Analysis of Body Mass Index, the Mandible, and Dental Alveolar Arch Factors in Prediction of Mandibular Third Molar Impaction: A Pilot Study

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Abstract

Aim: The aim of this study was to determine how some physical characteristics can be used to predict the occurrence of impacted mandibular third molars.

Background: While the concept of prophylactic removal of the asymptomatic erupting or impacted mandibular third molar has generated much controversy over the years, new theories of therapeutic surgical removal of the erupting tooth and therapeutic agenesis of the tooth bud are emerging. However, there are a few studies that address the anthropometric factors that could predict an impacted mandibular third molar.

Methods and Materials: The study included Nigerian patients of both genders who were at least 16 years of age. A total of 83 subjects participated in the study; there were 44 (53 percent) females and 39 (47 percent) males.

The subjects were divided into two categories: presence of impaction (Group 1) and absence of impaction (Group 2). Impaction of the mandibular third molar was assessed by clinical and radiographic evaluation. Body mass index (BMI) of each subject was determined by measuring the body weight (BW) and body height (BH), then dividing the weight of the body by the square of the height. The mandibular index (MI) was assessed by measuring the length and width of the mandible (MW). It was calculated by dividing the width of the mandible by the length of the mandible. The mandibular length (ML) consisted of the total teeth sizes of the three anterior teeth, the two premolars, and the first and second molars. These dimensions were measured with a divider/ruler and recorded. The anterior-posterior distance of the arch from the midline to the retromolar pad (alveolar arch length) also was measured.

Results: Eighty-one (97.6 percent) of the participants were between 16 and 23 years old, while 2 (2.4 percent) were between 30 and 39 years old, of which 44 (53 percent) were women and 39 (47 percent) were men. There were 38 (45.8 percent) cases of impaction and 45 (54.2 percent) cases of unimpacted third molar. The mean and standard deviation values of BMI for the two groups in males and females were 21.10±1.90, 22.40±2.70 and 22.00±2.40, 22.30±1.99 respectively, with no significant difference, $p>0.05$, CI 95%. The two determinant factors of impaction were mandibular length and the difference between alveolar arch length ($p=0.04$) and total teeth size. Both of these variables had significant inverse correlations with impaction values of $p=0.04$ and $p=0.003$, respectively. The prediction values were 59 percent for mandibular length and 81.9 percent for differences between mandibular length and teeth sizes, respectively. The synthesized prediction value by the two determinant factors is 75.6 percent.

Conclusion: The prediction of mandibular third molar impaction was mainly dependent on two factors: the length of the mandible and the difference between arch length and total teeth size.

Clinical Significance: Small mandible, small dental arch, and large teeth are risk factors that are strongly associated with the occurrence of impacted third molars.

Keywords: Body mass index, mandible, mandibular third molar, impaction

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Introduction

The mandibular third molars develop after birth at around four to five years of age and are the last tooth to erupt in the dental arch between 17 and 25 years of age.[1] Apart from dental caries, impaction of the mandibular third molar contributes to a significant proportion of the conditions that require dental treatment.[2] Clinical, diagnostic information, and radiologic assessments provide the presence and types of impaction (mesial, vertical, horizontal, distal, transverse, ectopic).

Body parameters like weight, height, body mass index, and skull/jaw factors like the length and width of the body and ramus of the mandible as well as the alveolar arch may predispose one to have an impacted mandibular third molar.[3,4] Weight is a measure of the amount of muscle and bone content of the body, while height assesses the vertical extent of the bones in the axial and appendicular skeleton.[4]

Body mass index (BMI) assesses the amount of fat as it relates to the weight and height of the body.[4] Sizes of individual bone/tooth can be related to the total height and weight of the individual, and there is a possibility of indirect relationship between BMI and impaction.[4,5] BMI is calculated as the weight in kilograms divided by the square of height in meters: weight (kg)/[height (m^2)]. An individual with a BMI of 25.0 to 29.9 is considered overweight; an individual is considered obese if his or her BMI is 30 or greater.[4,5]

The ultimate treatment for impacted third molars is surgical extraction;[6] however, some have advocated preventive removal of impacted third molars in the course of the eruption process or prior to the complete eruption phase while others do not support it.[7–10] Considering the fact that environmental/genetically determined disproportionate sizes of the teeth, jaw/arch, and body could be major factors predisposing to impaction, the aim of this study was to determine the physical parameters that may contribute to the occurrence of mandibular third molar impaction.

