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CONTENT

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Prevalence of taurodontism in a modern Austrian sample *

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Abstract

Taurodontism is a dental condition characterized by an abnormality in the tooth root formation, believed to be caused by defects in the invagination of the Hertwig epithelial sheath during root development. It is characterized by an enlarged, apically displaced pulp chamber, short roots, and a lack of constriction at the enamel-cementum junction. Taurodontism is classified into three degrees: hypo-, meso- and hypertaurodontism. The data was collected by measuring the height of the pulp chamber in relation to the length of the pulp chamber roof to the apex of the longest root in multirooted teeth. In this study, 1,000 panoramic radiographs (PAN) from a dental practice in Upper Austria were evaluated according to the classification of Shifman and Chanannel (1978). Hypotaurodontism was not recorded. Among the subjects evaluated, 5.9% were affected by taurodontism, and the prevalence of taurodontic teeth was 1.4%. It was found that slightly more women than men exhibited the presence of taurodontism. Mesotaurodontism was identified in 43 subjects (4.3%), hypertaurodontism in eight subjects (0.8%), and both forms were present in eight cases (0.8%). The anomaly occurred significantly more frequently in the maxilla than in the mandible. The prevalence of taurodontism varies considerably worldwide due to several factors: the use of different classifications, sample sizes, variable inclusion and exclusion criteria, and population genetic reasons. Clinically, taurodontism complicates procedures such as extractions, endodontic, prosthodontic, periodontal and orthodontic treatments, which underscores its relevance in dental practice.

Keywords: taurodontism; pyramidalism; molars; classification; prevalence; sex affected frequency

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Introduction

Anomalies of the teeth comprise deviations in the shape and number of the teeth, the structure of the dental hard tissue and in tooth position with occlusion (1). Knowing these deviations from the norm is crucial for their adequate diagnosis and treatment in dental practice, as well as for recognizing other diseases often associated with these particular anomalies. This study focusses on a specific shape anomaly of the pulp and the root known as taurodontism. First described by Heider and Wedl (2), the term "taurodontism" did not have a clear definition for a long time. Initially, the anomaly was referred to as prismatic or cylindrical teeth or even as "prismatic rootstock" (3). However, when human fossils were found in Krapina (Croatia) that were based on this observation, it triggered a lively discussion about the position of this species in the human family tree (4). Crucially for further research, the taurodont teeth from Krapina were correctly attributed to Homo neanderthalensis, whose phylogenetic position in the human family tree was finally confirmed through paleogenetics (5,6). The genomes of Europeans can be traced back to Neanderthals by 1-4% and is also evident in the phenotype, adding an intriguing aspect to the study (7,8). Numerous observations of taurodontism in human fossils provide evidence for a root anomaly that extends far back into the history of human evolution (9–12).

The origin of the name "taurodontism" is based on the Greek words ταῦρος (tauros=bull) and ὀδούς (odous=tooth). The term originated from Sir Arthur Keith, who interpretated it as "the tendency of the tooth body to enlarge at the expense of the roots" (13,14). He described a pulp chamber that extends widely to the apex, resembling the horns of a bull. Keith distinguished the taurodont tooth with the pointed cone-shaped normal tooth root of humans, which he equated with that of dogs and described as cynodont (gr.: kynos=dog). The first classification of taurodontism by Shaw (15) remains valid to this day. During studies conducted in South Africa, the author diagnosed moderate manifestations of taurodontism, which he called hypotaurodontism. Stronger manifestations were classified as meso- and hypertaurodontism, with the respective assignment depending on the degree of displacement of the pulp chamber toward the root apex (Figure 1). One issue with Shaw's (15) classification is that the subjective evaluation of cynodont and hypotaurodont resulted in numerous teeth being incorrectly classified as hypotaurodont (16).

Taurodontism occurs in both deciduous and permanent dentition and can be manifested unilateral or bilateral and in numerous variants in the maxilla and/or mandible (17,18). While molars are most commonly affected, cases of taurodont premolars are also described in the literature, with a much lower prevalence than molars (19,20). When comparing the three molars of the maxilla and mandible, the 2nd molars in the maxilla are reported to have the highest incidence of taurodontism (21–25).

