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Gender determination using dental arch characteristics among a south Indian pediatric population: A morphometric study

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Highlights

Dental remains become a source of human identification. Dental morphometrics also play a pivotal role in identification of gender.

The study found a definitive sexual dimorphism using dental arch characteristics. One hundred percent of correct classification of gender was achieved by measuring dental arch dimensions.

The dental arch characteristics may be used as an additional tool for gender identification especially in juvenile skeletons where other dimorphic features are not well developed.

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Abstract

Aim: To establish the normative data of dental arch characteristics and use them to determine the gender among a pediatric population of south India. **Methods:** Three hundred children aged 3 to 5 years were selected. The intra oral examination of each child was carried-out using a sterile disposable mouth mirror and a CPI probe. To receive maximum illumination, the oral examination was done in adequate natural daylight seating the child in upright positioning on a chair. Following, the molar and canine relationship was recorded. The investigators prepared the maxillary and mandibular impression of teeth and their dental casts. The intercanine width, intermolar width, dental arch form, arch length and arch perimeter was measured. The descriptive analysis of all the explanatory and outcome parameters was done using frequency and proportions for categorical variables, whereas in Mean & SD for continuous variables. To compare the selected dental arch parameters between genders, Independent Student t-test Chi-Square test were used. P≤0.05 was set as the level of significance. **Results:** The mesial step molar relationship and Class I canine relationship were found be more common among males compared to females, however it was not statistically significant (p<0.26). Although, the ovoid arch form was commonly seen especially among males followed by square and tapered, it was not statistically significant (p=0.14). The intercanine width, intermolar width, arch length and arch perimeter was greater in males than females. (p<0.001) **Conclusions:** Sexual dimorphism was observed among the studied dental arch parameters. Dental arch dimensions like intercanine width of the maxillary arch, intermolar width, and arch perimeter of both maxillary and mandibular arches showed to be an indicator for gender determination with an accuracy of 100%.

Keywords: Dental Arch; Primary Teeth, Sexual Dimorphism

INTRODUCTION

The protection of children and their rights is of paramount important as they are more vulnerable and are at risk of abuse, exploitation, and neglect. Despite the efforts of the child protection system, child maltreatment fatalities remain a serious problem. Child abuse is shrouded in secrecy and there is a conspiracy of silence around the entire subject.[1]

It has become difficult to address the issue of child abuse and neglect comprehensively due to lack of empirical evidence and qualitative information. Despite this, many professionals have made a great effort to detect and document various cases of child abuse, but most of them have focused on the children who are living.[1] Regrettably, due to the cruel act of human many children have lost their loveable and beautiful life who also deserve justice as much as the living children.

In forensic investigation, one of the integral parts of victim's identification process is the determination of the gender from the recovered remains. Faultless gender prediction narrows down the search of forensic experts by half and assist the law enforcers into more centered search of the lost persons.[2] One hundred percent or near 100% accuracy for gender identification is shown by pelvis bone.[3] However, when the other skeletal remains are not available or missing or mutilated due to various disastrous events such as trauma and incineration, the dental remains take prominence.[2] Additionally, in young children in whom secondary skeletal sexual characteristics have not matured, teeth play a pivotal role in gender determination. Hence, due to the presence of sexual dimorphism of teeth, odontometeric data have been widely used by forensic odontologist to determine the gender with 100% accuracy.[4,5] Further, different dimensions of the maxillary and mandibular dental arches are used to determine the gender.[6,7] However, these studies have been conducted among adult population but not among pediatric age group. Furthermore, the morphometric features not only vary among the different populations but also among the same population stating that no two mouths are the same.[2] Thus, morphometric characteristics of one population cannot be generalized to the world at large. Additionally, to best of our knowledge no study has been carried out to determine gender using dental arch morphometrics. Hence, the purpose of this study was to establish the normative data of dental arch characteristics and use them to determine the gender among a south Indian pediatric population.

METHODS

The ethical approval to conduct this research was obtained from Institutional ethics committee (IEC/HIMS/RR27/02-11-2018). The guidelines of World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research were followed during entire study period. Children aged 3 to 5 years who were normal and healthy were randomly selected irrespective of their race and socioeconomic status. Informed consent was obtained from all participants and legal guardians.

