoramic or bitewing radiographic examinations.^{12,13} CBCT is a viable 3-dimensional modality which can prove helpful in prevalence studies, diagnosis, classification, accurate measurement and in the treatment of taurodontism.^{14,15} An extensive literature search revealed only one study using CBCT to study the prevalence of taurodontism.^{12,16,17} Hence, the present study was undertaken with the pursuit of identifying

taurodontism and quantifying its prevalence between different age groups, genders, and maxillary and mandibular first and second molars in subjects of Saudi origin from Jazan region of Saudi Arabia.

SUBJECTS AND METHODS

This cross-sectional study involved patients of Saudi origin who had undergone CBCT scanning for diagnostic purposes. Formal approval was obtained from the Scientific Research Committee, College of Dentistry, Jazan University (Reference no. CODJU-18251) before the start of the study and all methods were performed in accordance with the guidelines and regulations. Informed consent was obtained from all patients whose CBCT images were used in the present study. The CBCT machine used was a 3D Accuitomo 170 (Morita, Osaka, Japan), and the scanning parameters were FOV 170×120 mm, 90 Kv, 5-8 mA, 17.5 seconds exposure time and 0.25-mm voxel size. The images were processed, reconstructed and analyzed using 3D imaging software (i-Dixel, Morita). Software features such as change in contrast and brightness and magnification were used to optimally visualize the images. Maxillary and mandibular teeth, including first and second permanent molars with fully formed roots assuring complete tooth development were included in this study. Teeth with root canal fillings or previously initiated root canal treatment, partially erupted and distorted or unclear images were excluded from the study. Two experienced endodontists examined the CBCT images. The examiners independently assessed each image in two sessions at an interval of two-week. Any disagreements between examiners were resolved by discussion to reach consensus. A tooth was diagnosed as taurodontic or not on the basis of the criteria of Shifman and Chanannel.⁷ The degree of taurodontism was determined by the taurodontism index, which was calculated by a standardized formula (**Figure 1**). Taurodontism index (TI)=distance from the lowest point at the occlusal end of the pulp chamber to the highest point at the apical end of the chamber (denoted: a) ÷ distance from the lowest point at the occlusal end of the pulp chamber to the apex of longest root (denoted: b)×100. The tooth is categorized as hypotaurodontism if TI is 20-30%, mesotaurodontism if TI is 30-40% and hypertaurodontism if TI is 40-75%.^{7,10,11} All measurements and calibrations were done using the digital scale provided with CBCT machine. The results were analyzed using the computer program IBM SPSS version 12. The chi-square test was used for intergroup comparisons. A *P* value of <.001 was considered highly significant while a *P* value <.01 was considered significant.

RESULTS

We examined 1839 teeth in 300 patients who included 148 male and 152 female subjects. Taurodontic subjects were younger than normal subjects (median age 26.5 years vs 32.0 years, $P<.001$). Most subjects were between 21-40 years of age (**Figure 2**). The highest

prevalence of taurodontism was in subjects between 21 and 40 years, which was statistically significant compared to the other age groups ($P<.001$) (**Table 1**). Twenty-four (8.0%) had taurodontism (12 males and 12 females). Among the 24 subjects, 19 had taurodontism in more than one tooth. Of the 1839 teeth, 71 were taurodontic (3.9%). Of the 71 taurodontic teeth, 48 (67.6%) were hypotaurodontic, 17 (23.9%) were mesotaurodontic and 6 (8.5%) were hypertaurodontic (**Figure 3**) (**Table 2**). Maxillary teeth were more frequently taurodontic compared with mandibular teeth but the difference was not statistically significant ($P=.086$) (**Table 1**).

