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Occlusal Morphology of Mandibular First Primary Molars in a Sample of Egyptian Children: A Cross-Sectional Study

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Abstract

Background: The occlusal morphology of primary teeth plays a crucial role in dental development, masticatory function, and long-term occlusal stability. Despite extensive documentation of morphological variations across populations, limited data exist on Egyptian children. This study aimed to investigate the occlusal morphological features of mandibular first primary molars in a sample of Egyptian children, addressing a critical gap in anthropological and clinical dental research.

Methods: A cross-sectional study was conducted on 150 dental casts obtained from Egyptian children visiting the clinics of Department of Pedodontics Faculty of Dentistry of October University for Modern Sciences and Arts. Standardized alginate impressions were poured in Type III dental stone and evaluated by three calibrated examiners. Key occlusal features: cusp number, groove configuration (Y-shaped or H-shaped), and outline morphology (oval, rhomboidal, or heart-shaped) were assessed. Statistical analysis was performed using SPSS 20®, with frequency distributions and chi-square tests for comparisons.

Results: The most prevalent morphology was a 3-cusp arrangement with Y-shaped grooves (40.0%), followed by 4-cusps with H-shaped grooves (33.3%). Oval occlusal outlines predominate (50.0%), with rhomboidal (33.3%) and heart-shaped (16.7%) forms being less common. Significant differences were observed between occlusal outline shapes ($p < 0.0001$). The findings align partially with global trends but reveal distinct population-specific patterns, particularly the high prevalence of Y-shaped grooves and oval outlines

Conclusion: This study provides the first comprehensive analysis of mandibular first primary molar morphology in a sample of Egyptian children, highlighting unique traits with implications for clinical dentistry and anthropological research.

1 Introduction

The occlusal morphology of primary teeth represents a critical factor influencing dental development, masticatory efficiency, and long-term occlusal stability [1]. Of particular interest are mandibular first primary molars, which demonstrate unique anatomical characteristics that significantly affect occlusal relationships and caries predisposition. [2] While these morphological features have been well-documented in various populations, a notable research gap exists regarding Egyptian children, despite the recognized influence of ethnic and geographic factors on dental morphology. [3,4]

Contemporary research has demonstrated significant ethnic and geographic variations in primary molar morphology. Studies comparing global populations

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reveal distinct patterns, with Southeast Asian children showing a higher frequency of deflecting wrinkles and accessory ridges on occlusal surfaces compared to Caucasian populations [3]. These morphological differences underline the necessity for population-specific dental databases to inform both clinical practice and anthropological understanding [4]. In Egypt specifically, where unique genetic admixtures [5] may influence odontogenesis, the absence of detailed morphological data for primary dentition creates a critical knowledge gap. This deficiency is particularly noteworthy given evidence that Egyptian permanent dentition exhibits distinctive trait combinations [6], suggesting primary teeth may similarly demonstrate population-specific characteristics requiring documentation.

The clinical implications of occlusal morphology are particularly noteworthy. Specific features including groove patterns, cusp configuration, and fissure depth directly correlate with caries susceptibility and affect the success of preventive interventions such as sealant application [7]. Moreover, atypical morphological presentations may pose challenges for restorative procedures and early orthodontic management [8].

This cross-sectional study was therefore designed to systematically evaluate the occlusal morphology of mandibular first primary molars in Egyptian children aged 4-7 years. The investigation aims to establish population-specific morphological data. The resulting findings will serve dual purposes: providing clinically relevant information for pediatric dental practice in Egypt, while simultaneously contributing to the global understanding of dental morphological diversity in primary dentition.

2 Material and Methods

2.1 Ethical Approval

The method employed in this study was approved by the research ethical committee (Faculty of Dentistry - MSA University). The research was granted confirmation of conductance number (REC-D11194-5).

2.2 Sample size

This cross-sectional study examined 150 dental casts from a sample of Egyptian children aged 4-7 years attending the Pediatric Dentistry Department at MSA University, Cairo. The sample size was determined through power analysis based on previous morphological study by Alsakhawy et al. [9], with calculations performed using EPI INFO version 7.2.5.0 (CDC, Atlanta).

