

# Skeletal and dental characteristics of subjects with incompetent lips

Ali H. Hassan, BDS, PhD, Azza A. Turkistani, BDS, Mona H. Hassan, MPH, PhD.

## ABSTRACT

**الأهداف:** لتقييم الخصائص السفالومترية في عينة من الناس الذين لديهم شفاه مفتوحة ولمعرفة أهم المتغيرات المسببة لهذه المعضلة من بين: بروز الأسنان، والانحناء السفوي للأسنان، وعلاقات الهيكل العظمي الرأسية وأبعاد شفة.

**الطريقة:** أجريت هذه الدراسة بأثر رجعي في جامعة الملك عبد العزيز، جدة، المملكة العربية السعودية، خلال الفترة ما بين 2011م و 2012م. تم جمع أشعاع سفالومترية 84 شخصاً ( 22 ذكور و 62 إناث ، تتراوح أعمارهم بين  $20.18 \pm 3.65$  سنة ) تم تشخيصهم على ان لديهم شفاه مفتوحة وتمت مقارنة مع المجموعة الضابطة لديها شفاه مثالية الوضع، مطابقة في العمر والجنس. وجرى تقييم ومقارنة خمسة وثلاثين من القياسات الخطية والزاوية. وتم إجراء تحليل التمايز التدريجي لمعرفة الأسباب وراء العضة المفتوحة.

**النتائج:** بالمقارنة مع المجموعة الضابطة، تميزت المجموعة بعدة مزايا هيكلية وسنية ومزايا خاصة بالشفاه أيضاً، وكانت أهم صفات التمايز بين من لديهم شفاه مفتوحة ممن لديهم شفاه مثالي الاتي: الزاوية بين القاطع العلوي والسفلي، ارتفاع الفرع من الفك السفلي، طول قاعدة الجمجمة الأمامية، ميلان محور الفك العلوي، الارتفاع السنخي العلوي والسفلي وطول وعرض الشفاه العلوية.

**الخلاصة:** يتميز المرضى الذين يعانون من شفاه مفتوحة بلامح متميزة تشمل قصر ونحف الشفة العليا وميزات أخرى سننية وهيكلية ويمكن أن يعزى ذلك لأكثر من سبب وليس فقط بروز الفكين. ينبغي اعتبار هذه العوامل وليس فقط بروز الأسنان عند علاج من لديهم شفاه مفتوحة.

**Objectives:** To evaluate the cephalometric features of subjects with incompetent lips, and to find the most discriminant variables for lip incompetence among the following: dental protrusion and proclination, antero-posterior and vertical skeletal relationships, and lip dimensions.

**Methods:** This retrospective study was conducted at King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia, between 2011 and 2012. Cephalograms of 84 subjects (22 males and 62 females, aged  $20.18 \pm 3.65$  years) diagnosed as having incompetent lips were collected (incompetent group [IG]) and compared with the control group (CG), matching in age and gender distribution. Thirty-five measurements were compared between the 2 groups using independent t-test. Stepwise discriminant analysis of lip incompetence was performed.

**Results:** Compared to the CG, subjects in the IG had thinner upper lips, shorter upper and lower lips, more retrognathic facial types, greater angle between nasion-point A and nasion-point B, shorter anterior and posterior cranial bases, shorter palatal length, shorter mandibular body length, shorter ramal length, steeper mandibular plane, less prominent chin, bimaxillary dental protrusion, and smaller inter-incisal angle. The significant discriminant variables, in order, were inter-incisor angle, inclination of upper incisors, ramal height, anterior cranial base, palatal plane to Frankfort horizontal plane angle, lower and then upper anterior dental height, upper lip thickness, and length.

**Conclusions:** The presence of incompetent lips can be attributed to more than one factor and not only bimaxillary protrusion. This should be considered during the treatment planning of such problem.