Methods and Materials

A randomized control clinical study was conducted in the Department of Oral and Maxillofacial Surgery, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria, between February and October 2009. The research protocol was approved by the College of Health Sciences Research and Ethics Committee.

The study population included subjects of both genders who were at least 16 years old and students at the College of Health Sciences, University of Port Harcourt, and Rivers State School of Science and Technology undergoing their clinical rotation. Patients that attended the oral and maxillofacial clinic also were included. A total of 83 subjects participated in the study of whom 44 (53 percent) were women and 39 (47 percent) were men. Eighty-one (97.6 percent) of the participants were between 16 and 23 years old, while 2 (2.4 percent) were between 30 and 39 years old. The exclusion criteria included the following: subjects less than 16 years, patients with one or more missing teeth, individuals with retained deciduous tooth/teeth, persons with moderate to severe malocclusion, and patients with facial asymmetry.

Identification of impaction

Patients selected to participate in the study were divided into two categories: Group 1, those who had impacted mandibular third molars, and Group 2, those who did not have impacted mandibular third molars. Impaction of the mandibular third molar was determined by a clinical evaluation. Periapical radiographs were taken if the third molars had not erupted into the arch, and if it was believed that the crown of these teeth was completely submerged in soft tissue or when patients requested treatment. Treatment may have been sought for reasons such as failure of a third molar to fully erupt or the level of the third molar clinical crown was below that of the second molar. In assessing, the inclination of the third molar to the second molar, the anterior ramus of the mandible was used to determine the presence, type, and position of the impacted third molar.

Body mass index (BMI)

The body mass index (BMI) of each subject was determined by measuring the body weight (BW) and body height (BH). A standard calibrated weight measuring device (scale) was used, with the subject standing upright on the scale and removing every object of significant size. Weight was read in kilograms. Also, the height of each subject was recorded in meters using a standardized calibrated meter rule. The body mass index of each subject was calculated by dividing the weight of the body by the square of the height (weight per height squared).

The mandibular index (MI) was assessed by measuring the length and width of the mandible (Figures 1 and 2). The measurements were done directly on the face of the patient by the same person to avoid interexaminer errors, but standard linear calibrations were made. Marks were drawn with ball pen markers at specific landmarks on the face: the tragus of the ear, soft tissues in the region of the angle, and the chin. The mandibular condyle is represented on the face by the midpoint of the tragus of the ear. The angle is at the junction between the vertical part (ramus) and the horizontal part (body) of the mandible. The symphysis of the mandible is represented on the face by the soft tissue in the region of the chin.

Mandibular Length (ML)

The mandibular length (ML) is the total distance from the condyle (represented by midpoint of tragus) to the symphysis (represented by the soft tissue in the region of the chin) as shown in Figure 1. The length is determined by adding the distance from the midpoint of the tragus to the soft tissue in the region of the angle of the

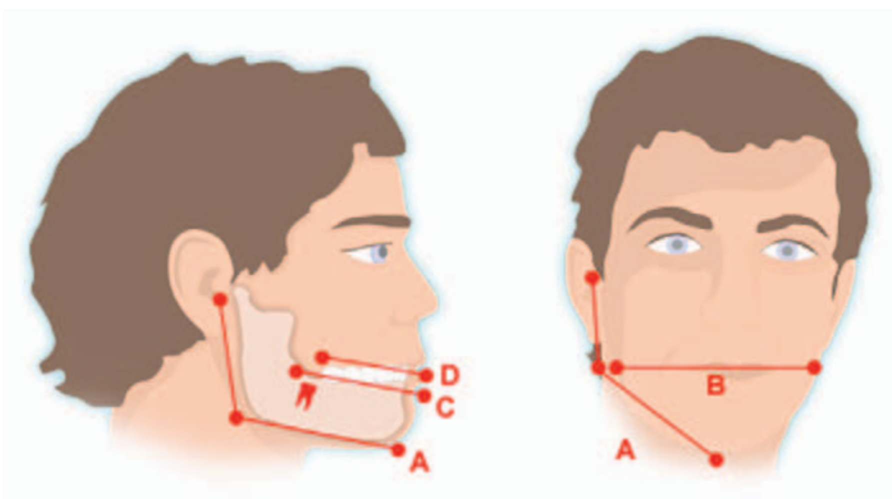

Figure 1. Side view of the face demonstrating right half of the mandible and front view of the face demonstrating mandibular width.