Using Alsakhawy et al.'s [9] reported 94% prevalence of rhomboidal occlusal shape, we calculated a minimum requirement of 106 specimens (97% CI, 5% margin of error), ultimately collecting 150 casts to ensure robust analysis.

The sample size (n=150) exceeded the minimum requirement (n=106) calculated via power analysis, enhancing statistical reliability. This method ensured a representative sample of Egyptian children with intact, morphologically assessable primary molars while minimizing selection bias through standardized eligibility checks.

2.3 Sample Duration

The study was completed over nine months, with patient recruitment (two months), cast fabrication and evaluation (five months), and data analysis (two months).

2.4 Samples Selection

The study utilized a convenience sampling approach with strict inclusion criteria to select participants. This sampling method was practical for a clinical setting, ensuring efficient data collection while maintaining scientific rigor through strict inclusion/exclusion criteria.

Inclusion Criteria

Children aged 4–7 years visiting the Pediatric Dentistry Department at MSA University, were screened for eligibility based on the following protocol:

Initial Screening

Parents/guardians of children in the target age group (4–7 years) were informed about the study during routine dental visits.

Willing participants were clinically examined for: Fully erupted, caries-free mandibular first primary molars this was confirmed via visual/tactile examination and radiographs if needed.

No prior orthodontic treatment or extensive occlusal wear.

Informed Consent

Parents/guardians of eligible children provided written informed consent before inclusion.

Final Selection

A total of 150 children meeting all criteria were enrolled consecutively until the sample size was reached.

Exclusion Criteria:

Children with uncooperative behavior (preventing proper alginate impressions) or incomplete records were omitted also Children with caries, developmental anomalies.

2.5 Cast Preparation

Metal stock trays were used with alginate impression material, all casts were poured within 30 minutes of impression taking, Water/powder ratio was 0.26 room, mixing was done at room temperature by applying

distilled water and powder in a bowl, waiting for 1.5 minutes, and then spatulated for 30 seconds with a metal spatula. Casts were separated from the molds after a waiting time of 1 hour for setting [14]. casts were stored at 100% relative humidity for 24 hours prior to evaluation[15].

2.6 Assessment Technique

According to Jordan *et al.,* [10] the cusp was considered as a pronounced elevation on the occlusal surface of the tooth terminating in a conical, rounded or flat surface. After that, the occlusal pattern of each molar was classified according to the standards of morphological variants of permanent teeth [11]. This was determined after marking the developmental grooves using non-permanent markers.

2.7 Examiner Calibration

2.7.1 Calibration training phase for 4-weeks preceded the study, involving:

Theoretical training: Review of Jordan et al.'s cusp criteria [10] and standardized groove marking techniques using reference atlas images [11].

Practical sessions: Dual evaluation of 50 non-study casts to refine feature identification

2.7.2 Calibration Phase during the study

Three calibrated examiners independently evaluated 150 dental casts fabricated from alginate impressions using Type III dental stone (Elite Rock, Zhermack)[12,13].

Examiners assessed three key occlusal features: number of cusps, Groove configurations (Y-shaped or H-shaped) and Occlusal outline morphology [16].

2.7.3 Recalibration phase

Twenty percent of casts (n=30) were randomly selected for re-evaluation after two weeks to assess intra-examiner reliability, Inter-examiner calibration was confirmed through consensus evaluation of 15 training casts prior to study commencement [17].

2.8 Statistical Analysis

Statistical analysis was performed with SPSS 20®, Graph Pad Prism® and Microsoft Excel 2016. All data were presented as frequency and percentages. Comparison between different classes was performed by using Chi square test.

3 Results

3.1 Cups number and groove pattern in mandibular first primary molar

The cusp numbers and groove patterns in mandibular first primary molars were presented in **Table 1** and **(Fig. 1)**.

Table 1. cusp number and groove pattern in mandibular first primary molar

Criteria	Number of teeth	Percentage	P value
3 cusps – H shaped	25	16.67 [a]	<0.0001*
4 cusps – H shaped	50	33.33 [b]	
3 cusps – Y shaped	63	42.00 [b]	
4 cusps - Y shaped	12	8.00 [c]	

*Significant difference as p ≤ o.o5.

