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# Određivanje dentalne dobi očitavanjem sa ortopantomograma

## *Dental Age Estimation in Children Using Orthopantomograms*

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### Sažetak

Razvojne faze zubi koriste se za određivanje zrelosti i procjenu dobi u brojnim disciplinama; poput dječje i preventivne stomatologije, ortodontije, forenzične stomatologije, i dr. **Cilj:** Točnost različitih metoda nije dosad sistematično proučena u hrvatskoj populaciji pa je cilj ovog istraživanja bio odrediti točnost dvije metode; prema Demirjian-u i Haavikko. **Materijal i metode:** Razvojne faze zuba promatrale su se na ortopantomogramima (OPG) zdrave djece, pacijenata Stomatološkog fakulteta, Sveučilišta u Zagrebu. Uzorak se sastojao od 324 ortopantomograma djece u dobi od 6-16 godina (149 dječaka i 175 djevojčica). Na OPG-ovima je promatrano sedam mandibularnih zuba i određen im je stadij po skalama zrelosti zuba prema Demirjian-u i Haavikko. U obradi podataka primijenjena je deskriptivna statistika, korelacijska analiza (Spearmanov test korelacije rangova) te testovi (Lilliefors test za testiranje normalnosti distribucije, t-test za testiranje značajnosti Spearmanovog koeficijenta korelacije rangova te Mann-Whitneyev test za testiranje razlika između dječaka i djevojčica). **Rezultati:** Dentalna dob i srednja vrijednost ( $\pm$ S.D. u godinama) između dentalne i realne dobi izračunata je za obje metode. Rezultati su pokazali da Demirjian-ova metoda precjenjuje dob dok Haavikko podcjenjuje dob. Svi podaci bili su obrađeni korelacijskom i regresijskom analizom koja je pokazala da su obje aplicirane metode pokazale signifikantnu korelaciju s realnom dobi (Demirjian-ova metoda imala je koeficijent korelacije 0.93, a metoda po Haavikko 0.89,  $p < 0.05$ ). **Zaključak:** Ovo istraživanje na populaciji hrvatske djece pokazalo je visoki koeficijent korelacije za obje metode i ukazalo na njihovu mogućnost primjene u kliničkoj, znanstvenoj i forenzičnoj primjeni.

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### Adresa za dopisivanje

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### Ključne riječi

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### Uvod

Određivanje dentalne dobi danas se koristi u različitim kliničkim i znanstvenim disciplinama: u dječjoj stomatologiji, ortodontiji, arheologiji, paleostomatologiji te forenzičnoj stomatologiji (1-4). U nekim društvima kronološka dob živih osoba ima

### Introduction

Dental age determination is required in various clinical and scientific disciplines: pediatric dentistry, orthodontics, archeology, paleodontology and forensic dentistry (1-4). In certain communities, the chronological age of living people bears significant

veliko značenje zbog socijalnih olakšica, zapošljavanja i braka (5). Posljednjih godina mnogobrojni imigranti ulaze u zemlje visokog standarda, a kao jedan od najvažnijih postupaka njihova identificiranja je određivanje dentalne dobi očitavanjem s ortopantomograma (OPG), (6,7).

Dentalna dob djece temelji se na fazama rasta i razvoja mliječnih i trajnih zuba očitanih s rendgenskih snimaka, a najčešće s OPG-a.

Danas se koriste mnogobrojni postupci kako bi se odredila dentalna dob, a najčešći je onaj prema Demirijanu i suradnicima. Prvi put je opisan i objavljen godine 1973., a studija je pripremljena na temelju analize francusko-kanadske djece (8,9). Do danas je taj postupak ispitan na mnogobrojnim populacijama diljem svijeta i pokazao se vrlo primjenjiv kad je riječ o djeci bijele rase (10-15).

Svrha ovoga rada bila je odrediti dentalnu dob s OPG-a koristeći se metodama Demirijana i Haavikka te ih usporediti s poznatom kronološkom dobi na uzorku hrvatske djece.

## Materijal i metode

Dentalna baza podataka korištena u ovom istraživanju sastojala se od 324 OPG-a - 149 dječaka i 175 djevojčica u dobi od 6 do 16 godina. Rabili su se već postojeći OPG-i snimljeni prema strogim pedodontskim i/ili ortodontskim kliničkim indikacijama. Ortopantomogrami pacijenata s hipodoncijom ili hiperdonicijom te obostranim ekstrakcijama prvoga donjeg kutnjak bili su izuzeti iz istraživanja zbog nemogućnosti očitavanja vrijednosti. Očitavali su se samo OPG-i svih sedam zuba u donjem lijevom kvadrantu (za metodu prema Demirijanu), ili svih sedam zuba u donjem lijevom i svih sedam zuba u donjem desnom kvadrantu (za metodu prema Haavikku), (16). U slučaju jednostrane ekstrakcije prvoga donjeg kutnjaka, očitavala se vrijednost kontralateralnoga prvoga donjeg kutnjaka, a treći donji kutnjak nije bio uključen u istraživanje zbog čestih varijacija u pojavnosti.