Little is known about the pathogenesis of taurodontism (18,26). Schulze (26) suggests that an error in the invagination of the Hertwig epithelial sheath after correct formation of the tooth crown leads to a malformation of the root. Ultimately, the remodeling of the epithelial sheath into two or three epithelial sheaths, which is a prerequisite for proper root formation, fails or is delayed from the neck of the tooth. This results in shortened roots and a lengthened tooth body (27). Other authors favor a delayed apical epithelial membrane outgrowth (20) or specific ectodermal disorders during odontogenesis (23). The frequency of taurodontism in the Neanderthals of Krapina suggests a genetic etiology. Fischer (28) and Goldstein and Gottlieb (29) confirmed the hereditary nature of the anomaly by studying a family in which all members exhibited meso- and hypertaurodontism, suspecting a dominant autosomal gene. However, differences in expressivity were observed among the individual family members, similar to the case of the Krapina-Neanderthals. Other authors assume an x-linked inheritance (15,30–32).

Taurodontism usually occurs as an isolated anomaly (33). A clustered occurrence has been described in association with oligodontia, hyperodontia, pulp stones, amelogenesis imperfecta, cleft lip and palate, and with certain syndromes like Down syndrome, Klinefelter syndrome (34–45). Taurodontism is never pathognomonic in this context, but merely occurs in a clustered fashion. Clinically, the anomaly is of significant importance, as its presence can complicate dental treatments such as extractions, endodontics, orthodontics, periodontics, and prosthetics (46,47). Therefore, it is highly advantageous for dentists to detected and diagnosed the anomaly before initiating treatment. Moreover, taurodontimus holds a significance not only in the field of dentistry but also in forensics (48) and bioarchaeology (49).

Figure 1. Graphic illustration of the different forms of taurodontism according to Shaw (15): hypotaurodont= slight enlargement of the pulp chamber with a decrease in root length; mesotaurodont= pulp chamber is relatively large and the roots are short, but still separated from each other; hypertaurodont= prismatic or cylindrical form, in which the pulp chamber almost touches the apex and the roots only separate in the apex region (© M. Wiesinger).

The potential relationship between taurodontism and another root variant, pyramidalism, remains inconclusive. Schulz (26) states "As in the maxilla, 'unions' of regular roots to form a more or less uniform rootstock occur not infrequently in the mandible. They occur in two versions, the prismatic version being called taurodont and the tapering one pyramidal or cuneiform - wedge-shaped" (26). He points out that some authors consider pyramidalism to be the most extreme degree of taurodontism. A subdivision of pyramidalism is proposed by Brabant and Kovacs (50). Out of the four types, two are pyramidal in the strict sense (A, B) and differ in the shape of the pulp cavity (Figure 2). The remaining types (C, D) feature an externally uniform rootstock, yet additional roots or parts of the interradicular septum are still identifiable. The discourse about pyramidalism continous until today (26).
Due to the unexplained etiology of pyramidalism, data on prevalences are not conclusive. With the exception of one case study that included the first molar, the occurrence in the mandibular first molar seems to be rare (26). Brabant and Kovacs (50) and Uneoka (51) both reported on case studies. Trost (52) and Hofmann (53) evaluated 3,083 resp. 2,122 panoramic radiographs and did not find a single case of pyramidalism in the first molars in the mandible. The examination of the maxilla was not conduced due to the potential overlapping of the palatal roots. However, the situation appears to be different for the mandibular second and third molars, as the anomaly has been observed more frequently. For instance, in a comprehensive study on dental roots of mandibular molars, Visser (54) reported prevalence values of 25.7% for mandibular 2nd molars and 31.1% for mandibular 3rd molars (26).