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*From the Department of Orthodontics (Hassan A), Saudi Board in Orthodontics (Turkistani), Department of Dental Public Health (Hassan M), Faculty of Dentistry, King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia.*

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*Address correspondence and reprint request to: Dr. Ali H. Hassan, Department of Orthodontics, Faculty of Dentistry, King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia. E-mail: aakbr@kau.edu.sa*

Lip incompetence is a common complaint among patients and is usually attributed to excessive protrusion of incisors.<sup>1</sup> Incompetent lips is a term used to describe lips that are separated more than 3–4 mm and unable to close adequately at rest.<sup>1</sup> This can be considered a pathological problem, which can result in serious oral complications due to the presence of inadequate lip seal, which can indirectly lead to esthetic, orthodontic, and periodontal problems. It is a problem of interest in many different specialties that deal with lip esthetics such as plastic surgery, maxillofacial surgery, periodontics, and orthodontics. Distinction between incompetent lips and prominent lips is important during orthodontic treatment planning. The presence of incompetent lips is considered as a pathological problem, which is treated by extraction of teeth to allow retraction of incisors.<sup>2–4</sup> Lip prominence without incompetence can be considered a normal finding, which does not require a treatment.<sup>1</sup> This type of lip prominence is strongly influenced by racial and ethnic backgrounds. For example, Asians, Africans, and Middle-Easterners have greater degrees of normal lip prominence when compared to Caucasians.<sup>5–9</sup> The concept that incompetent lips is solely a consequence of bimaxillary dentoalveolar protrusion (BDAP) and requires extraction type of orthodontic treatment is popular in the orthodontic literature, although it is not always accurate. Several previous studies evaluated the cephalometric features of patients with BDAP and concluded that lip incompetence is a consequence of BDAP,<sup>2,7,9</sup> without paying attention to other skeletal and soft tissue discrepancies which might be involved in the etiology of this problem, although their assessment is critical for better outcome of treatment. In addition, incisor retraction for the purpose of resolving lip incompetence in some cases might not be adequate to resolve the problem and other options of treatment, such as dental intrusion, orthognathic surgery, or possible soft tissue cosmetic work might be the choice of treatment. These possible etiological factors include vertical and sagittal skeletal and dental discrepancies, as well as discrepancies in lip morphology and dimensions. Unfortunately, there is no single study in the literature evaluated the etiological background of lip incompetence. We hypothesize that lip incompetence is a multifactorial in nature and cannot be blamed solely on BDAP. This retrospective study was designed to investigate the skeletal and dental characteristics of subjects with lip incompetence. The aims of this study is to evaluate the cephalometric features of patients with incompetent lips, to find the most discriminant features to the etiology of lip incompetence among the following

dental protrusion and proclination, antero-posterior skeletal relationships, vertical skeletal relationships, and lip dimensions.

**Methods.** The ethics committee approval was granted by the Research Ethics Committee of the Faculty of Dentistry at King Abdulaziz University, Jeddah, Saudi Arabia. This study was carried out in compliance with the Helsinki Declaration. A literature search was performed to identify all relevant studies to be used in the current study and evaluated the lip incompetence, etiology, and bimaxillary protrusion. A systematic literature search was carried out between 1990 and 2013 in PubMed and Medline using key words such as lip incompetence, bimaxillary protrusion, bimaxillary dentoalveolar protrusion, and cephalometric.

In this retrospective study, cephalometric radiographs of 84 adult patients (22 males and 62 females, aged  $20.18 \pm 3.65$  years) diagnosed as having incompetent lips were collected from the records of the Saudi Board in Orthodontics clinics in King Abdulaziz University, Faculty of Dentistry, between 2007 and 2010 (incompetent group [IG]) (Table 1 & 2).

Inclusion criteria were adult healthy subjects, fairly symmetrical faces, no previous trauma, no previous orthodontic treatment, and lips separated at rest not less than 3 millimeters. Exclusion criteria were patients with syndromes, any medical illnesses, severe Class II or Class III malocclusion, severe open bite or deep bite, and history of orthodontic treatment. A control group (CG), age and gender matched, was also collected from the data used in a previous study to establish Saudi norms. The CG had balanced and acceptable facial profiles, minimum overbite and overjet, Class I skeletal and dental relationships, competent lips, and no previous orthodontic treatment.<sup>8</sup> Radiographs were scanned and then traced and analyzed using Dolphin Imaging 10.0 software (Dolphin Imaging and Management Solution, Chatsworth, California, United States). Magnification errors were counted by entering the actual length of the ruler from the head positioner in the Dolphin software. Analysis was performed by a single operator to minimize potential bias. Analysis included 35 linear and angular measurements (Table 1). To assess error of measurements, a second analysis was performed, 10 days after the first analysis by the same examiner for 10 randomly selected radiographs.