Distribucija OPG-a prema dobi i spolu prikazana je u Tablici 1.

## Statističke metode

Za prikaz kronološke i postignute dentalne dobi korištena je frekvencija distribucije, srednja i standardna devijacija. Korelacija između kronološke i dentalne dobi postignuta je Spearmanovim testom

importance regarding social benefits, employment and marriage (5). Recently, countries with high living standard have noted high immigration rates, and one of the most important methods of identifying the incoming population is dental age determination through orthopantomogram (OPG) analysis (6, 7).

Children's dental age is based on phases in the growth and development of deciduous and permanent teeth, which can be seen on x-ray images. The most common x-ray image used is the OPGs.

Currently, there are a number of different methods for determining dental age, and the most widespread method is the one according to Demirijan and his associates. It was first described in 1973, and comprises a study of French-Canadian children (8, 9). This method has been tested on various populations around the world, and has proven very applicable on Caucasian children (10-15).

The purpose of this paper was to determine dental age through by OPG analysis employing Demirijan and Haavikko methods, as well as to compare the results of two methods with the actual chronological age on a sample population of Croatian children.

## Materials and methods

The dental data base used in this study consisted of 324 OPGs, 149 belonged to boys and 175 to girls, both from the ages of 6 to 16 years. The radiographs images used were already on file at the Department of Pediatric dentistry and were taken according to very strict pedodontic and/or orthodontic clinical indications. OPG's of patients with hypodontia or hyperdontia, as well as those with bilaterally extracted mandibular first molars were excluded from the study since it was impossible to obtain complete data from them. The OPGs included in the study were those with all seven teeth in the lower left and lower right quadrants (for the Haavikko method) (16). Where there was a first molar missing, the value used was from the contralateral first molar. Third molars were not included in the study due to the high degree of variability in their appearance. Table 1 shows OPG distribution by age and sex.

## Statistical methods

Chronological age and both estimates of dental age were described by frequency distribution, means and standard deviation. Correlation between chronological age and dental age was examined by

**Tablica 1.** Distribucija OPG-a prema dobi i spolu  
**Table 1** OPG distribution according to age and sex

Godine • Age	Djevojčice • Girls. Frequency %	Dječaci • Boys. Frequency %	Ukupno • Total
6	2 (1.14%)	2 (1.34%)	4
7	9 (5.14%)	11 (7.38)	20
8	26 (14.86%)	22 (11.44%)	48
9	29 (16.57%)	27 (18.12%)	56
10	31 (17.71%)	23 (15.44%)	54
11	20 (11.43%)	26 (17.45%)	46
12	16 (9.14%)	20 (13.42%)	36
13	18 (10.29%)	7 (4.70%)	25
14	13 (7.43%)	9 (6.04%)	22
15	8 (4.57%)	2 (1.34%)	10
16	3 (1.71%)	0 (0.00%)	3
Sve skupine • All Groups	175	149	324

korelacije, a razlika između kronološke i dentalne dobi testirana je pomoću Wilcoxon testa. Od neparametrijskih testova za ispitivanje normalnosti distribucije u ovom istraživanju korišten je Lilliefors test.

## Rezultati

U ovom istraživanju koristio se uzorak od 324 ortopantomograma - 175 djevojčica (54 %) i 149 dječaka (46 %) prosječne kronološke dobi 10,4, raspona godina od 6 do 16. Nakon statističke obrade podataka, kod primjene metode prema Demirjianu dobivena prosječna dentalna dob iznosila je 11,3 (od 7,0 do 16,0), a kod metode prema Haavikku bila je 9,6 (od 6,6 do 11,1). Srednja kronološka dob djevojčica bila je 10,6, a dječaka 10,1. Kod metode prema Demirjianu srednja dentalna dob djevojčica bila je 11,6, a dječaka 11, a metoda prema Haavikku dala je istu srednju dentalnu dob za oba spola - 9,6. Kada se kronološka dob usporedila s dobivenom dentalnom dobi prema Demirjianu, rezultati su pokazali da je dob prema Demirjianu kod djevojčica bila precijenjena u prosjeku za 12 mjeseci, a kod dječaka za 11 mjeseci. U odnosu prema kronološkoj dobi, dobivena dentalna dob prema Haavikku bila je podcijenjena za 12 mjeseci kod djevojčica te za 6 mjeseci kod dječaka. Dobiveni rezultati prikazani su u Tablici 2.