Material and Methods

The aim of this quantitative retrospective study was to radiographically evaluate panoramic radiographs (PAN) from a dental practice in Linz/Austria, regarding to the occurrence of taurodontism and pyramidalism. The PAN images were captured during dental treatments using a Sirona Orthophos XG X-ray unit. The "Softdent" management program was utilized, applying various filters to select ekigible patients based on the inclusion and exclusion criteria (Table 1). Out of the prefiltered images, 1280 PANs were reviewed, but 280 had to be excluded due to various criteria (see below), such as poor quality or insufficiently assessable teeth. Among the 1,000 patients in the study, 449 were male (44.9%) and 551 were female (55.1%).

Table 1 Overview of the inclusion and exclusion criteria of taurodont teeth in the study.

Inclusion criteria:
• Patients who received a PAN during their treatment in the dental practice • Patients aged between 15-50 years old • All molars in maxilla and mandible • Teeth that were meso- or hypertaurodont according to the classification of Shifman and Chanannel (21) • Patients with at least 4 evaluable molars • Creation of the PAN's between 2016-2018
Exclusion criteria:
• Poor quality of the PANs • Unerupted third molars • Not completed root growth • Fractured or endodontically treated teeth • Teeth in which it was not possible to evaluate the pulp cavity due to restorative treatments • Teeth that are considered hypotaurodont according to the classification of Shifman and Chanannel (21)

The average age of the subjects studied was 35 years. The inclusion criterion was a minimum number of four molars, which was fulfilled by 1.6% of the participants studied. The majority of patients (36.7%) had a minimum of eight molars, and all 12 molars could be evaluated in 12.4%. The PAN images were evaluated using the Sidexis program. Statistical analysis was performed involving the chi-square test and Yates' chi-square test. The programs used were SPSS 24.0 and the calculator for chi-square test provided by quantpsy.org.

In general, there are various classifications and methods for evaluating taurodontism (21,55–58), which have been developed over time since Shaw's initial classification in 1928. In the presented study, the authors used the classification by Shifman and Chanannel (21) to evaluate taurodontism. However, due to stricter quality specifications, the assessment of hypotaurodontism was excluded and only meso- and hypertaurodontism were evaluated. It is noteworthy that numerous authors have reported very high prevalences of hypotaurodontism and at the same time the differentiation of cynodont and hypotaurodont teeth has been presented as problematic.
To assess whether hypo-, meso-, or hypertaurodontism is present, Shifman and Chanannel (21) used the following parameters: Point A represents the lowest point of the pulp chamber roof, Point B indicates the highest point of the pulp chamber floor, ECJ characterizes the enamel-cementum junction, and the apex of the longest root seves as the lowest measurement point (Figure 3). The classification as taurodont is based on the so-called "taurodontism index" (TI). This is calculated by measuring the distance from A to B, dividing it by the distance from A to the apex of the longest root and multiplying it by 100. The obtained value must be equal to or greater than 20. Additionally, the distance from B to the ECJ must be greater than or equal to 2.5mm. According to the authors, these criteria lead to the following classifications for the three specific forms of taurodontism: hypotaurodont (20-29.9%), mesotaurodont (30-39.9%), hypertaurodont (40-75%).
The methodical approach for recording pyramidalism in this study adheres to the recommendations of Schulze (59) and evaluates only the types A and B (cf. Figure 2) according to Brabant and Kovacs (50), which can be diagnosed with relatively reliably in the radiograph.

Results

The prevalence for taurodontism generated from the total data set was 5.9% (59 subjects). Among the total 8,625 molars assessed, 119 teeth were classified as taurodont, resulting in a prevalence of 1.4%. Specifically, the mandible was affected in nine cases (0.9%), while the maxilla was affected in 56 cases (5.6%) (Table 2). Among the 59 patients diagnosed with this anomaly, three cases (5.1%) were found to be isolated in the mandible and 50 cases (84.7%) in the maxilla; in six individuals, taurodont teeth were found in both the maxilla and the mandible (10.2%). Thus, taurodontism occurred significantly (p=0.000) more frequently in the maxilla than in the mandible.
Of the three molars on each side of the jaw, it was observed that the 2nd molars were most commonly affected in the maxilla, followed by the 1st molars, while the 3rd molars were least frequently affected. The frequency of taurodontism diagnosed in the maxilla was 2.3% for a singular tooth, 2% for two teeth, 0.8% for three teeth, 0.4% for four teeth, and 0.1% for five teeth. No taurodont 1st molars were diagnosed in