Sample size calculation

According to Cohen's Thumb rule: 100+P* [*P= Predictable (2 measurements for each tooth) X 20 teeth = 40]. Therefore, the sample size was 100+ 40= 140. Approximated to 150 children among each gender (i.e., 150 children each in male and female).

Procedure

Six hundred and thirteen children were screened. The following were inclusion criteria:[8-10] a) children with a full complement of primary dentition and with no history of orthodontic or prosthodontic treatment; b) children having completely erupted and morphologically normal teeth; c) children with normal overjet and overbite; d) children having teeth with a healthy state of periodontal structures and intact mesiodistal and buccolingual dimensions of the crown with no evidence of tooth loss due to attrition or restorations. Children with one more permanent tooth, congenitally missing teeth in any of the segments, presence of teeth with developmental anomalies, restoration, clinically evident inter-proximal dental caries, or fracture of teeth were excluded.[8-10] Children with any orthodontic appliance or any other deleterious oral habits were also not included. Three hundred children meeting the inclusion criteria were included in the study. The procedure protocol involved in the research was explained for the parents of the selected children following which their informed written consent was obtained.

The intra oral examination of each child was carried out using a sterile disposable mouth mirror and a CPI probe.[11] To receive maximum illumination, the oral examination was done in adequate natural daylight seating the child in upright positioning on a chair. The occlusal relationship of the second molar and canine was recorded. To determine the occlusion relationship of molar and canine, both the right and left relationship was noted. If there was a distal step or mesial step molar relationship on one side and flush terminal plane on the other side, then the decision was made as flush terminal plane.[12-14] Similarly, in canine relationship, if there was Class II or III canine relationship on one side and Class I on the other, the decision was made as Class I canine relationship.[12-14] The regular-setting very high viscosity impression material (Aquasil® Soft Putty Regular set, Dentsply DeTrey GmbH 78467 Konstanz, Germany) was used to obtain the negative replica of both maxillary and mandibular teeth. Each impression was analyzed for any presence of a defect like bubble, precise recording of all teeth, and vestibular depth. Any impressions lacking these features were remade. Following, the 0.5% sodium hypochlorite was used to disinfect the impressions. The die stone was used to prepare the dental casts. The dental casts were carefully separated from the impressions and was analyzed for its quality. The dental cast with broken teeth, broken cusp tips and incisal edges, and an increased number of porosities were excluded and repeated. The preparation of dental casts is inexpensive, simple, reliable, and easy to measure, thus it was used to measure the dental arch dimensions. The dental arch form templates (Orthoform; 3M Unitek, Monrovia,CA, USA) were used to assess the dental arch form. They were overlaid on the dental cast and best suited arch form was noted and were grouped as ovoid, tapered and square.[15] The Vernier's caliper (calibrated with an error of ±0.01 mm) were used to measure the dental arch dimensions like inter-molar width, inter-canine width, arch length, and arch perimeter.[16,17] The maxillary and mandibular dental arches were measured for their dental arch dimensions separately.

The second investigator (KG) was trained and calibrated in our department (kappa value=0.88). to perform the intra oral examination and to prepare the dental casts. The assistance of a resident was used to record the occlusal relationship of molar and canine. The resident was made to sit beside the investigator so that the codes given are clearly heard and the investigator can see the correct recording of the data given. To avoid the investigator fatigue error, the oral examination and preparation of dental casts were limited to 20 children per day. To check the intra-examiner reliability, 10% of children were reexamined after a week. The kappa value for the intra-examiner agreement was 0.89.

The dental arch dimensions were measured by two independent examiners blinded to the type of gender. To minimize the examiner error, the Kappa test was performed for both the examiners and 0.87 and 0.90 were the score obtained. Both the examiners jointly reviewed and discussed about the measurement to be recorded, if there was any disagreement with the measurement. If the disagreement with the measurement. If the disagreement persisted, the lower measurement was considered. Each measurement was taken three times and their mean was recorded for the analysis. To calculate the method error, 50 randomly selected dental casts were measured after a month of initial measurement by the same examiner.