Uporabom deskriptivne statistike za dobivenu dentalnu dob (prema Demirjianu i prema Haavikku) konstruirane su zasebne tablice za svaku dob posebno (od 6 do 16). Rezultati su pokazali manja odstupanja dentalne dobi prema Haavikku od kronološke dobi, ali samo kod pacijenata do 12 godina. Kod starijih pacijenata metoda prema Demirjianu dala je

Spearman's rank correlation coefficient. Differences of chronological age and dental ages were tested by Wilcoxon matched pairs test. Non parametric methods were applied because of non-normality of distributions (it was tested by applying Lilliefors' test).

## Results

This study covered 324 OPG's from 175 girls (54%) and 149 boys (46%), whose average chronological age was 10,4 years old, ranging from the ages of 6 - 16. After statistical data processing, the value gained using the Demirjian method was an average dental age of 11,3 (from 7,0 to 16,0), whereas value reached with the Haavikko method was an average dental age of 9,6 (from 6,6 to 11,1). For girls, the mean chronological age was 10,6, and 10,1 for boys. The Demirjian method gave 11,6 for girls and 11 for boys, whereas the Haavikko method yielded the same mean dental age for both sexes: 9,6. When comparing chronological age and dental age according to the Demirjian method, it appears that the Demirjian method overestimates the age by an average of 12 months for girls and by 11 months for boys. When the results from the Haavikko method are compared with chronological age, the Haavikko values turn out to be underestimated by 12 months for girls and by 6 months for boys. The results are demonstrated in Table 2.

Table 3 shows mean and standard deviation of dental age estimated by both Demirjian and Haavikko for each age group (from 6 to 16). The results showed less deviation from true chronological age in the dental age values reached through the Haavikko method, but only for younger age groups (not older than 12 years). The Demirjian method gave

**Tablica 2.** Prikaz dobivene dentalne dobi u promatranom uzorku  
**Table 2** Overview of dental ages in the observed sample

	Djevojčice • Girls		Dječaci • Boys		Ukupno • Total	
	Raspon godina • Min & Max	Prosječna dob • Mean	Raspon godina • Min & Max	Prosječna dob • Mean	Raspon godina • Min & Max	Prosječna dob • Mean
		SD		SD		SD
Kronološka dob • Chronological Age	6.0 -16.0	10.6	6.0 -15.0	10.1	6.0 -16.0	10.4
		2.3		2.0		2.2
Dentalna dob • Dental age – Demirjian	7.0 – 16.0	11.6	7.2 – 15.7	11.0	7.0 – 16.0	11.3
		2.4		2.0		2.3
Dentalna dob • Dental age – Haavikko	6.4 – 11.8	9.6	6.4 – 11.8	9.6	6.6 – 11.1	9.6
		1.2		1.3		1.2
Ukupno • Total (N)	175		149		324	

bolje rezultate te se pokazala preciznijom kod starije djece.

Objekti postignute dentalne dobi prema Demirjiju i Haavikko bile su u korelaciji sa kronološkom dobi ( $p < 0.05$ ). Razlika između kronološke dobi i postignute dentalne dobi prema Demirjiju i Haavikko nije bila veća od jedne godine, dok je Wilcoxon-ov test pokazao značajnu statističku razliku.

better results and proved to be more precise when applied to older children.

Both estimates of dental age, Demirjian and Haavikko, are highly correlated with chronological age ( $p < 0.05$ ). Differences between chronological age and dental age estimates by Demirjian and Haavikko are not higher than 1 year. Wilcoxon matched pairs test showed statistically significant differences.

**Tablica 3.** Deskriptivna statistika za metode prema Demirjiju i prema Haavikko – prema dobi (N = ukupan broj, D = metoda prema Demirjiju, H = metoda prema Haavikko)

**Table 3** Descriptive statistics for the Demirjian and Haavikko methods – by age (N = total number, D = Demirjian method, H = Haavikko method)

Dob • Age	Metoda • Method	N	X (Mean)	c (Median)	Standardna devijacija • Standard deviation (Sd)
6	D	4	7.5	7.7	0.37
	H		6.7	6.7	0.39
7	D	20	8.1	8.0	0.58
	H		7.5	7.4	0.61
8	D	48	8.8	8.7	0.72
	H		8.2	8.3	0.69
9	D	56	10.1	9.9	0.87
	H		9.1	9.0	0.58
10	D	54	11.1	11.2	0.83
	H		9.6	9.6	0.51
11	D	46	12.2	12.3	0.79
	H		10.3	10.4	0.62
12	D	36	12.8	12.5	0.96
	H		10.6	10.6	0.61
13	D	25	13.9	13.7	1.02
	H		10.7	10.7	0.43
14	D	22	14.7	14.5	1.08
	H		11.0	11.0	0.38
15	D	10	15.5	16.0	0.66
	H		11.1	11.0	0.19
16	D	3	16.0	16.0	0.00
	H		11.0	11.0	0.08