Percentages with different superscript letters were significantly different as p ≤ o.o5.

Percentages with the same superscript letters were insignificantly different as p > o.o5.

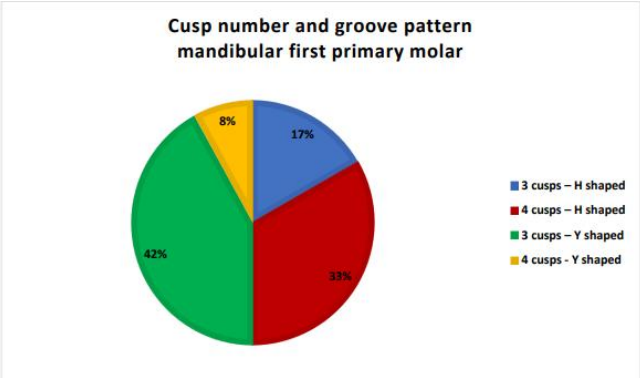

Figure 1. pie chart representing distribution of different cusp number and groove pattern in mandibular first primary molar

The total sample size is 150 teeth. The table presents a distribution of tooth morphology among four different categories. The p-value is <0.0001, which indicates a statistically significant difference between these groups as the most common cusp number and groove pattern is three cusps with Y-shaped groove pattern (63 teeth), its percentage is 40.00 % **(Fig. 2 A)** with insignificant difference with four cusps with H-shaped groove pattern (50 teeth), its percentage is 33.33 % **(Fig. 2 B).** Followed by three cusps with H-shaped groove pattern (25 teeth), its percentage is 16.67 % **(Fig. 2 C)**. On the other hand, the least common cusp number and groove pattern are four cusps with Y-shaped groove pattern (12 teeth), its percentage is 8.00 % **(Fig. 2 D)**.

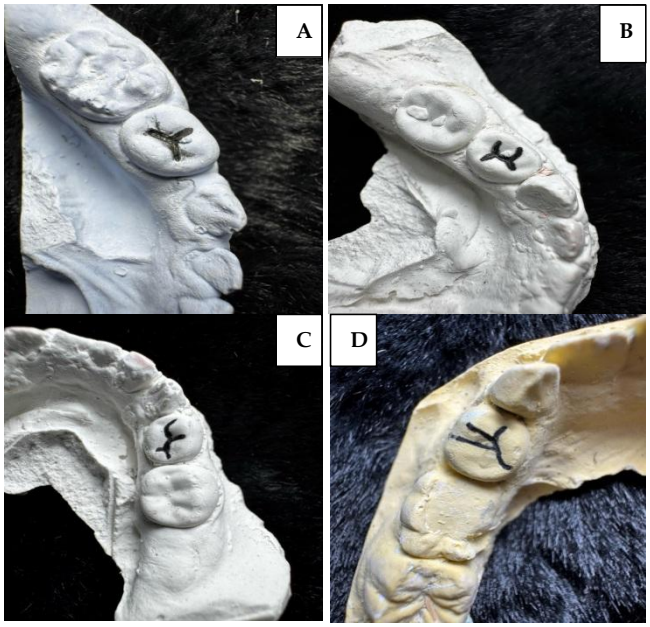

Figure 2. A photograph of a study cast showing mandibular primary first molar with 3 cusps and Y groove pattern occlusal morphology (A), mandibular primary first molar with 4 cusps and H groove pattern occlusal morphology (B), mandibular primary first molar with 3 cusps and H groove pattern occlusal morphology (C), mandibular primary first molar with 4 cusps and Y groove pattern occlusal morphology (D)

3.2 Occlusal different outlines

The distribution of different occlusal shapes among samples was presented in **Table 2** and **(Fig. 3)**. Comparison between different outlines was performed and revealed that there was a statistically significant difference between these outlines (P<0.0001) as the most common outline is oval shape (75 primary molars) its percentage is 50%, then rhomboidal shape (50 molars) with 33.33% percentage, while heart-shaped (25 primary molars) was significantly the least common outline its percentage is 16.67%.

Table 2. Occlusal different outlines distribution in mandibular first primary molar.