Statistical analysis

The statistical analyses were performed using Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp. Descriptive Statistics: Descriptive analysis of all the explanatory and outcome parameters was done using frequency and proportions for categorical variables, whereas in Mean & SD for continuous variables. Inferential Statistics: To compare the mean age and the selected dental arch parameters between genders Independent Student t-test was used. The molar and canine occlusal relationship and dental arch form was compared between genders using Chi-Square test. To predict the gender based on dental arch parameters, Stepwise Discriminant Function Analysis was performed. P<0.05 was set as the level of significance.

RESULTS

A total of 300 children (150 males and 150 females) participated in this study. The mean age of males and females were 4.36±0.56 and 4.31±0.63, respectively (Table 1).

On the right side, the flush terminal, mesial step, and distal step molar relationship were observed in 40%, 54%, and 6%, respectively, among males. Among females, 38%, 48%, and 14% of the flush terminal, mesial step, and distal step molar relationships, respectively, was recorded. On the left side, among males, 42% had flush terminal, 52% had a mesial step and 6% had distal step molar relationship. Among females, we observed 38%, 52%, and 10% of the flushterminal, mesial step, and distal step molar relationships, respectively. The type of molar relationship was not statistically significant when compared between gender (Figure 1). Among males, both on the right and left side the Class I and Class II Canine relationship was observed in 94% and 6%, respectively, and none of them had a Class III Canine relationship. Among females, both on right and left side 86%, 10%, and 4% of Class I, Class II, and Class III Canine relationship, respectively, was recorded. The type of Canine relationship was not statistically significant when compared between the gender (Figure 2). In the maxillary arch, among males, we observed 80%,14%, and 6% of ovoid, tapered, and square forms of the dental arch, respectively, was recorded. Sixty-two percent of ovoid, 28% of tapered, and 10% of square maxillary arch form was recorded among females. In the mandibular arch, males had 76% ovoid, 18% tapered, and 6% of square dental arch form. Seventy-two percent, 24%, and 4% of ovoid, tapered, and square mandibular arch form, respectively, was recorded among females (Figure 3). As these three parameters were found to be statistically non-significant when compared between gender, they were not considered for further analysis.

Table 1. Comparison of mean age (in years) among gender

		Males		Females		
Variable	Category	Mean	SD	Mean	SD	P-Value
Age	Mean & SD	4.36	0.56	4.31	0.63	0.67
	Range	03 - 05		03 - 05		

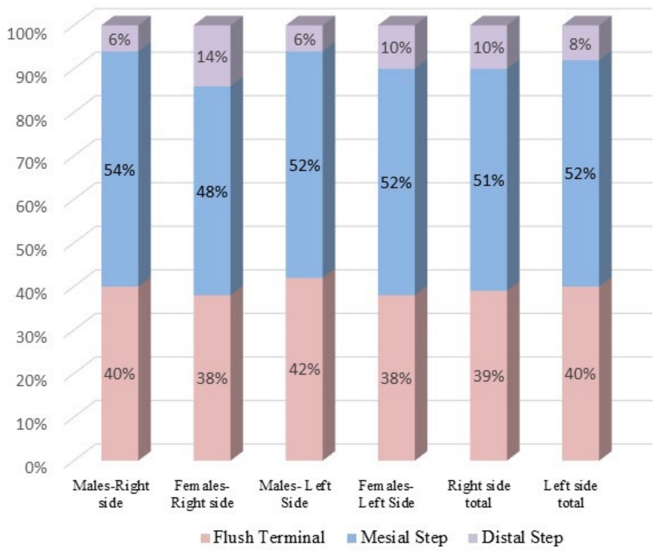

Figure 1. Comparison of primary second molar relationship on the right and left side according to gender

