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A Comparative Study on Some Odontometric Measurements among Adult Egyptian versus Adult Far Eastern Populations Using Multidetector Computed Tomography

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ABSTRACT

Identification is the recognition of a person based on certain characteristics like age, sex, stature and race which is the most controversial issue that a forensic anthropologist usually faces. Computed tomography (CT) allows effective imaging with three-dimensional reconstruction, also dental examination is broadly used to assist in postmortem identification. The present study aimed to evaluate the odontometric data of adult Egyptian and Far Eastern populations based on CT imaging as to assist in sex and race identification for medicolegal purposes. The study was carried out on 212 adult subjects (100 Egyptians and 112 Far Eastern) of both sexes (above 25 years old). Multidetector Computed Tomography scans of the skull with Multiplanar reformatting and reconstruction of high quality 3D models were performed. Mesiodistal (MD) widths of permanent right maxillary and mandibular canines as well as intercanine arch widths on both arches were measured. Mandibular and Maxillary canine indices of each subject were calculated. Mean values of Mandibular Canine Index (MCI) and MD dimensions of right mandibular canine were significantly greater in males compared to females in both population samples. There was no significant difference for maxillary canine index between both sexes in both groups. For both sexes, MD width of the mandibular canine showed the greatest racial dimorphism. Discriminate function analysis showed that Far Eastern population sample was classified with better accuracy (75.9%) than Egyptian sample (74%). Egyptian and Far eastern males were classified with better accuracy (92.5%, 92% respectively) than Egyptian and Far Eastern females (75 %, 90% respectively).

Keywords: *Egyptian, Far Eastern, ethnicity, race, discrimination, odontometric, Mandibular, Maxillary, Canine.*

1. INTRODUCTION

Identification is the recognition of a person based on certain characteristics which differentiate him from all others [1]. It is an essential part of post-mortem examination, and it is specially required in cases of sudden unexpected deaths and mass disasters [2]. It comprises either the establishment of certain broad basic categories, such as sex, age , race and stature [3], or comparison of the remains with ante-mortem information and records from those thought to be the victims.

The determination of ethnicity is the most controversial issue in identifying unknown individuals [4]. In general, biological and cultural factors mostly interfere in the normal processes of bone growth and loss causing disease episodes and/or periods of delayed growth and these occurrences are usually recorded on the skeleton and dentition [2]. Forensic anthropologists are asked to determine race based on morphological and/or metric variations .The skull is the most studied element in this regard as the craniofacial area is one of the parts of the body which undergoes major changes, particularly the face [5].

The oral and maxillofacial regions have been shown to be a particularly defining region of variability between racial/ethnic groups with target characteristic features include facial structure with its relative proportions, dental and neurocranial morphology [6]. It is important to put into consideration that these structural polymorphism are derived from combined sex and race designations and there are certain traits are more sex-sensitive than others [3].

Recently, Imaging modalities with three-dimensional (3D) technologies like helicoidal and /or cone-beam computerized tomography (CT), Magnetic Resonance Imaging (MRI), and 3D Stereophotogrammetry allow effective imaging of three-dimensional structures and are systematically utilized for anthropometric assessment instead of the traditional direct caliper-based measurement [7]. They have been proved to be very valuable in mass fatality incidents [8]. Dental radiography is also broadly used in conjunction with the odontological examination to assist in postmortem identifications [9].Standards of morphological and morphometric sex differences in the skeleton may differ with the population sample involved especially with reference to dimensions and indices and thus cannot be applied universally. Also tooth morphology is known to be influenced by cultural, environmental and racial factors [10]. So, the primary purpose of this study was to evaluate the odontometric data of adult Egyptian and Far Eastern populations based on Computed Tomographic imaging, as well as providing evidence of those odontometric measures in sex and race identification for medicolegal purposes.

2. METHODS:

2.1 Participants:

The study was carried out on 212 adult subjects of both sexes. Their ages were ≥ 25 years. **Egyptian population** group was constituted 100 adult subjects (67 were males and 33 were female). They were referred to Radio-diagnosis Department, Faculty of Medicine, Alexandria University. **Far Eastern population** group was constituted 112 adult patients (59 patients were males and 53 were female). They were referred to Universiti Kebangsaan Malaysia Medical Centre (UKMMC), Kuala Lumbur, Malaysia. 54 subjects of them were Malaysian, 46 were Chinese and 12 subjects were Indian.