**Statistical analysis.** A post-hoc power analysis was performed using G\*Power Version 3.1.5.<sup>10</sup> A one-to-one ratio between IG and CG revealed that a sample size of 84 cases and 84 controls provide a 0.896 power to detect significant differences with 0.50 effect size at  $\alpha=0.05$

error. The mean values and standard deviations were measured for each variable and were compared between the 2 groups using independent samples t-tests. Stepwise discriminant analysis of lip separation was performed to determine the most significant discriminating variables between the 2 groups. Statistical Package Software System, version 16 (SPSS Inc., Chicago, Illinois, USA) was used in performing the previously mentioned analyses.

**Results.** The mean error in linear measurements was 0.25 mm and in angular measurements was 0.31° with an intra-examiner reliability ranging from 0.84-0.97. The demographic data of the patients showed age and gender matched (Table 2). Subjects in the IG had significantly larger inter-labial gap, thinner upper lips, shorter upper and lower lips, more prominent upper ( $p=0.001$ ) and lower ( $p=0.000$ ) lips, more acute

naso-labial angle and more protruded upper and lower lips relative to E-line compared with the CG (Table 3). Skeletally, subjects in the IG had more retrognathic facial types (facial angle) ( $p=0.015$ ), more positive

**Table 2 -** Demographic data of study samples.

Demographic data	Incompetent group (n = 84)	Control group (n = 84)	P-value*
<i>Gender</i>			0.722
Male	22 (26.2)	20 (23.8)	
Female	62 (73.8)	64 (76.2)	
<i>Age (years)</i>			0.850
<20	41 (48.8)	39 (46.4)	
20-24	27 (32.1)	26 (31.0)	
25-30	16 (19.0)	19 (22.6)	
Mean (SD)	20.18±3.65	21.21±3.12	0.053

\*Chi square for gender/age groups and t-test for mean age

**Table 1 -** Cephalometric angular and linear measurements used in the present study.

Variable	Definition
NPg-SN	Facial plane angle: between nasion-pogonion and sella-nasion angle
SNA (°)	Angle between sella-nasion line and nasion-A point line
SNB (°)	Angle between sella-nasion and nasion-B point
ANB (°)	Angle between nasion-point A and nasion-point B
ANS-PNS (mm)	Palatal plane length: distance between anterior nasal spine (ANS) and posterior nasal spine (PNS)
S-N (mm)	Anterior cranial base length
S-Ba (mm)	Posterior cranial base length
Go-Me (mm)	Length of mandibular body
SN-MP (°)	Mandibular plane angle: between (Go-Gn) and S-N line
PP-FH (°)	Palatal plane angle: between (ANS-PNS) and Frankfort horizontal line
Co-Me (mm)	Mandibular ramal height
ANS-Gn (mm)	Lower face height
N-Gn (mm)	Total face height
A-NV (mm)	Distance between point A and nasion vertical line
Pg-NV (mm)	Distance between pogonion and nasion vertical line
Pg-NB (mm)	Distance between pogonion and NB line
LI-NB (mm)	Distance between labial surface of lower incisors and NB line
LI-MP (°)	Angle between long axis of lower incisors and mandibular plane
LI-NB (°)	Angle between long axis of lower incisors and NB line
UI-NA (mm)	Distance between labial surface of upper incisors and NA line
UI-SN (°)	Angle between long axis of upper incisors and SN line
UI-NA (°)	Angle between long axis of upper incisors and SN line
UI-LI (°)	Angle between long axis of upper incisors and long axis of lower incisors
UADH (mm)	Distance between incisal edge of maxillary central incisor and its apex
LADH (mm)	Distance between incisal edges of mandibular central incisor and its apex
U-lip thick (mm)	Distance between vermilion border of upper lip to labial surface of upper central incisors
U-lip length (mm)	Distance from base of the nose to the inferior border of the upper lip
L-lip thickness	Distance from vermilion border lower lip to labial surface of lower central incisors
U-lip prominence (mm)	Perpendicular distance from most anterior point of the upper lip to the line connecting soft tissue subnasale to soft tissue pogonion
L-lip prominence (mm)	Perpendicular distance from most anterior point of the lower lip to the line connecting soft tissue subnasale to soft tissue pogonion
U. Lip-E line mm	Distance between upper lip and esthetic (nose-chin) line.
L. lip-E line mm	Distance between lower lip and esthetic (nose-chin) line.
Inter-labial gap	The vertical distance between upper and lower lips
NLA (°)	Angle between line tangent to base of the nose and line tangent to upper lip.

