

# Research Journal of Pharmaceutical, Biological and Chemical Sciences

## The Relative Position of Greater Palatine Foramen in Dried Human Adult Unsexed Skull Bones.

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### ABSTRACT

The relative position of the greater palatine foramen (GPF) was evaluated for precise injection of local anesthetics for optimal pain control in maxillofacial and dental surgeries. The study was conducted in 132 adult dried unsexed skulls which were normal with fully erupted third molars and free from any pathological changes. Unambiguous and well-defined points were taken and the observations were made. All the distances were measured with vernier caliper to the nearest millimeter. The statistical analysis indicated there was no significant difference in the measurement between the right and left sides with regard to the distance of GPF to the midline, GPF to the incisive fossa, GPF to the posterior border of the hard palate. The angle made by the line joining the GPF to the incisive foramen with the palatal midline (GIM angle) on two sides showed statistical significance. The mean angle on the left side was 21.2 +/- 4.2 degrees and 20.1 +/- 4.2 degrees on the right side. In 74.6 percent of skulls, the GPF was located opposite the third maxillary molars, whereas 24.2 percent showed the GPF between the second and third molars. In 0.4 percent of skulls, the GPF was opposite to the second molar and in 0.8 percent of skulls; the GPF was situated beyond the third molar. 46.2 percent of the GPF was directed forward and medially, whereas 41.3 percent was directed forward, and 12.5 percent as directed forward and laterally. The present study indicated that the location of the GPF was more variable than is implied in the anatomy textbooks. The perpendicular distance of the GPF in Indian skulls was about 15 mm, the distance of GPF to incisive fossa was approximately 37 mm and the GIM angle was 21 degrees.

**Keywords:** Greater palatine foramen, hard palate, incisive foramen, skull anatomy

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## INTRODUCTION

The aim of the present study was to determine the relative distance, direction and angle made by the greater palatine foramen (GPF) with the palatal midline. Though the GPF is of great clinical significance, the published descriptions of the position of this foramen in the adult human skulls have not been consistent. Most of the textbooks locate the foramen in a general way, e.g. near the lateral palatal border, in the posterolateral border, medial to last molar or opposite to the last molar. The position of the GPF in relation to the maxillary molars is stated to be opposite the second molar, opposite to the third molar or anywhere between the second and third molars. The first description of the location of GPF was reported by Matsuda [1]. The GPF was found to lie 15 mm from the palatal midline and 1.9 mm anterior to the posterior border of the hard palate in East Indians. In Negroid skulls, the location of the foramen was 10–16 mm anteromedial to the pterygoid hamulus and was usually distal to the third maxillary molar on its midpalatal aspect. In a study on Kenyan skulls, 76% of cases showed the location of GPF opposite the third maxillary molar [2-4]. In Chinese skulls, the GPF was commonly located between the second and third maxillary molars[5,6]. The foramen was located at a distance of 4.11 mm from the posterior border of the hard palate and 16 mm from the mid-sagittal plane. The location of the GPF from the posterior border of the hard palate in Indian skulls was 3.7 mm and in Nigerian skulls 3.5 mm, and this is fairly consistent. The foramen was commonly located medial to the third maxillary molar.

### Aim

The aim of the study is to analyze the variations in position of the greater palatine foramen in the dry adult human skull bones.

### Objective

To determine the relative position of the greater palatine foramen (GPF) for precise injection of local anesthetics for optimal pain control in maxillofacial and dental surgeries.

### Hypothesis

Significant difference is observed in the measurement between the right and left sides with regards to the distance of greater palatine foramen (GPF) from the midline, incisive fossa, posterior border of the hard palate, angle formed by GPF with the midline, (GIM angle) number of lesser palatine foramina, the relation of GPF to maxillary molars and the direction of GPF in the oral cavity

### Null hypothesis

No significant difference is observed in the measurement between the right and left sides with regards to the distance of greater palatine foramen (GPF) from the midline, incisive fossa, posterior border of the hard palate, angle formed by GPF with the midline, (GIM angle) number of lesser palatine foramina, the relation of GPF to maxillary molars and the direction of GPF in the oral cavity

## MATERIALS AND METHODS

The study was conducted in 132 adult dried, unsexed human Indian skulls which fulfilled the inclusion criteria were enrolled for the study

### Inclusion Criteria

- Dry human adult bones with fully erupted third molar and free from any pathological changes.