Shape of the occlusal surface	Number of Primary molars	Percentage	P value
Rhomboidal	50	33.33 [a]	<0.0001*
Heart shaped	25	16.67 [b]	
Oval	75	50.00 [c]	

*Significant difference as $p \leq 0.05$.

Percentages with different superscript letters were significantly different as $p \leq 0.05$.

Percentages with the same superscript letters were insignificantly different as $p > 0.05$.

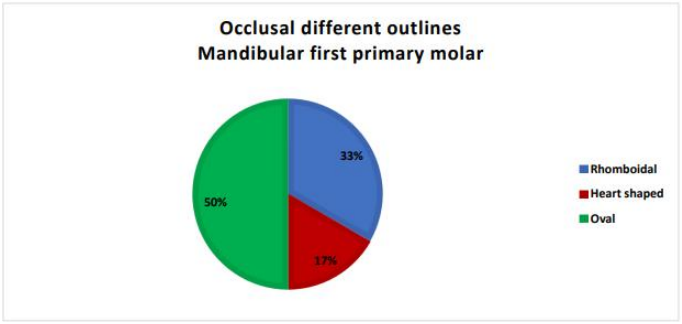

Figure 3. The pie chart represents the distribution of occlusal outlines in mandibular first primary molar

4.Discussion:

The diverse physical traits of human dentition can be used as a diagnostic tool in anthropological research to classify and characterize different ethnic groups. Occlusal morphology is essential for both efficient chewing and overall tooth health. Variations in morphology can have an impact on occlusal relationships, dental caries development, and the effectiveness of restorative therapies.[2]

Significantly, the arrangement of occlusal grooves and fissures is a developmental characteristic that is distinct from cusp number and is mediated by polygenic inheritance patterns mediated by multiple genetic loci. [18] Tooth development is a multi-stage, complex process that is regulated by intricate molecular and cellular interactions. Genetic predisposition, epigenetic modifications, and environmental exposures are some of the factors that influence this process. [19]

Several studies have demonstrated that various populations have different anatomical patterns in their primary and permanent dentitions. This is because of several factors, such as racial, cultural, and environmental ones, have an impact [20,21]. Alsakhawy *et al*.[9] and Alaa Medhat *et al*.[22] investigated the morphological characteristics of permanent teeth in Egyptian population, Alsakhawy *et al*. [9] investigated the number of cusps and groove patterns in maxillary molars of the Egyptian population. Alaa Medhat *et al*. [22] studied the occlusal morphology of premolars.

This study provides the first comprehensive analysis of occlusal morphology in mandibular first primary molars among Egyptian children aged 4-7 years. Our study focused specifically on the mandibular first primary molar for several key reasons. This tooth demonstrates the greatest morphological variation within the primary dentition, presenting multiple cusp arrangements (typically 3-4 cusps) and distinct groove patterns (Y-shaped, H-shaped forms). Its position in the dental arch and early eruption timing makes it particularly susceptible to caries and occlusal wear, necessitating a thorough understanding of its anatomical characteristics.

This study's age range was selected for a

variety of reasons. Usually erupting between 14 and 18 months, the mandibular first primary molar continues to function until it is exfoliated, which occurs between 9 and 11 years of age. These molars fully erupted by the time they are 4–7 years old, which eliminates the need for advanced exfoliation or incomplete eruption to impede an accurate occlusal assessment. [23] Compared to younger toddlers, children between the ages of 4 and 7 are typically more cooperative for intraoral exams and alginate impressions. [24] Finally, to standardize comparisons of primary molar characteristics, earlier morphological studies concentrated on the same age ranges. [25]

Although there are other ways to compare morphological differences, the analysis of study casts was chosen for this investigation because of its benefits for precise recording and correct tooth identification. Felembam et al and Alsakhawy et al. [9] also preferred to study using this approach. [9,26]Direct intraoral inspection was preferred in certain trials. [27,28] While Phulari et al have combined the two approaches. [29]

The examination of 150 mandibular first primary molars in the present study revealed significant findings regarding cusp-groove configurations and occlusal outline forms. The most prevalent morphology combination was the 3-cusp arrangement with Y-shaped groove pattern, observed in 63 teeth. This was closely followed by 4-cusp teeth exhibiting H-shaped grooves, found in 50 specimens. Statistical analysis showed no significant difference in prevalence between these two dominant patterns ($p > 0.05$). Less common combinations included 3-cusp/H-shaped morphology (25 teeth,) and the relatively rare 4-cusp/Y-shaped configuration, which accounted for only 12 teeth in our sample.