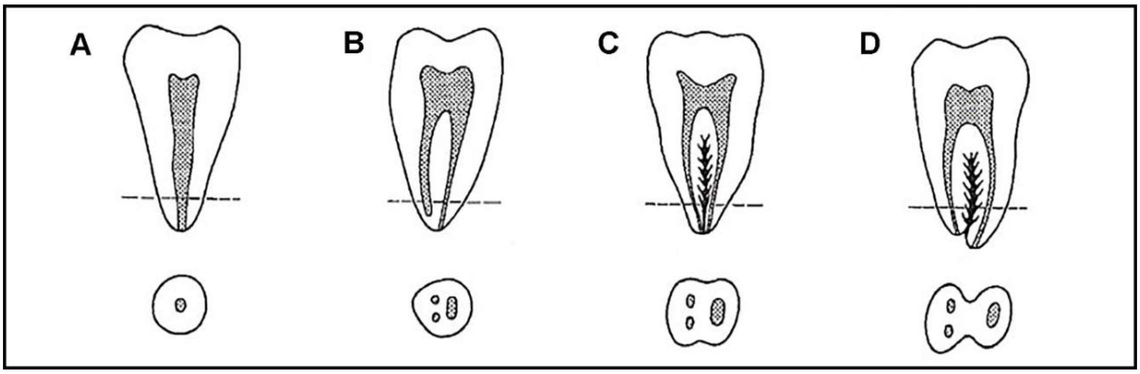

Figure 2 Classification of pyramidal rootstocks on lower molars according to Brabant and Kovacs (50). A: uniform conical rootstock with single-piece pulp cavum; B: similar to type A, but with subdivided pulp cavum, two root canals in the mesial root section, three in the distal; C: pyramidal rootstock with longitudinal furrows that still reveal the two-rooted "blueprint", three root canals as in type B; D: Longitudinal furrows are deeper compared to type C, causing the corticalis of the socket to protrude into the longitudinal furrow, resembling a septum interradicular.

the mandible. Similar to the maxilla, the most frequent occurrence of taurodontism in the mandible mainly affected the 2nd molars. Additionally, as in the maxilla, the anomaly in the mandible was often limited to a single molar, followed by two or more affected molars.
Regarding biological sex, 22 males (4.8%) and 34 females (6.2%) had taurodont teeth in the maxilla (Table 2). The prevalence of taurodontism in the mandible was 0.4% for males (n=2) and 1.5% for females (n=7). Thus, the maxilla was most commonly affected by taurodontism in both sexes. The combined occurrence of the anomaly in both the maxilla and mandible was significantly lower. This involved five females and one male. The differences between the sexes were not statistically significant.
When differentiating between mesotaurodontism and hypertaurodontism (Table 2), a significantly higher prevalence was found for mesotaurodontism (n=43; 4.3%) compared to hypertaurodontism (n=8; 0.8%) (p=0.000). Out of the total 119 taurodont molars, 99 were identified as mesotaurodont (83.2%) and 20 as hypertaurodont (16.8%). In eight cases, a combination of mesotaurodontism and hypertaurodontism was observed (0.8%). Again, no statistically significant differences were found between the sexes.