**Table 3** - Comparison of lip dimensions between incompetent and control groups.

Lip dimensions (soft tissue)	Incompetent group (n=84)		Control group (n=84)		P-value
	Mean	SD	Mean	SD	
Upper lip thickness	12.43	2.22	13.83	2.45	0.000*
Upper lip length	23.54	3.74	25.13	2.98	0.003*
Upper lip prominence	6.58	2.97	5.30	1.70	0.001*
Lower lip thickness	14.58	2.12	14.79	1.98	0.520
Lower lip length	17.07	2.54	19.70	2.02	0.000*
Lower lip prominence	6.48	2.51	5.15	2.06	0.000*
Upper lip-E line	-0.40	3.31	-2.81	2.10	0.000*
Lower lip-E line	2.51	3.40	0.36	2.42	0.000*
Naso-labial angle	90.32	9.74	98.64	9.27	0.000*
Inter labial gap	6.80	2.40	0.51	0.72	0.000*

\*p<0.05 (significant) t-test

maxilla-mandibular sagittal discrepancies (increased angle between Nasion-point A and Nasion-point B planes [ANB°]), shorter anterior and posterior cranial bases, shorter palatal length (ANS-PNS), shorter mandibular body length (Go-Me), less prominent chins (Pog-NB distance) steeper mandibular plane (MP\_SN), flatter palatal plane (PP-FH), and shorter ramal height (Co-Go) (Table 4). Lower face height and total face height were insignificantly different between the 2 groups. Dentally, subjects in the IG had significantly more proclined and protruded upper incisors, more proclined lower incisors and smaller inter-incisal angle. Upper and lower anterior dental heights were insignificantly different between the 2 groups (Table 5).

The significant variables that added to the discrimination between the 2 groups are presented in Table 6. The discriminant dental variables, in sequence from the most significant to the least significant, were inter-incisor angle, upper incisor inclination to SN, and upper and lower anterior dental heights. The discriminant soft tissue variables, in sequence from the most significant to the least significant, were naso-labial angle, upper lip prominence to the E-line, upper lip thickness, and upper lip length. The discriminant skeletal variables, in sequence from the most significant to the least significant, were Co-Go, the inclination of PP-FH, and anterior cranial base length.

**Discussion.** Lip incompetence is a condition characterized by excessive separation of lips and can be attributed to more than one etiological factor. The presence of incompetent lips is considered as a pathological problem, which if untreated, can result in several oral complications due to the presence of inadequate lip seal. These possible complications

**Table 4** - Skeletal linear and angular measurements between incompetent and control groups.

Skeletal	Incompetent group (n = 84)		Control group (n = 84)		P-value
	Mean	SD	Mean	SD	
<i>Antero posterior</i>					
Facial angle	78.27	3.51	79.70	3.98	0.015*
SNA angle	83.60	3.59	82.81	2.96	0.123
SNB angle	77.98	3.36	78.23	2.23	0.559
ANB angle	4.60	2.73	3.57	2.00	0.006*
ANS_PNS mm	53.14	4.72	54.70	3.82	0.020*
Anterior cranial base length	70.65	4.21	73.43	3.77	0.000*
Posterior cranial base length	46.40	3.69	47.81	3.80	0.016*
Go Me Length	72.42	5.98	74.98	4.34	0.002*
A-NV distance	1.80	4.09	1.17	3.66	0.297
Pg-NV distance	-6.52	7.33	-4.30	7.34	0.051
Pg-NB distance	1.23	1.93	1.81	1.32	0.024*
<i>Vertical</i>					
MP_SN angle	35.54	5.28	32.72	4.96	0.000*
PP_FH angle	.893	4.29	3.14	2.96	0.001*
Lower face length (ANS-Gn)	67.20	5.67	67.57	5.49	0.666
Total face length (N-Gn)	119.26	7.59	121.02	7.77	0.140
Co-Go length	54.85	5.42	59.06	6.30	0.000*