Regarding occlusal outline shapes, oval forms predominated, appearing in 75 molars. Rhomboidal outlines represented the second most frequent morphology (50 teeth, while heart-shaped outlines were significantly less common (25 teeth; $p < 0.01$).

The Y-shaped groove pattern observed as most prevalent in our study is consistent with findings from multiple international studies examining primary molar morphology. Research across different populations has consistently identified this pattern as dominant, though with varying prevalence rates that most likely reflect population-specific characteristics [29].

Pradhan *et al.* [29] found Y-groove patterns in 61.05% of left mandibular first molars and 55.77% of right molars in their examination of 303 Nepali children. Other Indian studies have documented prevalence rates ranging from 50.36% to 73.34% in different populations [16,30-32]. This consistency across geographically diverse samples suggests the Y-groove configuration represents a fundamental morphological feature in primary molars.

The development of these groove patterns appears to be genetically determined through complex polygenic mechanisms. Unlike cusp number, which follows more straightforward inheritance patterns, fissure configuration results from interactions between multiple genetic loci. [31] This genetic complexity likely accounts for the observed variations in prevalence across different populations while maintaining the overall predominance of Y-shaped patterns.

The cusp morphology observed in our study contrasts significantly with findings from several international studies. Tsai [33] in their examination of 144 Taiwanese children, developed a detailed six-type classification system for primary first molars: Type A-C: Various 4-cusp configurations; Type D-E: 5-cusp variants; Type F: 3-cusp form. Their investigation revealed that 93% of primary mandibular first molars have four cusps (Types A, B, and C), 5% have five cusps (Types D and E), and 2% have three cusps (Type F).

This distribution differs markedly from our Egyptian sample, where 3-cusp arrangements predominated. Similar variations appear in other studies Poornima et al.[34] documented a rare triangular 5-cusp configuration of the first mandibular primary molar in Indian children. Pradhan et al. [28] reported that 4-cusp patterns were found in 65.02% of cases, while 5-cusp forms were found in 34.98% of left molars and 34.32% of right molars.

More extreme variations appear in studies by Ahsana *et al*.[16] and Felemban *et al*.[26]. Ahsana *et al.* [16] in their study, reported a predominance of 5-cusp patterns in 96.4% of the population. Similarly, the prevalence status of a 5-cusp pattern was reported by Felemban et al. [26]. This difference could be due to the selection of different teeth in these conducted studies, as few of the studies have considered primary first molars.

This study has some limitations, including the use of a convenience sample from a single university clinic in Cairo, which may restrict the generalizability of findings to the broader Egyptian population. While reliance on dental casts rather than direct intraoral examination or advanced imaging (e.g., 3D scans) may have overlooked subtle morphological variations. Despite examiner calibration, subjective interpretation of occlusal features could introduce bias, and the exclusion of caries-affected or restored molars may have skewed results toward idealized anatomy. Finally, the study did not account for regional, genetic, or environmental influences, which could further explain observed variations. Future multicenter studies incorporating digital imaging and genetic analysis are needed to address these gaps.

5 Conclusion:

This study establishes baseline data for occlusal morphology of mandibular first primary molars in Egyptian children, revealing both shared traits and unique characteristics compared to other populations. The findings highlight the need for population-specific dental approaches while contributing valuable information to anthropological understanding of dental variation. Further multicenter studies across Egypt's geographic regions would help clarify potential sub-population variations

Authors' Contributions:

Samah Kamel made a substantial contribution to the Study idea, data interpretation, data analysis, manuscript drafting and guidance in research study through her supervision. Lougine Mostafa Elkhousht contributed to the manuscript drafting, data analysis and data interpretation. Areej Othman, Hanin Ahmed, Marian Essam, Nanis Nasser and Yasmine Hossam contributed to the Data collection, data analysis and data interpretation.

All authors have read and approved the manuscript

Conflict of interest

The authors declare that they hold no competing interests

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