Among the 1,000 reviewed radiographs, a prevalence of 28.1% for pyramidalism was identified. Out of the total of 8,625 molars, 674 (7.8%) were classified as pyramidal. Among the 281 affected patients, pyramidalism occurred in 183 females (33.2%) and 98 males (21.8%) (Table 3), with 24 of them also exhibiting taurodontism. In terms of location, pyramidalism was detected a total of 254 times in the maxilla (25.4%) and 107 times in the mandible (10.7%). Among the affected patients, the root anomaly of pyramidalism was isolated in the maxilla in 174 subjects and in the mandible in 27 subjects. In 80 subjects, pyramidal teeth were found in both the maxilla and the mandible.
In the maxilla, pyramidalism most frequently affected the wisdom teeth, followed by the 2nd molars. When pyramidalism was diagnosed in the maxilla, it often occurred bilaterally. In the mandible, the 2nd molars were most commonly affected by pyramidalism, followed by the 3rd molars. Among the 1,000 patients, only four cases of pyramidal roots were observed in the 1st molars and all of them were located in the mandible. The occurrence of pyramidalism in both jaws involved 19 males (4.2%) and 61 females (11.1%). Pyramidalism was significantly more common in females than in males in both the maxilla (p=0.000) and the mandible (p=0.000).

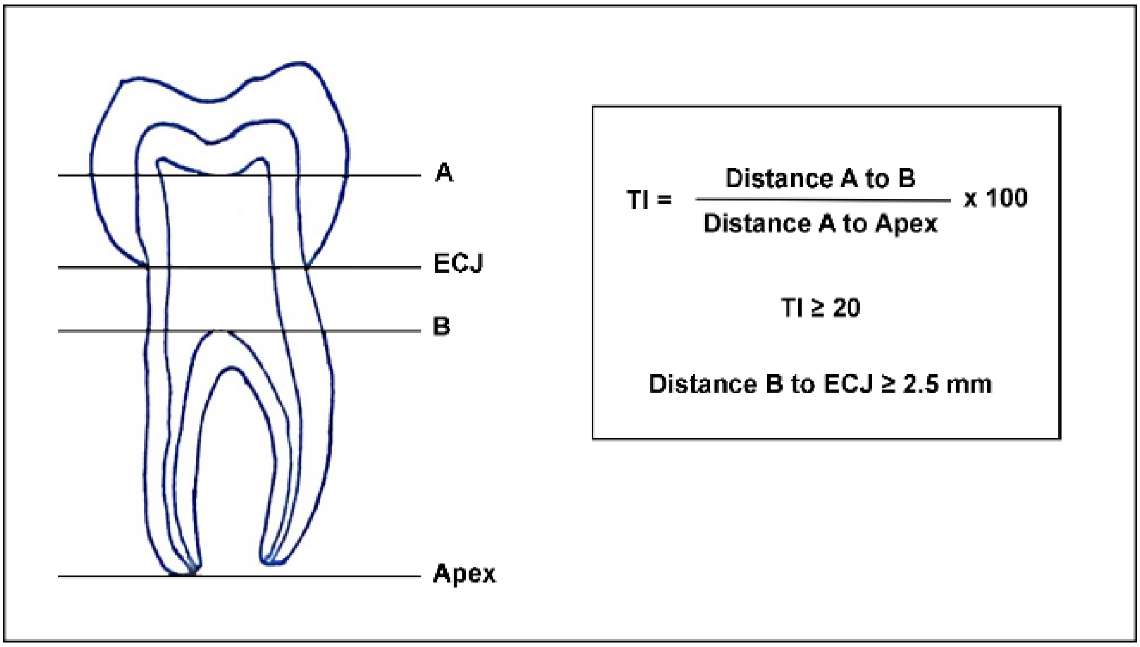

Figure 3 Measured distances and formulas for quantifying taurodontism according to Shifman and Chanannel (21): TI=taurodontism index, further measured values in the text (© M. Wiesinger).

Regarding the multiple occurrences of the anomaly, two molars were most frequently affected (12.6%), followed by singular occurrence (8.4%). Significantly less frequently, three (2.1%), four (1.8%), or five (0.5%) molars were affected. Multiple occurrences of pyramidal teeth were also significantly more common in females compared to males (mandible: p=0.001, maxilla: p=0.004).

Table 2 Prevalence of taurodontism by jaw, males (M) and females (F), and subdivided in mesotaurodont (Meso) and hypertaurodont (Hyper). Significant p-values are marked in bold.