1.	ML or mandibular length (A): represents the addition of the linked vertical (condyle head to angle or gonium) and horizontal (angle to mentum) red lines.
2.	MW or mandibular width (B)
3.	Alveolar arch length (C)
4.	TTS or total tooth size (D)
5.	Alveolar arch length and total tooth size (C – D): represents difference between alveolar arch length and total tooth size, which is the space available for the third molar (in red) to erupt.

Figure 2. The five parameters measured.

mandible and the distance from the soft tissue in the region of the angle to that of the chin. Both distances were measured separately on the skin with a flexible tape rule and then added together to avoid the difficulty of measuring around a curve.

Mandibular Width (MW)

The mandibular width (MW) is the distance between the two angles of the mandible (Figure 2). The submental tissue folds in our subjects were not bulky so they did not impede measurement of the mandibular width. The measurements were made directly on the patients with a flexible tape rule closely adapted to displace the facial soft tissues. Rigid calipers are useful when submental tissues are bulky.

Mandibular Index (MI)

The mandibular index (MI) was calculated by dividing the width of the mandible (B) by the length of the mandible (A). These values were recorded for Group 1 (impaction) and Group 2 (no impaction).

Total Tooth Size (TTS)

The total tooth size (TTS) of the three anterior teeth, the two premolars, and the two molars (D) were measured with the two pointed sharp ends of a sterilized divider from the mathematical set. First, the three anterior teeth (the central incisors, lateral incisors, and canine) were measured, with one point of the divider touching the mesial surface of the central incisor and the other point of the divider touching the distal surface of the canine. This distance between the two points of the divider was then determined for each subject using the ruler. The same measurement was done for the two premolars and for the two molars, and the three values were added to give the total tooth size.

Dental Alveolar Arch Measurement

The anterior-posterior distance of the arch from the midline to the retromolar pad (C) on the right or left side was measured. The anterior end of the dental arch is represented by the interdental papilla between the central incisors and the posterior end of the arch is represented by the mesial edge of the retromolar pad. A sterile strip was placed between these two points in the patient's mouth for measurement; the distance was determined by marking the posterior limit on the strip with a pen; and the marked strip was removed and positioned on a ruler to determine the length of the dental alveolar arch. The difference between the dental alveolar arch and the total tooth size of the seven teeth was calculated (C – D) and recorded for both groups.

Statistical Analysis

Descriptive statistics (frequency, mean, and standard deviation) were calculated for each variable (BW, BH, BMI, MW, ML, MI, and difference between the dental arch length and total tooth size) for the two groups. The data were analyzed using the statistical package of the SPSS version 10 (SPSS, Inc., Chicago, IL, USA). The one-sample t-test was used to compare differences between the groups (p=0.05, CI 95% and p=0.01, CI 99% for differences between the dental arch and total tooth size). Values of p less than 0.05 and 0.01 were considered statistically significant.

Univariate analysis of the relationship between impacted teeth and the various factors was done and the coefficient of regression for individual and combined factors was analyzed with a multiple logistic regression construct. The third molar impaction represented the dependent factor; the individual and combined contributions of the factors were determined. Significance of correlation was tested using the Spearman's correlation coefficient for discrete variable comparisons.

Results

Among the total 83 test subjects, there were 38 (45.8 percent) cases of impaction (Group 1) and 45 (54.2 percent) cases of nonimpacted mandibular third molars (Group 2). The mean and standard deviation values of BMI for the two groups in males and females were 21.10±1.90 and 22.40±2.70 for Group 1 and 22.00±2.40 and 22.30±1.99 for Group 2, respectively. There was no significant difference between the two groups in both genders (p>0.05, CI 95%), as shown in Tables 1 and 2.