All included cases were imaged for medical reasons such as pain or infection in the head, neck or facial regions. All subjects had complete set of fully erupted, morphologically well-formed, healthy and non-carious teeth. Subjects with odontological anomalies, attrition, crowns or tooth extraction were excluded.

2.2 Ethical considerations:

1. No one was subjected to hazards of radiation without a medical indication.
2. Informed consent was taken from each subject before using his/her CT image in the present study.
3. All CT images were anonymous with no break in patient confidentiality.

2.3 Procedures:

Multidetector Computed Tomography (MDCT) scans of the skull were performed to all studied subjects using 64-slice helical CT scanner. At slice thickness of 1mm, focal size 0.6 mm, pitch 0.8mm, rotation time one second with mAs of 240 and 120 kV. Reconstruction increment was at 0.7mm. Multiplanar reformatting and reconstruction of high quality 3D models was performed in bone window using commercially available software (MicroDicom).

Measurements were taken from the reformatted images (figures 1,2,3) using desktop computer 27"display with 2560x1440 resolutions with the computer software tools. The most prominent view was selected for the best visualization and proper measurements. Then, the following data were collected [11-13]

1- Mesiodistal (MD) width of the crown of permanent right canines (the greatest distance between the contact points on the mesial and distal surfaces of the perminant canine parallel to the occlusal surface), on maxillary and mandibular dental arches.

2- Intercanine arch width (Distance between the tips of right and left canines on the occlusal surface), on maxillary and mandibular arches.

3- The canine index of each individual was derived as a ratio between the above two parameters .

Maxillary canine index = MD width of maxillary canine / Maxillary canine arch width

Mandibular Canine index = MD width of mandibular canine / Mandibular canine arch width

N.B: Each linear parameter was taken for three times and then the mean value of each was tabulated for statistical analysis.

2.4 Statistical analysis:

Data was collected and analyzed using statistical package for social science (SPSS, version 20) software. Descriptive analysis *i.e.* mean (μ) and standard deviation (SD) was done for all parameters of both groups. Unpaired t-test was used for comparison of different groups. A p-value < 0.05 was considered to be of statistical significance.

Discriminant function analysis was used to classify subjects by gender and by race. This technique creates an equation which will minimize the possibility of misclassifying subjects into their respective groups or categories.

3. RESULTS

Descriptive statistics revealed that the age of Egyptian subjects ranged from 25up to 69 years with a mean of 43.59± 14.68 years. While that of Far Eastern subjects ranged from 25 up to 68 years, with a mean of 55.61 ± 15.142 years.

As regards sex, in the Egyptian group males outnumbered females, where males constituted 67% (n=67) and females were 33% (n=33). For the Far Eastern group, males 52.7% (n= 59) were slightly more than females 47.3% (n=53)

Regarding the dental measurements, a statistically significant difference between the mean MD dimension of the mandibular canine in both sexes in Egyptian population sample (t= 5.897, P< 0.001*) as well as in the Far Eastern population sample (t=21.655, P< 0.001*) was noticed (table 1, 2).

It was observed that the Mandibular Canine Index (MCI) of Egyptian male subjects (mean = 0.2588± 0.032) exceeded those of females (mean = 0.2376 ± 0.027) and the difference was statistically significant (t = 3.248, P= 0.002). The same observation was noticed in the Far Eastern population sample where MCI of males (mean= 0.2616 ±0.01979) exceeded those of females (mean=0.2319 ± 0.02627) and again the difference was statistically significant (t =6.803, P < 0.001).

On the other hand, it was noticed that there was no significant difference in the mean value of maxillary canine index between both sexes among the Egyptian group (p = 0.081) as well as in the Far Eastern group (P= 0.049).