Jaw	M N (%)	F N (%)	Chi² p-value	Total N (%)	Chi² p-value
Maxilla	22 (4.8)	34 (6.2)	0.385	56 (5.6)	**0.000**
Mandible	2 (0.4)	7 (1.5)	0.300*	9 (0.9)	
Maxilla + Mandible	1 (0.2)	5 (0.9)	---	6 (0.6)	---
Grade of expression					
Meso	14 (3.1)	29 (5.3)	0.096	43 (4.3)	**0.000**
Hyper	4 (0.9)	4 (0.7)	0.930*	8 (0.8)	
Meso + Hyper	5 (1.1)	3 (0.5)	0.517*	8 (0.8)	---
Total ind	23/449 (5.1)	36/551 (6.5)	0.346	59/1000 (5.9)	---

*Yates' chi-square test

Table 3 Prevalence of pyramidalism by jaw and males (M) and females (F). Significant p-values are marked in bold.

Jaw	M N (%)	F N (%)	Chi² p-value	Total N (%)	Chi² p-value
Maxilla	90 (20.0)	164 (29.8)	**0.000**	254 (25.4)	**0.000**
Mandible	27 (6.0)	80 (14.5)	**0.000**	107 (10.7)	
Maxilla + Mandible	19 (4.2)	61 (11.1)	---	80 (8.0)	---
Total ind	98/449 (21.8)	183/551 (33.2)	**0.000**	281/1000 (28.1)	---

Discussion

Assessing the characteristics and comparability of studies on taurodontism poses certain challenges. First of all, one important consideration is that radiological PAN image do not provide an exact representation of tooth size, which can lead to bias. Furthermore, a PAN image of the maxilla provides little information about the precise position of the pulp chamber with respect to the 3rd root. To be able to obtain accurate calculations and valid values, 3D images of the teeth would be crucial. In practice, a molar may appear pyramidal on a radiograph with only one rootstock visible, but upon extraction, it may be clearly identified as hypertaurodont. While the assumption that pyramidalism is the most severe form of taurodontism appears reasonable (59), this particular aspect has not been thoroughly discussed in more recent studies.

All metric methods for diagnosing the degree of expression of taurodontism are similar in principle (21,55–58) but the value of the measured distances is judged differently (60). For example, one limitation of the measurement methods is that the landmarks represent biologically variable structures (18). This adds complexity to the comparability of studies, as various inclusion and exclusion criteria are applied (e.g., exclusion of wisdom teeth, inclusion of premolars). It has been suggested that the variability in prevalence rates among individual studies is partially attributed to the diverse selection criteria, as well as the utilization of specific measurement techniques and evaluation criteria. To minimize subjectivity in assessing the smooth transitions between the normal, cynodont tooth type and taurodont forms, it was originally proposed to quantify the extent of pulpal displacement by measuring certain parameters on the radiograph (21,56). The classification of Shaw (15) had proven to be of little use in differentiating cynodont from hypotaurodont.

Another source of error relates to the recognition of the enamel-cementum junction, which affected the diagnosis of weak feature expressions. In quantitative classifications, where the enamel-cementum junction is always a variable, it is often appearing indistinct in the radiographs and cannot be accurately represented. As a result, it has been recommended numerous times in dental anthropological studies to focus only on recording meso- and hypertaurodontism (60). This raises the question of whether measuring teeth is advantageous compared to estimating them. Detecting meso- and hypertaurodontism would not require calculations, and even if hypotaurodontism were to be "calculated," the result would always remain vague. In this context, it is worth mentioning the criticism by Gupta and Saxena (16) that "normal" cynodont pulps are often misdiagnosed as hypotaurodont, which could explain the high prevalences that exist for