### Exclusion Criteria

- Dry human adult bones with malposition of teeth
- Edentulous arch

- Palatal tori
- Palatal tubercles or
- Any other pathological changes.

### Data Collection Procedure

The subjects were selected according to inclusion criteria. Prior to taking measurements, unambiguous and well-defined points were marked on the skull and the observations were made. All the distances were measured with vernier caliper to the nearest millimeter.

### Tools for Data Collection

- 132 adult dried unsexed human skulls.
- Divider
- Metal scale
- Vernier caliper
- Recording sheet
- Computer

### Evaluation Parameters

Unambiguous and well-defined points were taken and the following observations were made as shown in Fig 1& 2. All the distances were measured with vernier caliper to the nearest millimeter. Each skull was examined for the following:

- Shortest perpendicular distance of the GPF to the midline
- Distance of the GPF from the incisive fossa.
- Distance of the GPF from the posterior border of hard palate
- Relation of the GPF to the maxillary molars.
- Direction of the opening of the GPF into the oral cavity.
- The angle made by the line joining the GPF to the incisive foramen with the palatal midline (GIM angle).
- Shape of the palatal vault.
- Number of lesser palatine foramina (LPF).

### Statistical Methods

- The findings were tabulated and statistically analyzed using Student's *t*-test.
- Side differences were analyzed by using the Chi-Square test.
- To assess all parameters Arithmetic Mean and Standard Deviation are used.

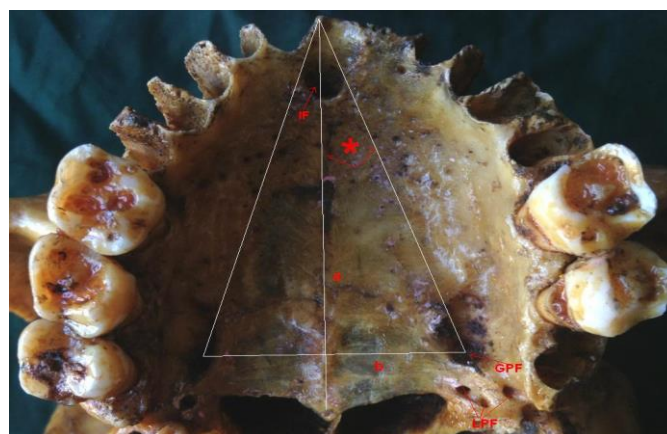


Figure 1: Ventral photograph of the hard palate.

\* Angle formed by the GPF with the midline

a: mid-sagittal line

b: line joining right and left GPF

GPF: greater palatine foramen.

LPF: lesser palatine foramen

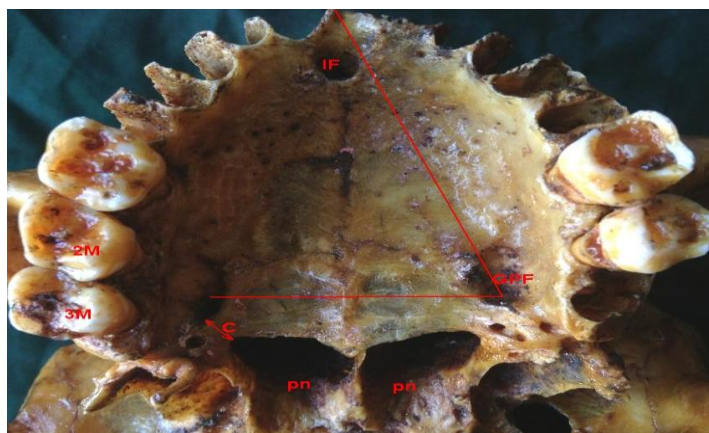


Figure 2: Ventral photograph of the hard palate.

pn: posterior nasal aperture

IF: incisive foramen

2m: second molar

GPF: greater palatine foramen

3m: third molar.

C: distance between GPF and posterior border of hardpalate

### Statistical Analysis & Result:

Table 1: The distance of GPF from the midline, incisive fossa, posterior border of the hard palate, angle formed by GPF with the midline and the number of lesser palatine foramina.