Regarding the measurements of male subjects in both groups, the MD width of the mandibular canine showed the greatest dimorphism (t= 6.140, p < 0.001*) followed by mandibular intercanine distance (t= 5.587, < 0.001*). Nevertheless, MCI was not significantly different. On the other hand, MD width of Maxillary Canine and the Maxillary Canine index were significantly different while the Maxillary

Intercanine arch width showed no significant difference between male subjects of both groups. (Table 3)

For females of both population samples, table 4 shows that the dimorphism in the MD dimension was greater in the mandibular than in the maxillary canines. And as noticed in males, MCI was not significantly different while there was a significant difference in the mean values of maxillary canine index. Regarding the Mandibular Intercanine arch width, it showed significant difference ($p= 0.004$) between females of both population groups while (like in males) the Maxillary Intercanine arch width was not significantly different.

To find the reliability of gender and ethnicity determination using studied linear measurements, discrimination function analysis was done:

- In addition to results exhibited in table 5, the unstandardized Canonical Discriminant Function coefficients were used to create the discriminant equation between both population samples using odontometric measurements, as follows:

D = (a x 3.231) + (b x 8.991) + (c x - 1.764) + (d x 2.336) – 9.260

Where:

D = Discriminant score

a = MD width of Maxillary Canine (Rt)

b = MD width of Mandibular Canine (Rt)

c = Maxillary Intercanine arch width

d = Mandibular Intercanine arch width

If "D" is equal to **<u>0.721</u>**, so it would be an Egyptian skull. If it is equal to **<u>- 0.644</u>**, the skull would belong to Far Eastern population.

Classification results showed that Far Eastern population was classified with better accuracy (75.9%) than Egyptian population (74%).

- Table 6 shows the linear dental measurements that were taken ordered according to their power of discrimination between both sexes in Egyptian group and the unstandardized Canonical Discriminate Function coefficients were used to create the discriminate equation between both sexes, as follows:

D = (a x2.084) + (b x13.161) + (c x-2.771) + (d x1.850) –7.058

Where:

D = Discriminant score

a = MD width of Maxillary Canine (Rt)

b = MD width of Mandibular Canine (Rt)

c = Maxillary Intercanine arch width

d = Mandibular Intercanine arch width.

If "D" is equal to **0.472**, so it would be an Egyptian male skull. If it is equal to **- 0.957** , the skull would belong to an Egyptian female.

Classification results showed that Egyptian males were classified with better accuracy (92.5%) than Egyptian females (75 %).

- Table 7 demonstrates the results of Discriminate function analysis to identify sex among Far Eastern.. (Dental measurements are ordered according to their power of discrimination). The unstandardized Canonical Discriminant Function coefficients were used to create the discriminant equation, as follows:

$$D = (a \times 5.527) + (b \times 38.994) + (c \times -0.012) + (d \times 0.044) - 30.763$$

Where:

D = Discriminant score

a = MD width of Maxillary Canine (Rt)

b = MD width of Mandibular Canine (Rt)

c = Maxillary Intercanine arch width

d = Mandibular Intercanine arch width

If "D" is equal to **1.956**, so it would be a Far Eastern male skull. If it is equal to **– 2.177**, the skull would belong to a Far Eastern female. This clearly classifies the subjects as male and female.

Classification results showed that Far Eastern males were classified with better accuracy (92%) than females (90 %).

4. DISCUSSION

The major advantage of using CT was to investigate the teeth in digital format without manual physical measurement and it allowed easy assessment of the three dimensional (3D) odontological morphology. In addition, the measurements were automatically calculated without magnification errors. Again documentation by radiological imaging is observer-independent, objective and non invasive. Digitally stored data could be recalled & provide fresh intact reconstruction years after organic remains have been decayed [14].

The accuracy and reliability of 3D CT landmark identification has been studied and it was found that no significant statistical difference from the physical measurement[15]. In addition, studies reported the advantages of 3D medical imaging software as a reliable tool to obtain valuable measurements [16].

The studied measurements were taken in an attempt to establish the main odontological characteristics of two

populations of different ethnicity and thereby differentiate between both groups. Sexual dimorphism represents a group of morphologic characteristics that differentiate a male from a female. Among these dimorphic traits, tooth size had been evaluated in various populations for its interest in anthropologic and forensic applications [17, 18].