hypotaurodontism. Additionally, it is essential to acknowledge that measured values obtained from the evaluation of PAN images may be subject to errors arising from variations in x-ray acquisition angles (59).
When examining the prevalence of taurodontism, international studies reveal significant variations in occurrence (21,22,24,25,61-63). The variation in the prevalence of taurodontism ranges from very low percentages below <1 to 5% to values between 30-50% (Table 4). Very low frequencies were observed in northern India with 0.4% (24) and 2.8% (64), as well as in Germany with 2.25% (63) and the USA with 2.5% (56). Moderate frequencies ranging from 5% to 15% were found in Israel with 5.6% (21), Austria with 5.9% (this study), Jordan with 8.0% (23), Turkey with 11,3% (65), Saudi Arabia with 11.3% (61) and in Germany with 12.5% (53). High frequencies were reported in Israel with 33.6% (66), Iran with 22.9% (67), and in China with 46.4% (22). Upon closer examination of individual studies, a notable pattern emerges. Almost all studies examined showed all three forms of taurodontism, with hypotaurodontism, the weakest form of expression, being the most challenging to diagnose and frequently appearing as the majority of cases. If, as suggested, hypotaurodontism were excluded from the evaluation, the prevalence (based on meso- and hyertaurodontism) would be significantly lower in all studies.
Since only reliably diagnosed meso- and hypertaurodont molars were recorded in the presented study, both the determined prevalence of 5.9%, based on the number of subjects examined, and the prevalence of 1.4% among the 8,625 molars recorded cannot be directly compared with corresponding prevalences in other studies. If hypotaurodontism is taken into account, the percentage of affected subjects in our study would likely be significantly higher, if the results for hypotaurodont molars from other studies are used as a benchmark (Patil et al. (24) 75%; Darijani et al. (68): > 90). Regarding the relative distribution of taurodontism between both sexes, a slightly higher prevalence is observed in females in the current study. This trend of higher taurodontism prevalence in females is supported by all reviewed studies except two publications from India (24,64). Upon reviewing the study designs from India, it seems possible that the underrepresentation of women in the samples could explain the discrepancy.
There is a consistent trend in the distribution of taurodontism between the maxilla and mandible. Except for one study (21), all the studies reviewed concluded that the maxilla is more frequently affected by taurodontism compared to the mandible. In our study, the distribution favoring the maxilla was higher than the average. Only three subjects exhibited taurodont molars exclusively in the mandible, while 50 subjects showed taurodont molars in the maxilla, and six subjects exhibited taurodont molars in both the maxilla and mandible. This distinction was not as clear in any of the other studies, possibly because they did not take hypotaurodontism into account. Furthermore, it is worth noting that out of the 59 patients diagnosed with taurodontism, 24 of them also exhibited pyramidal molars. Conversely, among the 281 patients affected by pyramidalism, only 24 showed taurodontism. These results suggest that although pyramidalism is common in patients with taurodontism, both anomalies occur independently and the co-occurrence cannot be considered pathognomonic (59).
Since knowledge of taurodontism is undoubtedly of clinical significance it should be discussed in detail. Due to the extended pulp, there is a highly increased risk of pulp exposure during numerous dental procedures (47). Endodontically, taurodont teeth challenges due to variations in the pulp chamber shape, size and configuration of the root canals. The presence of far apically located root canal entrances and additional canals complicates endodontic treatments (69). According to Jafarzadeh et al. (44), frequent occurrence of pulp stones in taurodontism complicates root canal procedures. The complex root canal anatomy makes sufficient root filling difficult (70). Sodium hypochlorite (2.5%) is recommended initially for pulp tissue removal in taurodonat teeth (71). In case of hypertaurodontism, a vital pulpotomy should be considered instead of a standard pulpectomy (21,44). Furthermore, the restoration of taurodont teeth after endodontic treatment poses challenges due to significant loss of tooth structure resulting from the unique pulp anatomy (72).
Due to the thin and often short roots of taurodont teeth, there is an increased risk of fractures during extractions. Conventional extraction forceps designed for molars are not suitable for taurodont teeth because the furcation is displaced too far apically. Therefore, rotational movements during extraction are not recommended (72). However, the extraction of taurodont teeth may be relatively easy as long as the roots do not diverge extensively (69). From a

periodontological perspective, taurodont teeth sometimes allow a more favorable prognosis. The apical placement of furcations in taurodont teeth results in a lower risk of furcation involvement in periodontal pockets and gingival recession, reducing the need for extensive destruction of the periodontium (70). During orthodontic treatment with fixed appliances, the short roots of taurodont teeth may be prone to root resorption (69). Therefore, a careful risk-benefit analysis must be conducted before initationg treatment (73). Finally, it is important to note that no long-term follow-up studies on the treatment of taurodontism have been published to date (73).