DISCUSSION

Taurodontism has been considered as one of the most important dental anomalies with altered tooth morphology. This dental anomaly is associated with an altered crown-to-root ratio leading to variations in morphology of the pulp chamber and root canals. Although these minor changes do not affect aesthetics, they are associated with clinical complications because of difficulties in performing endodontic treatment in taurodontic teeth. The prevalence of taurodontism seems to differ among different ethnic groups,¹⁶ but variations might be attributed to diagnostic criteria and technique.¹⁸ The condition is usually diagnosed by intraoral periapical radiography and orthopantomography. However, the commonly used radiographic techniques are only two dimensional and may not depict the dimensions of all parameters accurately. Hence, a three-dimensional imaging technique would aid in accurate tooth and root measurements. In this regard CBCT is recommended to aid in the accurate diagnosis of taurodontism.¹⁴

In the present study the prevalence of taurodontism in the southern region of Saudi Arabia was 8%. These findings are similar to the prevalence of taurodontism in Jordanian dental patients (8%),¹⁹ lower than in a young adult Chinese population (46.4%),⁸ higher than in a north Indian (0.4%)²⁰ and south Iranian population (5.5%).²¹ The prevalence was more than the 0.1% in the western region of Saudi Arabia reported by Afify et al,²² 1.7% reported by Al-Halal et al,²³ and 1.4% by Alassiry.²⁴ The differences could be attributed to the sample size and radiographic technique. Among the 1839 teeth screened 71 teeth (3.9%) had taurodontism. A study by Aricioğlu et al¹⁷ reported 65 taurodontic teeth (8.6%) among 757 mandibular molars. The variations could be attributed to the variation in ethnic group and the sample size. Although the difference between maxillary and mandibular molars in regard to prevalence of taurodontism was found to be

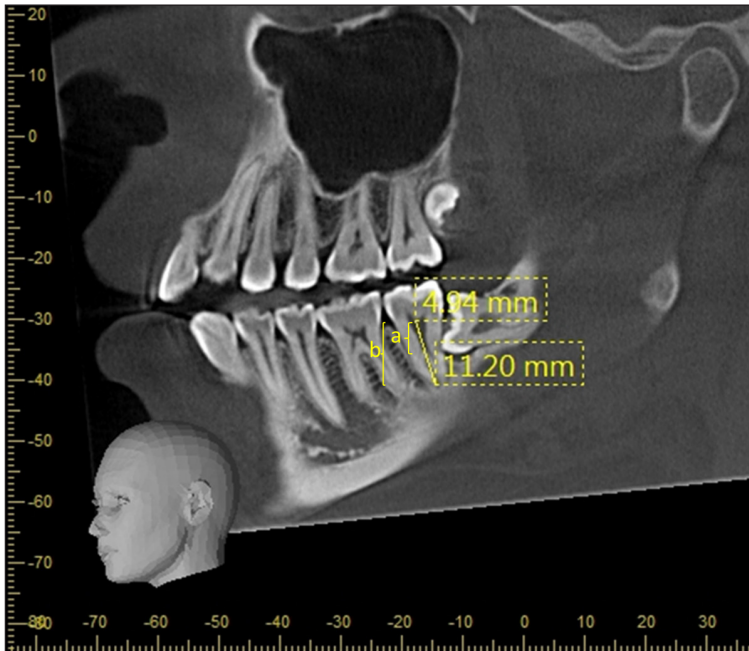


Figure 1. Sagittal view of CBCT, acquiring measurements of a mandibular second molar for taurodontism index (TI). $TI = a \div b \times 100$, where 'a' is distance from the lowest point at the occlusal end of the pulp chamber to the highest point at the apical end of the chamber = 4.94; 'b' is distance from the lowest point at the occlusal end of the pulp chamber to the apex of longest root = 11.20; $TI = 44.10$, diagnosed as hypertaurodontism.

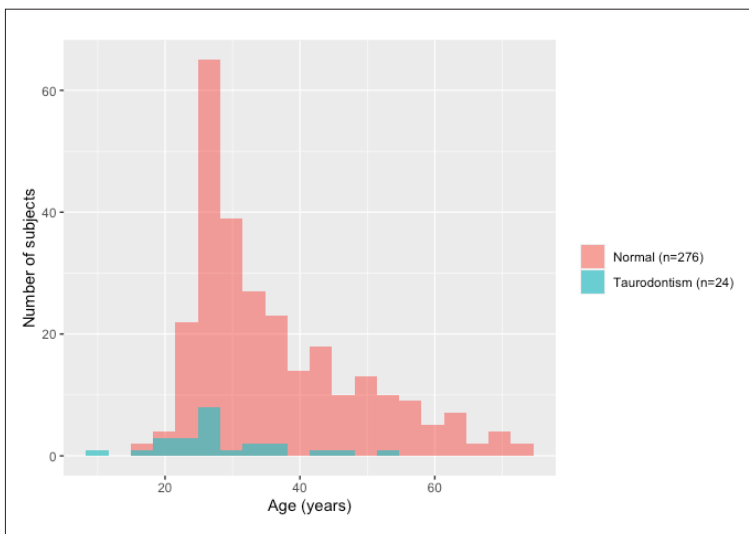


Figure 2. Distribution of age.