Right & Left sides n = 30	Right		Left		Total	
	Mean	±SD	Mean	±SD	Mean	±SD
GPF to midline (mm)	14.7	0.155	14.7	0.146	14.7	0.261 p=0.795ns
GPF to incisive fossa (mm)	37.2	0.292	37.4	0.301	37.3	0.731 p=0.466ns
GPF to posterior border of hard palate (mm)	4.2	0.139	4.2	0.133	4.2	0.151 p=0.88ns
Angle between GPF to midline(mm)	21.1	4.2	21.2	4.2	21.1	2.0 p=0.039sig
Lesser palatine foramina	1.8	0.802	1.9	0.887	1.8	0.655 p=0.513ns

SD: standard deviation; ns: not significant; sig: significant.

Table II: The relation of GPF to maxillary molars

Relation to maxillary molars	Right n(%)	Left n(%)	Total n(%)
Second molar	1(0.8)	0	1(0.4)
Between second & third molar	33(25)	31(23.5)	64(24.2)
Third molar	97(73.5)	100(75.8)	197(74.6)
Behind third molar	1(0.8)	1(0.8)	2(0.8)
Total	132(100)	132(100)	264(100)

$\chi^2 = 1.108$ ;  $p = 0.775$ , ns

**Table III: The direction of GPF in the oral cavity**

Direction of foramen	Right n (%)	Left n (%)	Total n (%)
Forward	54 (40.9)	55 (41.7)	109 (41.3)
Forward & lateral	18 (13.6)	15 (11.4)	33 (12.5)
Forward & medial	60 (45.5)	62 (47)	122 (46.2)
Total	132 (100)	132 (100)	132 (100)

**Table IV: Shape of the palatal vault**

Shape of the palate	Number of skulls
Arched	61 (46.2)
Flat	49 (37.1)
High arched	22 (16.7)
Total	132 (100)

**RESULTS**

The statistical analysis indicated there was no significant difference in the measurement between the right and left side with regard to the distance of GPF to the midline, GPF to the incisive fossa and GPF to the posterior border of hard palate( $p < 0.01$ ) (Table I, Graph 1 and Graph2).

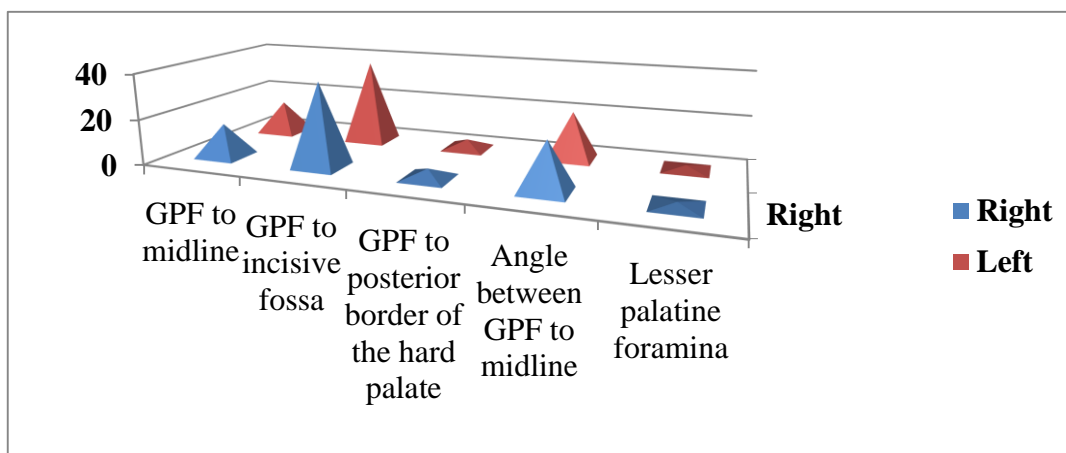
The GIM angle was variable on the right and the left sides ( $p < 0.05$ ) (Table I, Graph 1 and Graph2), the mean angle on the left side was  $21.2 \pm 4.2^\circ$  and  $20.1 \pm 4.2^\circ$  on the right side.

The relationship of the GPF to the maxillary molars was variable. In 74.6% of skulls, the GPF was located opposite the third maxillary molars, whereas 24.2% showed the GPF between the second and third molars. In 0.4% of skulls, the GPF was located opposite to the second molars, and in 0.8% of skulls, the GPF were situated beyond the third molar (Table II and Graph 3).