In the present study, subjects with age equal to or above 25 years were selected because the eruption of permanent teeth and growth in width of both jaws, including the width of the dental arches, are completed. Moreover, the intercanine distance does not increase after 12 years of age.[2]

Among the teeth, canines had been chosen as they are teeth most appropriate for identification and sex determination. Studies on permanent canines show that they are less frequently taken out, probably due to reduced caries incidence, and they are the least affected by periodontal diseases and they are last teeth to be taken out in view of age. Moreover, those are teeth that can survive many traumas and disasters. All the aforementioned indicate that canines are teeth that can be used as key teeth for identification [19, 20]. The right canines were selected to be studied as MCI on the right, indicates greater accuracy in sex determination in relation to left lower canines [19].

In the present study sexual dimorphism was evident in MD dimensions of maxillary and mandibular canines among Egyptian as well as Far Eastern groups with statistically significant differences which were favoring male teeth over those of females. Similar results obtained by Kaushal *et al* [21] who conducted a study on mandibular canines of north Indians. Also, a study conducted on Southern Chinese by Wong and Ling [22] showed that the Chinese male tooth dimensions were larger than those of females which is still in agreement with the present study results on Far Eastern.

Again results of the Egyptian group are in line with what was revealed by Omar and Azab [23] on their study on a sample of adult Egyptian population where there was sexual dimorphism in MD diameters of both maxillary and mandibular canines.

On the other hand, Iscan and Kedic [24] reported that dental measurements were not highly dimorphic in Turks. Moreover, Ateş *et al* [25] stated that dentition in Turkish people seems to be less sexually dimorphic than the population with which they were compared (Jordanians, Swedish and South Africans). The difference in the statistical significance of sexual dimorphism in both Egyptian and Far Eastern groups confirms that sexual dimorphism from dental measurements is ***population specific*** as was suggested by

Iscan and Kedic [24] as well as by Vodanovic [26] who also concluded that sex determination from odontometrical methods requires population specific standards.

According to the present study, there was a statistically significant difference in MCI between both sexes in each of the studied population groups. Similar findings were reported by Rao [13] who described establishment of sex identity using MCI in South Indian population with a high degree of accuracy. On the other hand, Acharya *et al* [27] reported that ratios obtained from teeth, such as MCI, do not reflect sexual dimorphism that may be present in absolute measurements. Furthermore, they believed that the basis for using MCI as a sex assessment tool is questionable, since it depends on the levels of sexual dimorphism between the absolute dimensions (MD measurement of canines and inter-canine arch width).

In the present study, it was found that dental measurements were less effective in discriminating race. This result is in accordance with what was revealed by Corruccini *et al* [28] who made a research on odontometric discriminate function analysis of African Americans and Caucasians, they mentioned that odontometric measurements of the mandibular and maxillary dentitions were less significant in discriminating race rather than sex.

Regarding discriminate function analysis in the present study, it was found that MD dimension of the mandibular canine followed by mandibular intercanine arch width were the most discriminate variables that can distinguish both studied ethnic groups while on discriminating sex, MD width of the mandibular canine followed by that of the maxillary canine were the most important discriminate variables in both groups. Accuracy of sex classification using the studied four parameters was 81% for Egyptian subjects and 98% for Far Eastern subjects.

Iscan and Kedici[24] observed that upper canine, lower canine and second molar are the most contributory teeth to sex discrimination where overall accuracy of sex diagnosis ranged from 73 to 77% in Turks which is relatively lower than the present finding.

Lakhanpal *et al* [29] revealed that MD dimensions have better sex discriminatory ability as compared to buccolingual dimensions of maxillary dentition, they stated that an accuracy of 72 % was found on gender determination with both variables of maxillary permanent teeth. In another study by Vodanovic [18], it was established that MD diameter of the crown of the upper canine was the variable providing the best sex discrimination among Croatian population, a discriminant function derived from it together with MD diameter of the cervix of the same tooth provided 94.1% accuracy. While using the studied parameters in the present study, it was 81% among Egyptian group and 98% among Far Eastern group. This discrepancy between all these values may be explained by the fact that sexual dimorphism from dental measurements is population specific and require population specific standards.[20, 24, 26,29]

5. CONCLUSION

The greatest disadvantage of odontometric analysis is the lack of reference values needed for comparison which may cause mistakes in determining sex and/or race. Therefore, in order to raise the level of confidence, it is best to combine several different methods of identification

However, going by the findings of this study and those of other populations, MD of the mandibular canine has proven beyond doubt high degree of sexual dimorphism, hence a useful material in forensic identification.