Mandibular Index and Alveolar Arch Length

The values for mandibular index for the two groups in males and females were 0.78±0.07 and 0.78±0.08 (Group 1) and 0.78±0.05 and 0.75±0.06 (Group 2) respectively. There was no significant difference between the two groups (p>0.05, CI 95%) as shown in Tables 3 and 4.

Alveolar Arch

The values for the difference between dental arch and total tooth size are 0.85±0.14 and 1.09±0.11

Table 1. Ranges, means, and standard deviations of body variables for males (n=39) in Group 1 and Group 2.

Variables	Diagnosis	Impaction (n=15) No impaction (n=24)		
		Min.	Max.	Mean±SD
Weight (kg)	Impaction	53.00	73.00	62.30±5.90
	No impaction	51.00	78.00	63.40±8.30
Height (m)	Impaction	1.63	1.80	1.71±0.04
	No impaction	1.55	1.84	1.68±0.06
Body mass index (kg/m^2)	Impaction	18.80	24.40	21.10±1.90
	No impaction	18.50	27.90	22.40±2.70

Table 2. Ranges, means, and standard deviations of body variables for females (n=44) in Group 1 and Group 2.

Variables	Diagnosis	Impaction (n=23) No impaction (n=21)		
		Min.	Max.	Mean±SD
Weight (kg)	Impaction	46.00	73.00	55.70±7.00
	No impaction	45.00	70.00	56.30±6.40
Height (m)	Impaction	1.50	1.73	1.59±0.05
	No impaction	1.50	1.76	1.59±0.07
Body mass index (kg/m^2)	Impaction	17.70	29.20	22.00±2.40
	No impaction	19.20	26.60	22.30±1.99

Table 3. Ranges, means, and standard deviations of mandible and dental arch variables for males (n=39) in Group 1 and Group 2.

Variables	Diagnosis	Impaction (n=15) No impaction (n=24)		
		Min.	Max.	Mean±SD
Mandibular width (cm)	Impaction	12.50	16.00	14.20±0.96
	No impaction	12.50	16.00	14.10±0.96
Mandibular length (cm)	Impaction	17.00	20.50	18.20±0.98
	No impaction	16.00	20.50	18.20±1.13
Mandibular index	Impaction	0.61	0.86	0.78±0.07
	No impaction	0.63	0.91	0.78±0.08
Alveolar arch length (cm)	Impaction	6.00	7.40	6.68±0.39
	No impaction	6.20	7.40	6.80±0.33
Total tooth size (cm)	Impaction	5.10	6.30	5.80±0.39
	No impaction	5.20	6.20	5.70±0.29
Diff. in arch length and tooth size (cm)	Impaction	0.60	1.20	0.85±0.14
	No impaction	0.80	1.40	1.09±0.11

Table 4. Ranges, means, and standard deviations of mandible and dental variables for females (n=44) in Group 1 and Group 2.

Variables	Diagnosis	Impaction (n=23) No impaction (n=21)		
		Min.	Max.	Mean±SD
Mandibular width (cm)	Impaction	11.50	15.00	13.30±0.87
	No impaction	12.00	15.00	13.20±0.83
Mandibular length (cm)	Impaction	15.50	18.50	17.20±0.76
	No impaction	15.30	19.00	17.60±1.07
Mandibular index	Impaction	0.68	0.85	0.78±0.05
	No impaction	0.63	0.91	0.75±0.06
Alveolar arch length (cm)	Impaction	5.90	6.80	6.48±0.22
	No impaction	6.00	7.10	6.48±0.25
Total tooth size (cm)	Impaction	4.90	5.90	5.47±0.27
	No impaction	5.00	6.00	5.43±0.26
Diff. in arch length and tooth size (cm)	Impaction	0.60	1.10	0.91±0.15
	No impaction	0.90	1.20	1.03±0.07

Table 5. Relationship of individual variables with impaction for all subjects.

Variables	Correlation		
	Spearman's Rho Coefficient	Test of Significance; *p*=0.05 or *p*=0.01	
		1-tail	2-tail
Mandibular width	1.000	0.500	1.000
Mandibular length	–0.193*	0.040	0.081
Mandibular index	0.137	0.108	0.217
Weight	–0.112	0.156	0.312
Height	0.008	0.473	0.946
Body mass index	–0.147	0.093	0.185
Alveolar arch length	–0.162	0.071	0.143
Total tooth size	0.084	0.226	0.453
Difference in arch length and total tooth size	–0.567**	0.003	0.003

*Significant a $p<0.05$.
**Significant at $p<0.01$.