\*p<0.05 (significant) t-test, SNA - angle between sella-nasion line and nasion-a point line, SNB - angle between sella-nasion and nasion-B point, ANB - angle between nasion-point A and nasion-point B, ANS - anterior nasal spine, PNS - posterior nasal spine, Go Me - length of mandibular body, A-NV - distance between point A and nasion vertical line, Pg-NV - distance between pogonion and nasion vertical line, Pg-NB - distance between pogonion and NB line, MP\_SN - mandibular plane angle: between (Go-Gn) and S-N line, PP\_FH - palatal plane to Frankfort horizontal plane angle, ANS-Gn - Lower face height N-Gn - total face height, Co-Go - mandibular ramal height

include poor facial esthetics, the development of open bite, and gingival inflammation related to incisors.<sup>1</sup> Due of the negative perception of protrusive dentition in most cultures, many patients with dental protrusion associated with incompetent lips seek orthodontic care to decrease this procumbency.<sup>2</sup> Patients with incompetent lips also seeks orthodontic correction regardless of whether they have dental protrusion or not. Unfortunately, there is a paucity of information in the literature in terms of the overall skeletal and dental characteristics related to lip incompetence. Unlike several other studies that investigated the cephalometric features of patients having lip procumbency as a linked problem to bimaxillary protrusion,<sup>2,7,9</sup> the present study evaluated the cephalometric features of subjects with incompetent lips, regardless of the status of their upper and lower incisors, in order to investigate the etiological background for this clinically important

**Table 5** - Dental linear and angular measurements.

Dental	Incompetent group (n=84)		Control group (n=84)		P-value
	Mean	SD	Mean	SD	
<i>Antero posterior</i>					
Upper incisor-NA distance	6.87	2.60	5.55	2.38	0.001*
Upper incisor-SN angle	113.81	6.91	105.06	9.20	0.000*
Upper incisor-NA angle	30.98	7.48	23.13	7.05	0.000*
Lower incisor-MP angle	101.42	8.33	98.32	6.87	0.009*
Lower incisor-NB angle	34.15	6.50	29.19	5.34	0.000*
Lower incisor-NB distance	8.40	2.68	7.81	4.48	0.297
Upper incisor-Lower incisor angle	110.61	9.84	123.17	9.29	0.000*
<i>Vertical</i>					
Upper anterior dental height	29.52	3.52	29.49	3.05	0.946
Lower anterior dental height	44.49	5.80	43.04	3.69	0.054

\* $p < 0.05$  (significant) t-test, NA - nasion-A point line, SN - sella-nasion line, MP - Mandibular plane, NB - nasion-B point

**Table 6** - Results of stepwise discriminant analysis of lip separation by different cephalometric measurements.

Cephalometric measurements	Function at group centroids for incompetent group	Wilks' Lambda	Standardized canonical discriminant function coefficients	Correctly classified (%)	
				Original	Cross-validated
<i>Skeletal</i>					
Co-Go length (ramal height)	-0.529	0.885	0.636	68.1	65.8
PP_FH angle		0.824	0.431		
Anterior cranial base length		0.799	0.391		
Facial angle		0.780	0.331		
<i>Dental</i>					
Inter-incisal angle	-0.789	0.696	0.719	75.9	74.9
Upper incisor-SN angle		0.662	-0.491		
Lower anterior dental height		0.637	0.337		
Upper anterior dental height		0.614	-0.324		
<i>Soft tissue</i>					
Naso-labial angle	-0.805	0.719	0.643	79.8	79.8
Upper lip-E line		0.723	-0.652		
Upper lip thickness		0.663	0.593		
Upper lip length		0.622	0.288		