The odontometric measurements of the mandibular and maxillary dentitions were less significant in discriminating race rather than sex.

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Table (1): Dental measurements of the Egyptian males and females:

DENTAL MEASUREMENTS	Male (n= 67)	Female (n=33)	t-test	p value
	Mean ± SD (cm)	Mean ± SD (cm)		
MD width of Maxillary Canine	0.7492 ± 0.05453	0.7117 ± 0.05931	2.997	0.003*
MD width of Mandibular Canine	0.7117± 0.05931	0.6104 ± 0.05913	5.897	< 0.001*
Maxillary Intercanine arch width	3.6737 ± 0.22444	3.6094 ±0.24200	2.003	0.048*
Mandibular Intercanine	2.9458	2.8642 ±0.26245	2.679	0.009*

arch width	±0.22075			
Maxillary Canine index	0.2233 ±0.01866	0.21710±.01145	1.764	0.081 NS
Mandibular Canine Index	0.2588 ± 0.03225	0.2376 ±0.02731	3.248	0.002*

*Significant at $p \leq 0.05$ MD: mesiodistal cm: centimeter

NS: Not Significant

Table (2): Dental measurements of Far Eastern males and females:

Dental measurements	**Male (n=59)**	**Female (n=53)**	**t-test**	**p value**
	Mean ± SD (cm)	**Mean ± SD (cm)**		
MD width of Maxillary Canine	0.7492± 0.05453	0.7117± .05931	14.223	< 0.001*
MD width of Mandibular Canine	0.6390 ± 0.06302	0.6104 ± .05913	21.655	< 0.001*
Maxillary Intercanine arch width	3.6737 ± 0.22444	3.6094 ± 0.242	1.169	0.245 NS
Mandibular Intercanine arch width	2.9458 ± 0.22075	2.8642 ± .26245	0.829	0.409 NS
Maxillary Canine index	0.2047±0.01982	0.1977 ±.01809	1.927	0.049 NS
Mandibular Canine Index	0.2616 ±0.01979	0.2319 ±.02627	6.803	< 0.001*

*Significant at p ≤ 0.05 NS: Not Significant

Table (3): Odontometric Data for Male Subjects in both Egyptian and Far Eastern Population samples.

Population Sample / Dental Measurements	Egyptian (n=67)	Far Eastern (n=59)	t-test	p value
	Mean ± SD (cm)	Mean ± SD (cm)		
MD width of Maxillary Canine	0.8210 ± 0.07268	0.7969 ± 0.02812	2.393	0.018*
MD width of Mandibular Canine	0.7860 ± 0.07404	0.7241± 0.02408	6.140	< 0.001*
Maxillary Intercanine arch width	3.6793 ±0.17644	3.6534 ± 0.21792	0.736	0.463 NS
Mandibular Intercanine arch width	3.0657 ±0.33123	2.7824± 0.21816	5.587	< 0.001*
Maxillary Canine index	0.2233 ±0.01866	0.2047± 0.01982	5.438	< 0.001*
Mandibular Canine Index	0.2588 ±0.03225	0.2616 ± 0.01979	0.578	0.564 NS

*Significant at p ≤ 0.05 NS: Not Significant

Table (4): Odontometric data for female subjects in both Egyptian and Far Eastern population Samples:

Population Sample	Egyptian (n=33)	Far Eastern (n= 53)	t-test	p value
	Mean ± SD (cm)	Mean ± SD (cm)		

Measurements				
MD width of Maxillary Canine (Rt)	0.7794 ± 0.04670	0.7209 ± 0.02837	5.053	< 0.001*
MD width of Mandibular Canine (Rt)	0.6894 ± 0.08280	0.6289 ± 0.02225	7.230	< 0.001*
Maxillary Intercanine arch width	3.5964± 0.22742	3.6019 ± 0.24845	0.104	0.918 NS
Mandibular Intercanine arch width	2.9030 ± 0.15255	2.7425 ± 0.28979	2.936	0.004*
Maxillary Canine index	0.2171±0.01145	0.1977± 0.01809	5.490	< 0.001*
Mandibular Canine Index	0.2376 ± 0.02731	0.2319 ± 0.02627	0.963	0.338 NS

Table (5): The Linear Dental Measurements according to Their Discriminate Power between Both Population Groups:

Variables	**Structure matrix coefficients**	**Standardized CDF Coefficients**	**F**	**Classification summary**
MD width of Mandibular Canine (Rt)	0.760	0.651	15.461 P <0.0001*	Accuracy of ethnic classification (Percent of subjects that were correctly classified to either group) = 75%
Mandibular Intercanine arch width	0.665	0.640		
MD width of Maxillary Canine (Rt)	0.585	0.187		
Maxillary Intercanine arch width	0.077	-0.383		

CDF: Canonical Discriminate Function

- ✓ Box's M= 157.860 ($p<0.001$)
- ✓ Canonical Correlation = 0.565
- ✓ Eigen value = 0.469
- ✓ Wilks' Lambda = 0.681 ($p<0.001$)

Table (6): Discriminate Function Analysis of the Odontometric Measurements among Egyptian Group:

Variables	Structure matrix coefficients	Standardized CDF Coefficients	F	Classification summary
MD width of Mandibular Canine (Rt)	0.878	1.013	4.901 p<0.001*	Accuracy of sex classification (Percent of subjects that were correctly classified to either group) = 81%
MD width of Maxillary Canine (Rt)	0.446	0.136		
Mandibular Intercanine arch width	0.399	0.528		
Maxillary Intercanine arch width	0.298	- 0.539		

CDF: Canonical Discriminate Function

- ✓ Box's M= 51.718 ($p<0.001$)
- ✓ Canonical Correlation = 0.562
- ✓ Eigen value = 0.461
- ✓ Wilks' Lambda = 0.685 ($p<0.001$)

Table (7): Discriminate function analysis of the odontometric measurements among Far Eastern:

Variables	**Structure matrix coefficients**	**Standardized CDF Coefficients**	**F**	**Classification summary**
MD width of Mandibular Canine (Rt)	0.991	0.906	1.149 P = 0.05	Accuracy of sex classification (Percent of subjects that were correctly classified to either group) = 98%
MD width of Maxillary Canine (Rt)	0.651	0.156		
Maxillary Intercanine arch width	0.054	- 0.003		
Mandibular Intercanine arch width	0.038	0.011		

CDF: Canonical Discriminate Function

- ✓ Box's M= 11.966 ($p<0.001$)
- ✓ Canonical Correlation = 0.901
- ✓ Eigen value = 4.337
- ✓ Wilks' Lambda = 0.187 ($p<0.001$)

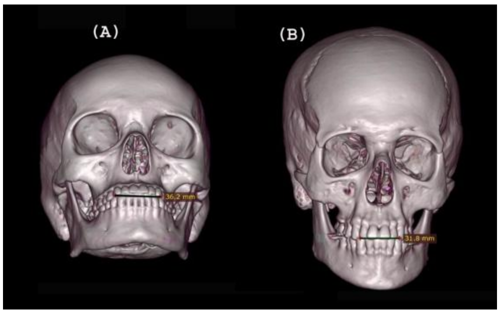

Fig. 1 Anterior View of the Skull on 3D CT Showing measurement of (A): Maxillary intercanine arch width and (B): Mandibular intercanine arch width.

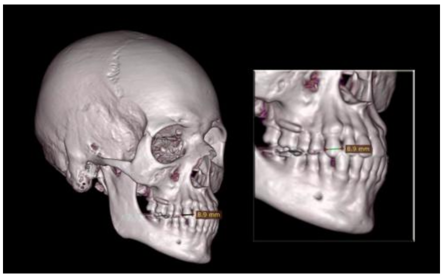

Fig. 2 Lateral View of the Skull on 3D CT Showing measurement of MD crown width of the right maxillary canine

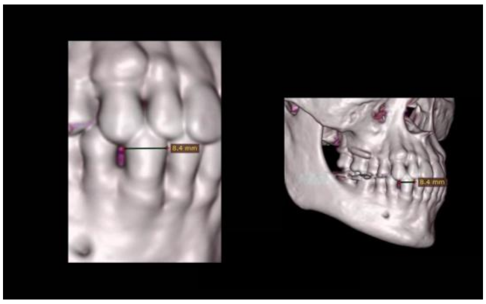

Fig. 3 Lateral View of the Skull on 3D CT Showing measurement of MD crown width of the right mandibular canine

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