(males, Groups 1 and 2, respectively) and 0.91±0.15 and 1.03±0.07 (females, Groups 1 and 2, respectively). There was a significant difference ($p<0.01$, CI 99%) (Tables 3 and 4).

Values for other variables are shown in the Tables 1, 2, 3, and 4. There were significant differences for body weight and mandibular length, $p<0.05$, CI 95%.

The relationship between individual variables and impaction was shown in Table 5.

Mandibular length and the difference between alveolar arch length and total tooth size were the main variables that were related and determined the presence of impaction. Both of these variables had a significant inverse correlation with impaction and a correlation coefficient of –0.193 ($p=0.04$) for MI and –0.567 ($p=0.003$) for the difference between alveolar arch length and total tooth size. However, none of the body variables was found to be related to impaction ($p> 0.05$).

The data for the logistic regression coefficient and the contributing prediction value of each variable are presented in Table 6.

Table 6. Individual variable logistic regression coefficient and individual percentage prediction for impaction in all subjects.

Variable	Logistic Regression			
	Coefficient	Standard Error	Significance p=0.05,0.01	Percentage Prediction (%)
Mandibular width	–0.025	0.225	0.910	54.2
Mandibular length	–0.303	0.214	0.156	59.0
Mandibular index	3.112	3.300	0.346	54.2
Weight	–0.030	0.029	0.307	57.8
Height	–0.091	2.742	0.974	54.2
Body mass index	–0.134	0.099	0.178	60.2
Alveolar arch length	–1.148	0.674	0.088	55.4
Total tooth size	0.534	0.690	0.439	53.0
Difference in arch length and total tooth size	–12.103	2.946	0.000 p<0.01	81.9

Table 7. Combined logistic regression of all the variables and summation of percentage prediction for impaction in all Groups 1 and 2.

Variables	Coefficient	Standard Error	Significance (p=0.05)	Percentage Prediction
Mandibular width	–0.408	0.931	0.661	54.2%
Mandibular length	–0.513	0.751	0.494	59.0%
Mandibular index	9.973	16.155	0.537	54.2%
Weight	0.341	0.309	0.270	57.8%
Height	–20.031	22.888	0.381	54.2%
Body mass index	–0.937	0.819	0.253	60.2%
Alveolar arch length	–5.009	4.576	0.274	55.4%
Total tooth size	6.782	4.743	0.153	53.0%
Difference in arch length and total tooth size	–8.738	5.060	0.084	81.9%
Mean value for all variables	43.816	38.597	0.256	81.9%
Mean value for the absolute variables	–33.782	29.124	0.189	75.6%

Mandibular length and the difference between dental arch length and total tooth size gave predictive values of 59 percent and 81.9 percent, respectively, with corresponding regression coefficient of –0.303 and –12.103. The other variables provided varying levels of predictive value and were found not to be absolute predictors for impaction of mandibular third molars.

From a combined logistic regression model of all the variables and the constant (Table 7), an overall percentage prediction of 81.9 percent was obtained; however, the synthesized prediction value by the two absolute predictors was 75.6 percent, suggesting that the estimated contribution by the other variables is only about 6.0 percent.

Discussion

The predictability index of mandibular third molar impaction is an important tool useful not only for determination of the probable occurrence of impaction but also for serving to avert the associated pre- and post-morbid problems through proper counsel, meticulous evaluation, and timely intervention.

In this study, the occurrence of mandibular third molar impaction was assessed by clinical anthropometric variables that include physical body factors (weight, height, and body mass index), mandibular factors (width, length, and index), and alveolar arch factors (arch length, total tooth size, and difference). These factors are invariably determined by the differential and complex effects of the interplay of both genetic and environmental influences on the pattern and direction of growth and development of the whole skull.[11–14]

Akadiri et al[11] described the various factors that influence the eruption of the third molar and factors that predict the degree of difficulty of the surgical extraction of this tooth. Furthermore, difficulties with surgical removal of the mandibular third molar are related to the depth of impaction and most probably the density of cortical bone around the tooth. However, the relationship between the density and prevalence of impaction itself is not well established.[11]

Among the factors that have been documented to contribute to the third molar eruption/impaction are growth of the jaws, tooth development, the direction of eruption, and the direction of growth of both teeth and jaw.[15,16] While direction of growth and eruption may not be easily assessed objectively, the extent of growth of the jaws/alveolar arch and sizes of the teeth can be evaluated.