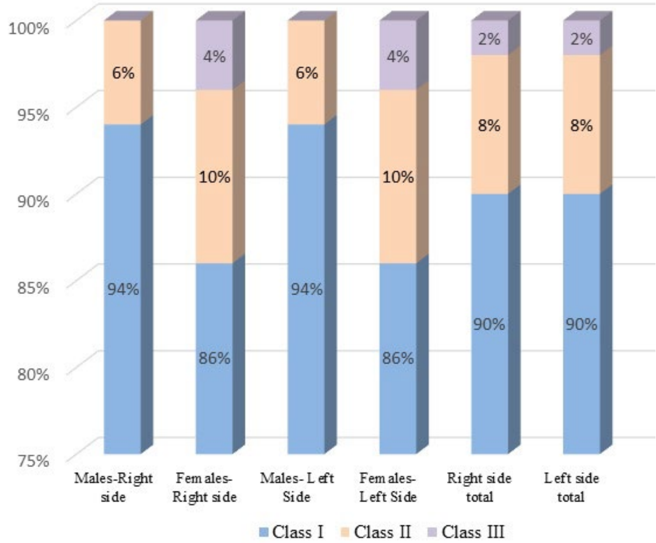

Figure 2. Comparison of canine relationship on the right and left side according to gender

Among males, in the maxillary arch, the mean value of intercanine width, intermolar width, arch length, and the arch perimeter was 31.29±0.819, 40.026±0.408, 25.912±0.478, and 84.242±2.709, respectively, and in the mandibular arch, it was 24.609±0.489, 36.356±0.641, 23.424±1.221 and 76.488±3.378, respectively. Among females, in the maxillary arch, the mean value of inter canine width, intermolar width, arch length, and the arch perimeter was 29.902±0.397, 39.202±0.542, 25.603±0.816 and 78.488±2.737, respectively, and in the mandibular arch, it was 23.910±0.470, 34.920±0.481, 22.896±0.580 and 65.941±3.374, respectively.

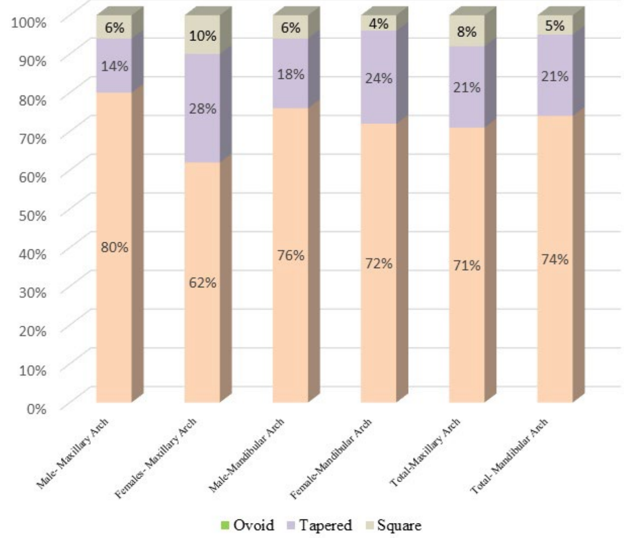

Figure 3. Comparison of maxillary and mandibular dental arch form among gender

On comparison of the dental arch dimensions between gender, there was a significant mean difference in the intercanine width ($p<0.001$ in maxillary and mandibular arches), intermolar width ($p<0.001$ in maxillary and mandibular arches), arch length ($p=0.02$ in maxillary arch and $p=0.007$ in mandibular arch), and arch perimeter ($p<0.001$ in maxillary and mandibular arches) (Table 2). Wilk's Lambda was determined among all these parameters. (Table 3).

The parameters with lesser Wilk's Lambda values and F-value less than 3.84 did not enter into the prediction model (Table 4). Further, the Unstandardized Discriminant function was evaluated at group means. Standard Matrix was pooled between gender for correlations between discriminating variables and standard canonical discriminant function.

Table 2. Comparison of mean values of dental arch dimensions between gender

Dental arch dimension	Dental arch	Gender	N	Mean	SD	Mean Diff	p-value
Inter Canine Width	Maxillary	Males	150	31.290	0.819	1.388	<0.001*
		Females	150	29.902	0.397		
	Mandibular	Males	150	24.609	0.489	0.700	<0.001*
		Females	150	23.910	0.470		
Inter Molar Width	Maxillary	Males	150	40.026	0.408	0.824	<0.001*
		Females	150	39.202	0.542		
	Mandibular	Males	150	36.356	0.641	1.436	<0.001*
		Females	150	34.920	0.481		
Arch Length	Maxillary	Males	150	25.912	0.478	0.310	0.02*
		Females	150	25.603	0.816		
	Mandibular	Males	150	23.424	1.221	0.527	0.007*
		Females	150	22.896	0.580		
Arch Perimeter	Maxillary	Males	150	84.242	2.709	5.754	<0.001*
		Females	150	78.488	2.737		
	Mandibular	Males	150	76.488	3.378	10.548	<0.001*