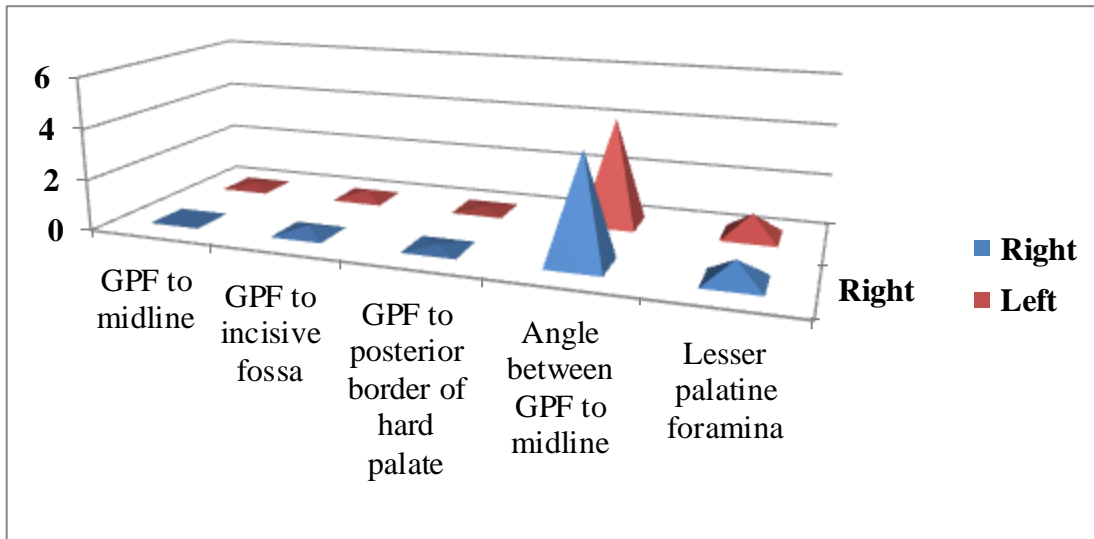
The numbers of lesser palatine foramina LPF on both sides were not symmetrical, and varied from one to four. In two skulls, the LPF on the left side were absent and in one skull, the GPF on the left side was double.( Graph 1 and Graph2)

46.2% of GPF was directed forward and medially on the lateral border of the hard palate, whereas 41.3% was directed forward, and 12.5% of GPF was directed forward and laterally (Table III, Graph 4).

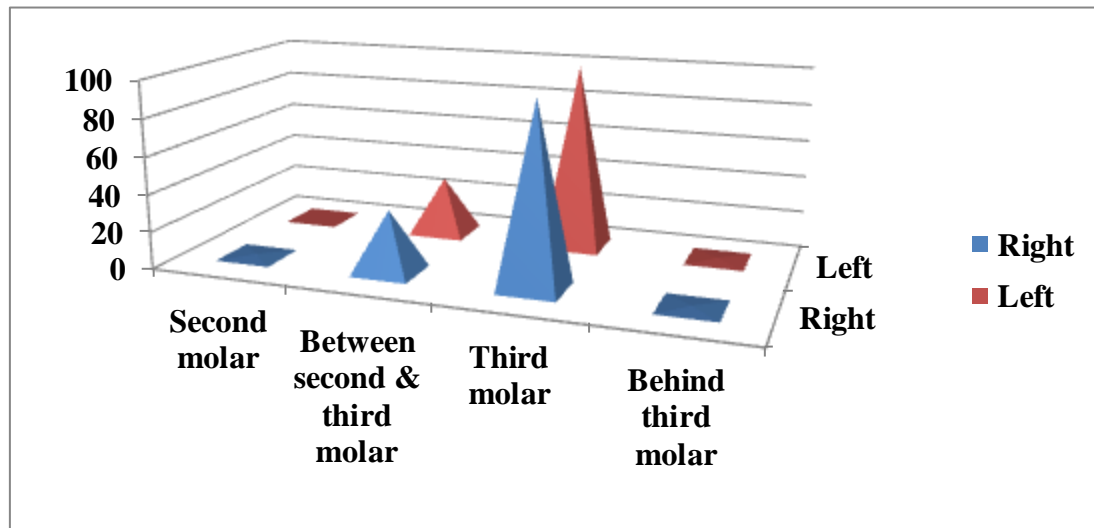
Most of the palates were arched 46.2 %,(  $n = 61$ ), whereas 37.1% ( $n = 49$ ) were flat and 16.7% ( $n = 22$ ) were high-arched palates (Table IV, Graph 5).