statistically insignificant, the maxillary right first molar was the tooth with the highest prevalence of taurodontism with a total number of 13 teeth (18.3%) out of the 71 taurodontic teeth, followed by maxillary left first and second molars with equal prevalence of 12 teeth (16.9%). Patil et al²⁰ reported a statistically significant prevalence of taurodontism in the maxilla than mandible in a north Indian population. Darwazeh et al¹⁹ reported that taurodontism was most common in the maxillary second molar. On the contrary, Macdonald et al⁸ and Rao and Arathi⁹ reported that taurodontism was more prevalent in mandibular molars. In the present study males and females were equally affected by taurodontism, similar to the findings of Jordanian population.¹⁹ These findings differ from those in a young adult Chinese population⁸ and a south Iranian population²¹ where females had a statistically higher prevalence of taurodontism than males. Aricioğlu et al¹⁷ reported higher prevalence of taurodontism in females in second molars and no statistical difference in first molars. The variations could be attributed to the variation in ethnic group and the sample size. In the present study the highest prevalence of taurodontism was in subjects

Table 1. Frequency of taurodontism by demographic and clinical characteristics (n=300).

Age (years) ^a	Taurodontism		Total
	Absent	Present	
≤20	5 (50.0)	5 (50.0)	10
21-40	184 (92.0)	16 (8.0)	200
41-60	70 (95.9)	3 (4.1)	73
>60	17 (100.0)	-	17
Total	276 (92.0)	24 (8.0)	300
Gender ^b			
Males	136 (91.9)	12 (8.1)	148
Females	140 (92.1)	12 (7.9)	152
Total	276 (92.0)	24 (8.0)	300
Side ^c			
Maxillary	277 (92.3)	23 (7.7)	300
Mandibular	287 (95.7)	13 (4.3)	300

Data are number (%).^aChi-square test, $\chi^2=26.947$; $df=3$; $P<.001$; ^b $\chi^2=0.005$; $df=1$; $P=.946$; ^c $\chi^2=2.955$; $df=1$; $P=.086$; Not-Significant