Conclusion

In conclusion, the current research situation on taurodontism is still insufficient. Given the high prevalence and clinical relevance of the anomaly, further research is strongly recommended. However, to ensure higher quality and better comparability of studies, it is imperative to adhere to international standards in study design, classification, measurement technique and evaluation (58). For instance, in cases of very high prevalences of taurodontism, it is important to consider whether sample composition using the selection criteria (including social, ethnic, geographical factors) may be responsible for the wide variability in the reported prevalence rates worldwide.

Declaration of Interest

None

Author Contributions

KWA and MW conceived the study; MW and NN finalised figures and tables; all authors wrote and revised the manuscript and provided final approval before submission.

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Table 4 Frequency of taurodontism in accessible studies from recent populations worldwide. The lack of international standardization or a best-practice guide prevents comparability of available research data on the root anomaly. Highly variable study designs, data quality of studies, and the lack of publicly available databases currently make it difficult to draw representative, epidemiologically relevant conclusions about the frequency and significance of taurodontism. The degree of severity A, B, and C represent hypo-, meso-, and hypertaurodontism. The bold assignment indicates which type was observed most frequently. The additional asterisk indicates that hypotaurodontism far outweighs the other two types; *Prevalence between white, brown, and black Brazilian subjects was relatively similar.

Study	**Population**	**N=probands MOL=molars**	**Prevalence% for N / Mol**	**Localisation Max vs Mand**	**Sex affected**	**Typ Taurodontism A, B, C observed molars**
This study 2023	Austria	1000 (m < f) 8625	5.9 1.4	Max > Mand	Female > Male	**B**, C all molars
Bürklein et al. 2011	Germany	800 4885	2.25 0.61	Max ≅ Mand	Female > Male	A, B, C all molars
Hofmann 1985	Germany	1078 8113	12.5 5.3	Max > Mand	Female > Male	**A***, B, C all molars
Pedreira et al. 2016	Brazilian mixed population*	562	4.98	Max > Mand	n.a. all dental anomalies f > m	n.a.
Porto et al. 2009	Brazilian	72 1300	5.3 8.3	Max > Mand	Male ≅ Female	**A***, B, C all molars
Gonçalves Filho et al. 2014	Brazilian mixed population	487	27.2	n.a.	Female > Male	n.a n.a.
Ruprecht et al. 1987	Saudi Arabian	1581 (m > f) 1647	11.3 43.2	n.a	Female ≅ Male	A, B, C all molars
Darwazeh et al. 1998	Jordania	875 (m > f) 2636	8.0 4.4	Max > Mand	Female > Male	A, B, C all molars
Colak et al. 2013	Turkey	6,912 97362	0.26 0.024	Mand > Max	Female ≅ Male	n.a. all posterior teeth
Bilge et al. 2018	Turkey	1000 (m < f)	11,27	n.a.	n.a.	n.a
Shifman/ Chanannel 1978	Israel	1200 10204	5.6 1.5	Mand > Max	Female > Male	A, B, C all molars
Einy et al. 2021	Israel	624 2849	33.6 11.5	Max > Mand	Female > Male	**A***, B, C only M1, M2
Shokri et al. 2014	Iranian	1649 (m < f)	3.34	Max > Mand	Female > Male	n.a. all teeth
Darijani et al. 2022	Iranian	424	7.78	Max > Mand	Female > Male	**A**, B, C
Bharti et al. 2015	Indian	1000 7615	2.8 0.53	Max > Mand	Male > Female	n.a. all molars
Patil et al. 2013	Indian	4143 19146	0.4 0.17	Max > Mand	Female ≅ Male	**A***, B, C all posterior teeth
MacDonald-Jankowski/Li 1993	China	196 1093	46.4 21.7	Max > Mand	Female > Male	n.a. n.a.

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