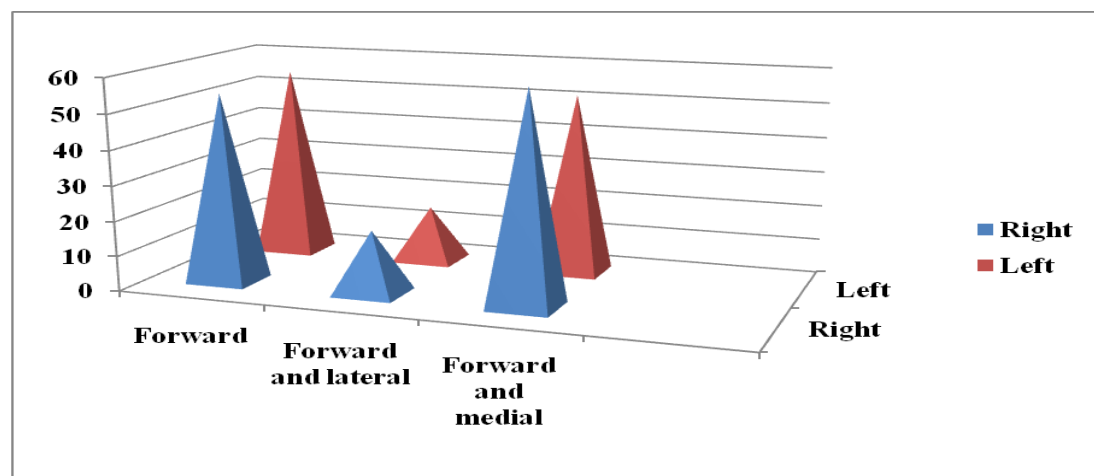
**Graph 1: The Arithmetic Mean of the distance of GPF From the Midline, Incisive Fossa, Posterior Border of the Hard Palate, Angle formed by GPF with the Midline and the number of Lesser Palatine Foramina**



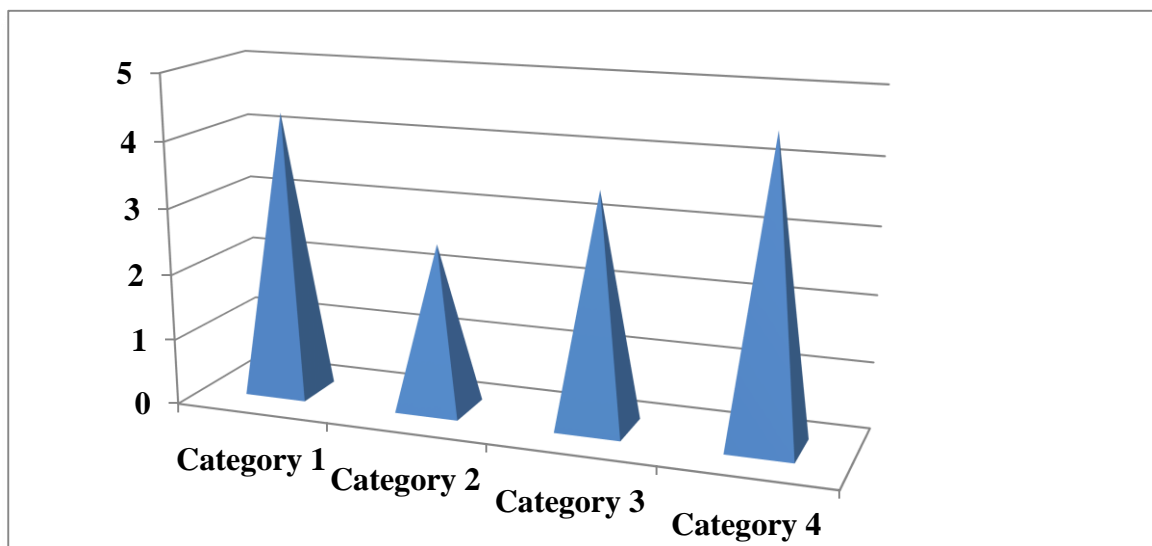
Graph 2: The Standard Deviation of the distance of GPF From the Midline, Incisive Fossa, Posterior Border of the Hard Palate, Angle formed by GPF with the Midline and the number of Lesser Palatine Foramina