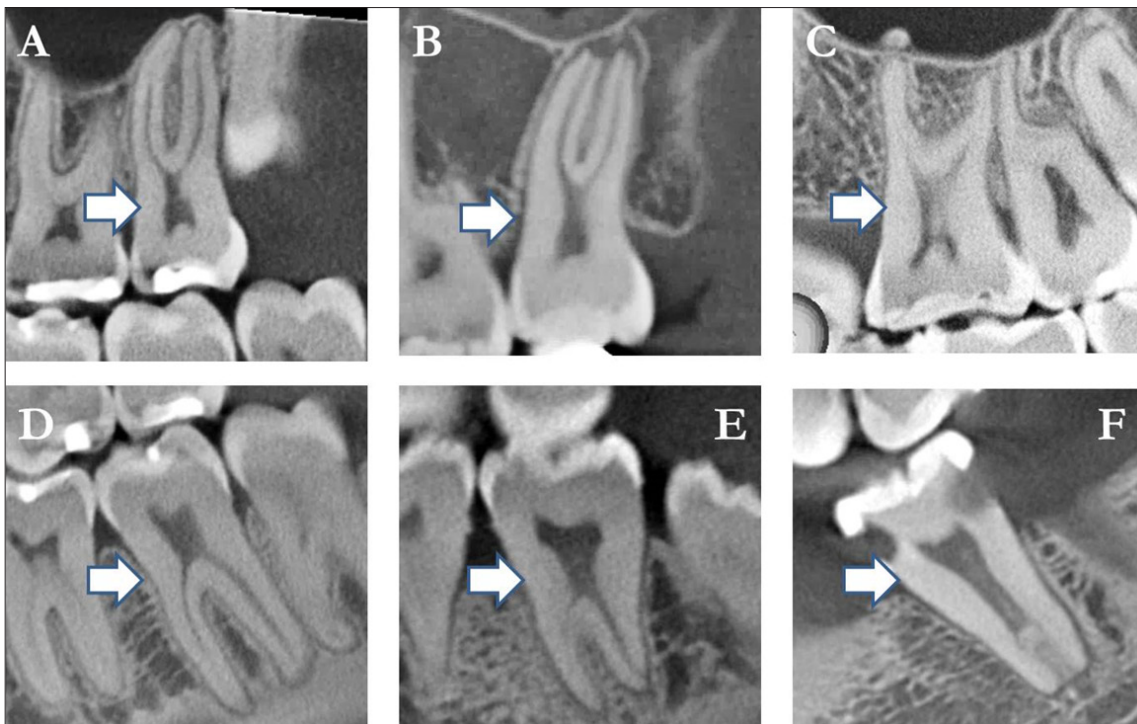


Figure 3. Sagittal views of CBCT showing the tooth (white arrow) and the types of taurodontism observed in the present study. Maxillary molars with hypotaurodontism (A), mesotaurodontism (B), and hypertaurodontism (C). Mandibular molars with hypotaurodontism (D), mesotaurodontism (E), and hypertaurodontism (F).

Table 2. Frequency of taurodontism by number of teeth (n=1839).

Tooth No.	Hypotaurodontism	Mesotaurodontism	Hypertaurodontism	Total
T-17	4 (36.4)	5 (45.4)	2 (18.2)	11
T-16	9 (69.2)	3 (23.1)	1 (7.7)	13
T-26	9 (75.0)	2 (16.7)	1 (8.3)	12
T-27	8 (66.7)	3 (25.0)	1 (8.3)	12
T-37	5 (62.5)	2 (25.0)	1 (12.5)	8
T-36	4 (100.0)	-	-	4
T-46	3 (100.0)	-	-	3
T-47	6 (75.0)	2 (25.0)	-	8

Data are number (%).

between 21 and 40 years, which was statistically significant compared to the other age groups ($P<.001$), which could be attributed to the unequal sample distribution in the present study. The majority of the study participants (200 out of 300 were of the age group 21 to 40 years of age).

The use of CBCT not only provides accurate information on tooth measurements to diagnose taurodontism, but also provides information on morphology of root canals that will aid in performing endodontic treatment. Aricioğlu et al¹⁷ reported an association between a C-shaped canal and taurodontism. It is well-known that C-shaped canals pose an endodontic challenge. Borges et al¹⁵ reported the advantage of CBCT in the diagnosis of multiple taurodontic teeth.

Although taurodontism is asymptomatic, clinicians must be aware of the prevalence as it has clinical implications for endodontic, prosthodontics or orthodontic treatment planning. During endodontic treatment taurodontic teeth present a difficulty during negotiation, instrumentation and obturation. Also, owing to the shift of furcation to the apical region and divergent roots at the apical third of the tooth extraction of taurodontic teeth may be associated with complications.¹⁶

However taurodontic teeth have a good periodontal prognosis as there must be significant periodontal destruction to reach the apically placed furcation. For prosthetic management of taurodontic teeth, it is better to avoid the placement of a post for tooth reconstruction and the tooth cannot be used as an abutment due to decreased stability and strength owing to the small surface area in the alveolus.²⁵ The limitations of the study include that the study was conducted in a particular center of southern Saudi Arabia and the morphological variations of root canal were not assessed. Further studies with a larger sample size and sample population assessing the root canal anomaly of taurodontism have to be carried out to establish clinical implications and treatment plan for such teeth.

In conclusion, dental clinicians should be familiar with the condition due to the clinical implications in endodontics, oral surgery and prosthodontics and its association with related syndromes. CBCT is not only a valuable tool for the precise measurements required for diagnosis, classification and treatment planning for taurodontic teeth, but is also a research tool in prevalence studies. However, taurodontism can be diagnosed during routine radiographic examinations.

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