Many authors have asserted that mandibular third molar impaction is associated with insufficient growth of the mandible.[13–16] They documented mandibular length as the single most important factor in the determination of third molar impaction. This view is consistent with the findings of this study, in which mandibular length has been found to contribute significantly to third molar impaction.

Also, the amount of space in the arch between the distal surface of the second molar and the anterior border of the ascending ramus has been invaluable in predicting the eruption of the tooth into its proper position of functional occlusion.[13,17] Bjork et al[13] suggested that the likelihood of impaction decreases as this distance increases. In this study, there was a significant inverse relationship between this distance variable and occurrence of impaction with a high predictive value. The summation of the predictive effect of both contributory variables was also highly significant when compared with the other variables used in this study.

It is important to mention that body characteristics such as BMI did not have an absolute contribution to impaction. In other words, weight (which is a reflection of the muscle and bone mass), height (a reflection of stature/appendicular and axial length), and body mass index (a measure of body fat) do not necessarily translate to or predict the occurrence of impaction in an individual. Also, mandibular width, which may be a measure of both the extent and the pattern of growth, did not have a significant contribution to prediction of third molar impaction in this study. The reason for this is not particularly clear, but unlike the individual anterior-posterior (length) dimension of the mandible, which is constant, the transverse diameter (width) varies at different positions. In other words, intercondylar width is slightly different from angle to angle distance and very much different from intercanine distance because of the u-shaped mandible. Therefore, it may be difficult to correlate width of the bone with insufficient growth and impaction of the lower third molar. In other words, the width may just be a determinant or reflection of shape rather than size of the mandible. However, additional studies with radiograph evaluations may be needed to assess the relationship of these transverse dimensions with third molar impaction.

Prediction of the eruption of third mandibular molars has been reported by some research for patients as young as 8 or 9 years of age.[12,13] However, this methodology can be criticized because, with the primary dentition, the teeth present are smaller in sizes and mandibular growth is not complete at this age. Jaw and arch size increase with increasing age up to and after puberty; arch size decreases with a relative increase in the size of the erupted permanent teeth.[18–21] Therefore, it is more reliable to mark predictions when the growth of the jaw/arch space is relatively stable and the permanent dentition is fully erupted.

It was observed in this study that there is a possibility of impaction even when crowding occurs in the spacing in the anterior segment of the alveolar arch. In other words, the occurrence of impaction is not necessarily dependent on the dimensions of the anterior or posterior segments of the arch only but indirectly on both the total dimension of both the anterior/posterior segments of the arch and the sizes of each tooth in the arch.[22] Again, it appears that the length of the arch is inversely linked to the width of the mandibular ramus.[23–25] Consequently, when assessing the individual anterior-posterior dimension (length), one may expect that with a larger ramus width, the arch length may be too short to accommodate the eruption of third molars.[26–28]

In the absence of three-dimensional and other forms of imaging, such as computerized tomography (CT) scans, panoramic radiographs, and cephalometric radiographs, clinical anthropometric measurements are very useful because of the small thickness of overlying soft tissues. As a matter of fact, plain radiologic/tomographic views may have to be corrected to compensate for image enlargement or reduction secondary to various possible radiographic faults.

Conclusion

In this study, the prediction of mandibular third molar impaction was mainly dependent on two factors: the length of the mandible and the arch length/total tooth size difference. In fact, the contribution of both of these variables was quite significant.

Clinical Significance

Small mandible, small dental alveolar arch, and large teeth are risk factors that are strongly associated with the occurrence of impacted third molars because of the high predictive values obtained for the length of the mandible and differences in the dental alveolar arch length and total tooth size. Therefore, it is recommended that clinicians may be justified in performing preventive surgical removal of the impacted lower third molars of the post-pubertal patients with small a mandible and large teeth.

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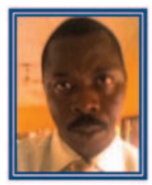

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