Table 3. Determination of Wilk's Lambda among dental arch dimensions for discrimination between genders

Dental arch dimensions	Wilks' Lambda	F	df1	df2	P-Value
Maxillary Intercanine width	0.117	178.908	4	95	<0.001*
Maxillary Intermolar width	0.134	207.237	3	96	<0.001*
Mandibular Intermolar width	0.170	237.103	2	97	<0.001*
Maxillary Arch Perimeter	0.107	157.080	5	94	<0.001*
Mandibular Arch Perimeter	0.287	244.007	1	98	<0.001*

A discriminant score of more than the sectioning point was categorized as males and less than the sectioning point was considered as females (Table 5). Thus, we were able to obtain an equation (Table 6). By using this equation, the participating children were able to classify correctly as males and females with an accuracy of 100% (Table 7). The inference of results was that, using Discriminant Functional Analysis, 100% correct classification of gender was achieved with dental arch dimensions like maxillary intercanine width, maxillary and mandibular intermolar width, and arch perimeter indicating that they are an good indicator for gender determination with an accuracy of 100%.

Table 4. Dental arch dimensions removed from the analysis

Dental arch dimensions	F	Wilks' Lambda
Mandibular Intercanine width	2.758	0.104
Maxillary Arch Length	0.007	0.107
Mandibular Arch Length	0.031	0.107

Table 5. Discriminant function coefficients for gender determination among other study parameters

				Group Centroids		
Dental arch dimensions	Unstd. Coeff	Str. Matrix	Std. Coeff	Males	Females	Sectioning Point
Maxillary Intercanine width	0.546	0.377	0.351	2.862	-2.862	-5.724
Maxillary Intermolar width	0.878	0.300	0.421			
Mandibular Intermolar width	1.119	0.443	0.634			
Maxillary Arch Perimeter	0.117	0.369	0.318			
Mandibular Arch Perimeter	0.186	0.546	0.629			
Constant	-114.114					

Table 6. Discriminant Function Equation for determination of gender using dental arch dimensions

Discriminant Function Equation: -114.114 + 0.546 x Maxillary inter canine width + 0.878 x Maxillary intermolar width + 1.119 x Mandibular intermolar width+ 0.117 x Maxillary arch perimeter+ 0.186 x Mandibular arch perimeter

Table 7. Group membership model for gender prediction by dental arch dimensions of primary dentition

			Predicted Group Membership		
Grouping type	Expression	Gender	Males	Females	Total
Original	n	Males	150	0	150
		Females	0	150	150
	%	Males	100.0	0.0	100
		Females	0.0	100.0	100

DISCUSSION

Sexual dimorphism refers to those differences in size, structure and appearance between male and female, which can be applied to dental identification. The increase in the trend of death of abused child makes it curial to determine the gender of the deceased child.[3,11] Although odontometeric analysis has been used for gender determination, the potential of dental arch characteristics has not been explored in the pediatric population.