Graph 3: The relation of GPF to Maxillary Molars



Graph 4: The direction of GPF in the Oral Cavity



Graph 5: Shape of the Palatal Vault

### DISCUSSION

The present study indicated that the location of the GPF was more variable than is implied in the anatomy textbooks. Ajmani (1983) observed the location of the GPF opposite the third maxillary molar in 64% of adult Indian skulls, in comparison to our study which was seen in 74.6% of the skulls[7]. Our study also showed the location of the GPF was opposite to the second maxillary molar in only 0.4% of the skulls, beyond the third maxillary molar in 0.8%, and between the second and third maxillary molars in 24.2% of skulls. The distance of the GPF from the midline was 14.7 mm on both sides in our study and almost equal to the data given by Ajmani (1983), i.e., 14.7 mm on right side and 14.6 mm on the left side. The GPF was  $16.2 \pm 1.3$  mm lateral to the median sagittal plane in the Thai skulls. The distance from the GPF to the incisive fosse was 37.3 mm on the left side and 37.2 mm on the right side in our study.

The distance of the GPF from the posterior border of hard palate on both sides was fairly constant, at a mean of 4.2 mm; Westmoreland and Blanton (1994) found a mean distance of 0.19 cm, from the posterior border of hard palate [8]. Methathrathip et al (2001) reported the GPF  $2.1 \pm 1.3$  mm anterior to the posterior border of the hard palate in Thais [9,10]. Ajmani found this distance to be 3.7 mm in Indian skulls. The sutural growth occurring between the palatine bone and maxilla may be one of the reasons for the increase in anteroposterior dimension of the palate with the eruption of the posterior teeth.

The GIM angle was unequal on the two sides, being more on the left side (Table I). This finding is of interest as it can reduce the attempts needed to introduce the local anesthetic agents in maxillofacial surgeries or for dental procedures<sup>[9]</sup>. This technique is also effectively useful in sinus and endodontic procedures, maxillary trauma, diagnosis and treatment of chronic oral and maxillofacial pain syndromes[11-14].

The direction of GPF in the oral cavity was forward and medially in 46.2% and forward in 41.3%, as compared to 91.4% of Indian skulls. In 82% of skulls, the GPF was directed forward<sup>[15]</sup>. The opening of the foramen was directed anterolaterally in a large number of Nigerian skulls (38.7%). This explains the variability of the GPF in different races and different geographical regions. This observation may explain the occasional difficulty encountered during surgery when attempting to insert the point of needle into the GPF[16,17].

The majority of the skulls in the present study (46.2%) showed arched palatal vaults. 37.1% were flat palates and 16.7% showed very highly-arched palatal vaults. The palatal growth takes place in length in the sagittal plane anterior to the GPF [18-21]. Bilateral symmetry in the number of LPF was seen in 40% of skulls[22]. In two skulls (1.51%), the LPF was absent on the left side. The present study gives an insight into the



relative position of the GPF. However, more skulls of different races and geographical distribution should be studied to give a more conclusive finding.

The variable GIM angle on two sides may indicate the near accuracy of the location of GPF and also the angle to be made by the needle for injecting local anesthetics for optimal pain control in maxillofacial and dental surgeries in patients where general anesthesia is contraindicated[13,14].

### CONCLUSION

In conclusion, this study shows that the perpendicular distance of GPF in Indian skulls was about 15 mm, the distance of GPF to the incisive fossa was approximately 37 mm and the GIM angle was 21 degrees. These data will be helpful in comparing the Indian skulls with those from various other regions as well as comparing skulls of different races.

### Limitation of the Study

- This study was limited to dry human adult bones with fully erupted third molar and free from any pathological changes.
- This study was limited only in a college which is not representative of the whole country.
- The study was limited to unsexed skull bones.

### Recommendations

- The study may be done in dried human skulls of known sex origin
- This study may be done to include sample to be representative of the country.

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