Cross-validated using the leave one out method, Inter labial gap was not included in the model as it is a main factor in diagnosis of cases, all model are statistically significant ( $p < 0.001$ ), Co-Go - Mandibular ramal height, PP\_FH - palatal plane to Frankfort horizontal plane angle, SN - sella-nasion line

distinction. Unlike other studies, which evaluated BDAP associated with incompetent lips in subjects with Class I relationship,<sup>7,9</sup> the present study evaluated subjects with lip incompetence regardless of their sagittal skeletal relationships, except for the severe Class II and severe Class III relationships, for which subjects were excluded. In general, it is unfair to compare the findings of the present study with the previous studies, which evaluated incompetent lips as a consequence of BDAP, except for certain specific aspects. Subjects with incompetent lips were found to have distinct dental, skeletal, and facial soft tissue features that distinguish them from control subjects. Dentally, subjects having

incompetent lips were characterized by bimaxillary dentoalveolar proclination, protrusion of upper incisors, and a decreased inter-incisal angle. This is in agreement with several previous studies<sup>2,7,9</sup> except for the lower incisor protrusion, which was insignificantly increased in the IG in the present study. In addition, the previous studies did not define status of lips as related to bimaxillary protrusion except in terms of prominence. Skeletally, the present study found that subjects having incompetent lips have distinct skeletal features when compared to the CG. Anteroposteriorly, the most significant finding associated with incompetent lips was the shorter anterior cranial base in the IG. Other



significant findings included more retrognathic facial type, more Class II relationships, shorter mandibular body, shorter palatal plane, shorter posterior cranial base, and less prominent chin. Vertically, the most significant finding associated with incompetent lips was the steeper mandibular plane and shorter total mandibular length, followed by the flatter palatal plane. This disagrees with the findings of Aldrees and Shamlan,<sup>7</sup> who found average mandibular plane and palatal plane angles in the subjects with bimaxillary protrusion. However, it agrees with the findings of Sheikh and Ijaz,<sup>8</sup> who found steeper mandibular plane angle in their Class II sample with bimaxillary protrusion. When looking at lip morphology, the present study found that subjects with incompetent lips have shorter upper and lower lips and thinner upper lips when compared to controls. To determine the most discriminant variables of incompetent lips, stepwise discriminant analysis of lip separation by different cephalometric measurements was performed. Table 6 summarizes the significant variables in sequence of their standardized canonical discriminant function coefficients. The larger the standardized coefficient, the greater the contribution of the respective variable to the discrimination between groups. Based on this, the most discriminant skeletal variable of lip incompetence was the ramal height (which was shorter in the IG), followed by the inclination of palatal plane to SN line (which was flatter in the IG), followed by anterior cranial base (which was also shorter in the IG), and finally the facial plane angle (which was more retrognathic in IG). The most discriminant dental variable of lip incompetence was the inter-incisal angle (which was smaller in the IG), followed by the proclination of upper incisors in the IG, followed by lower anterior height (which was insignificantly shorter in the IG), and finally the upper anterior height (which was insignificantly shorter in the IG too). The most discriminant lip variable of lip incompetence was upper lip thickness (which was less in the IG), followed by upper lip length (which was shorter in the IG). Although nasolabial angle and upper lip position to the E-line were the most discriminant among the soft tissue variables, they were considered consequences of lip incompetence (Table 6).

One of the limitations of the present study was the use of 2 dimensional radiographs and not 3 dimensional, which might overlook any possible differences between the 2 groups in the transverse dimension. In addition, gender and age effects on lip incompetence were not evaluated.

The findings of the present study have many important implications. Careful evaluation of the associated skeletal and dental features should be carried out before

taking decision in the treatment of incompetent lips, which should not be a routine extraction treatment. However, all the above discriminant variables should be considered in the treatment planning and should be discussed with the patients. Other appropriate options of treatment, other than extraction, should be suggested to the patients, which might include: absolute intrusion of teeth, lip augmentation, and orthognathic surgery. Future studies are needed to elaborate more on the etiological background of incompetence lips and to evaluate the gender effect on this clinically important problem.

In conclusion, lip incompetence can be described as a multi-factorial problem, as there are different dental, skeletal, and soft tissue discrepancies behind it other than bimaxillary protrusion. Lip incompetence can be attributed to several skeletal, dental, and lip soft tissue discrepancies. These include BDAP, shorter lower and upper dental heights, shorter ramal height, flatter palatal plane, shorter anterior cranial base, more retrognathic facial types, and thinner, and shorter upper lips. All of these factors should be considered when treating patients with incompetent lips. A comprehensive consideration of the problem will result in more specific treatment strategies other than extraction.

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