Baume[12] has described three types of occlusal molar relationships in the primary dentition i.e., flush terminal, mesial step, and distal step. In the present study, mesial step was the most common molar relationship in both the genders followed by the flush terminal and a small percentage of the distal step. Similarly, Alhaija et al.[18] observed a higher percentage of Jordanian children to be having mesial step than the other two molar relationships. Further, Infante[19] also found mesial step to be more frequent in black children than in white children. In contrast to the findings of the present study, Fernandes et al.[21] and Nanda et al.[22] observed flush terminal plane to be more common followed by mesial step and distal step among north Indian children. Among white American children and Saudi children, flush terminal plane was more predominant than the mesial and distal step.[12,13] Additionally, Keruso[23] reported the flush terminal molar relationship to be more common in black children than Finnish children. In agreement with other studies[18,20] there was asymmetrical molar relationship on right and left sides in the present study. This observation may be due to variations in space distribution. In the present study, the Class I canine relationship was observed in the majority of children followed by the Class II and Class III relationship. A similar observation was made among children of Saudi Arabia[13] and Jordan.[18] Even among children of other populations,[12,22,24,25] corresponding observations were reported. Regarding the dental arch form, the ovoid arch form was most commonly recorded followed by the tapered and square arch form in both the arches. Similar observations[26-28] were made among children of Jordan, Egypt, and Sudan. In contrast to present study, Kook et al.[29] found that the square arch form to be more common among the Korean population and the tapered arch form to be predominant among the North American white population. Although the males scored a higher percentage than females in the occlusal molar relationship, canine relationship, and dental arch form, it was not found to be statistically significant. This is in agreement with the findings of De Castro et al.[30] and Pinkham et al.,[31] In contrast, Owasi et al.[26] found a significant difference in arch form among genders. The variation in the observation confirms the concept that dental arch characteristics are affected by ethnicity, race, and variable environmental factors.[26,27] Additionally, the use of different classification systems, different age groups, and sample sizes would have influenced the variation in the results. Further, distinct genetics and diverse living condition of different continents would have added to the variations.[32]

The intercanine width, in both the dental arches, was significantly higher in males compared to females. This finding is in accordance with the observation made among Caucasian[33] and Indian children.[34] Homogenous observation has been reported by other researchers among different populations.[35,36] Among Jordanian children, although there was sexual dimorphism (Males>Females) in both maxillary and mandibular intercanine width, it was not statistically significant.[18] Among Indian children, Shankar et al.[17] reported sexual dimorphism (Males> Females) in maxillary intercanine width. Hussein et al.[37] found a sexual dimorphism in the intercanine width of the mandibular arch among Malay school children. In contrast, other researchers[10,38,39] found no significant difference between the mean mandibular intercanine width between males and females. The intermolar width showed sexual dimorphism i.e., the intermolar width of males measured significantly higher value compared to females, both in the maxillary and mandibular dental arches. In accordance with the findings of present study, the intermolar width of both arches was significantly higher in males among Jordanian children.[18] Even among Indian children a higher measurement of mandibular intermolar width among males were observed, however, their mean difference was not statistically significant.[10,34] Shankar et al.[17] reported a non-significant mean difference in maxillary intermolar width between males and females.

In the present study, the arch length was significantly higher among males than females. A similar observation was reported by Zarafmand et al.[40] among Filipino children. Additionally, Alhaija et al.[18] observed a higher measurement of dental arch length among Jordanian male children than females, however, it did not reach statistical significance. The dental arch perimeter of male children measured a significantly higher value than females both in maxillary and mandibular arches. Similar values were observed by Sharaf et al.[27] among Egyptian children. All the studied dental arch dimensions were higher in males compared to females. This may be because the dental arch dimensions reflect the size of the basal bone. In general, males have larger basal bones than females, so the same concept may be applied to the dimensions of the dental arch. [41]

Among the studied dental arch dimensions, one hundred percent correct classification of gender was achieved with intercanine width of the maxillary arch, intermolar width, and arch perimeter of both maxillary and mandibular arches. This indicates that these dental arch dimensions are a good indicator for gender determination with an accuracy of 100%. Shankar et al.[17] reported the determination of the gender using primary maxillary arch width with the accuracy of 89.75 and 77% for males and females, respectively.[17] Additionally, Nagaveni et al.[10] stated that mandibular intermolar width can be used as an alternative tool for gender determination in young children. These two studies evaluated the use of maxillary and mandibular width per se to determine the gender, not other dental arch dimensions.

The sample size and use of the dental cast to measure the dimensions of the dental arches are the limitations of this study. Future studies may be conducted by measuring the dental arch dimensions more accurately using Moire topography and Fourier.

CONCLUSIONS

There was a definitive sexual dimorphism in the studied dental arch characteristics. Using Discriminant Functional Analysis, one hundred percent of correct classification was achieved by measuring the dental arch dimensions like intercanine width of the maxillary arch, intermolar width, and arch perimeter of both maxillary and mandibular arches indicating that they are a good indicator for gender determination with an accuracy of one hundred percent. However, the results should be cautiously adapted for gender determination among other pediatric populations as this was the first study that attempted to determine gender using all the dental arch characteristics among pediatric population.

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Declarations

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