**Tablica 4.** Prikaz korelacije kronološke i dentalne dobi (Spearmanov koeficijent korelacije)  
**Table 4** Correlation and difference of chronological and dental age

	Djevojčice • Girls		Dječaci • Boys		Ukupno (djevojčice i dječaci) • Total (Boys and Girls)	
	Koeficijent korelacije • Spearman's Correlation coefficient	Statistička značajnost • Difference (years)	Koeficijent korelacije • Spearman's Correlation coefficient	Statistička značajnost • Difference (years)	Koeficijent korelacije • Spearman's Correlation coefficient	Statistička značajnost • Difference (years)
Kronološka dob • Chronological age - Demirjian	0.94*	1**	0.92	-0.9**	0.93*	1**
Kronološka dob • Chronological age - Haavikko	0.9*	1**	0.89	0.5**	0.89*	0.8**
Ukupno • Total (N)	175		149		324	

In spite of very closed values of mean and median of chronological and dental ages the Liiifors' test showed that distributions were not normal ( $p < 0.001$ ).

\* $p < 0.05$   
 \*\* $p < 0.001$

**Rasprava**

Kod djece iste kronološke dobi često zapažamo velike razlike u brzini rasta i razvoja različitih sustava u tijelu. Zbog toga je definirana biološka dob - ona označava različite stupnjeve razvoja i zrelosti djeteta, a kronološka dob daje samo približnu procjenu njegove zrelosti (17).

Jedan od ključnih sustava u tijelu čiji se stupanj razvoja koristi kao jedan od indeksa biološke dobi, su zubi. Većina studija objavljenih nakon godine 1960. radovi su koji temelje dentalnu dob na stupnju razvoja cijelog zuba, a ne na njegovoj erupciji te se zato smatraju pouzdanima za određivanje dentalne dobi (18).

Metoda prema Demirjianu jedna je od najjednostavnijih, najpraktičnijih i najčešće korištenih načina. Njezina je prednost u jasno definiranim stadijima i točno opisanim promjenama u obliku krune i korijena zuba, što kliničaru ne ostavlja mogućnosti za nagađanje (8,9).

Budući da su Demirjianove tablice prvotno bile namijenjene širokom krugu pacijenata i predstavljale su pokušaj da se stvore standardizirane mjere na međunarodnoj razini, ispitivači iz različitih zemalja primijenili su ih na vlastitim pacijentima. Kako su neka ispitivanja pokazala one se ne mogu primijeniti na nekim narodima, a na određenim etničkim skupinama vidljiva su, pak, velika odstupanja. Zato je ovo je istraživanje, provedeno na hrvatskoj djeci, bilo usmjereno na procjenu točnosti metode prema

**Discussion**

We often notice large differences in growth and development rates among children of the same chronological age. This is why biological age is defined, and it demarks different stages in the child's development and maturity, whereas chronological age only roughly estimates the child's maturity (17).

Teeth are one of the key systems in the body, and their degree of development is used as one of the indices of biological age. Most studies conducted after 1960 base dental age on the degree of development of the whole tooth, and not upon tooth eruption, and are thus considered reliable in determining dental age (18).

The Demirjian method is one of the simplest and most practical and widespread methods. Its advantage rests in the clearly defined stages and the precisely described changes occurring in crown and root shape, leaving the clinician not much space for guessing (8,9).

Demirjian's standardized charts were initially meant for large groups of patients, and represented an attempt to standardize measures on an international scale, so investigators from various countries applied them to their own patients. Since certain studies showed that Demirjian's standardized charts could be applied to members of particular nationalities and not on others, this study conducted on Croatian children aims to evaluate the Demirjian's method accuracy, to correlate the obtained results with



Demirjšanu, korelaciju dobivenih rezultata s kronološkom dobi djece te njihovu usporedbu s rezultatima metode prema Haavikko (16). Metoda prema Haavikko pokazala se najtočnijom za djecu do 12 godina, a za sve starije davala je u ovoj studiji pre-male rezultate.

Liversidge i suradnici (19) dokazali su da metoda prema Demirjšanu daje precijenjene rezultate, pa smatraju da je uzrok tomu pozitivan trend rasta i razvoja u posljednjih 25 godina. Rezultati ovog istraživanja tu činjenicu potvrđuju.

Nakon toga su Liversidge i Speechly u svojoj su studiji usporedili rast i razvoj 7 zuba s lijeve strane donje čeljusti kod obaju spolova te su gotovo za svaki stadij razvoja pokazali brži razvoj zuba kod djevojčica prema razvoju zuba kod dječaka (20).

Naše je istraživanje pokazalo veću precijenjenost rezultata kod djevojčica od one kod dječaka metodom prema Demirjšanu. Ako pretpostavimo da je metoda točna i pouzdana, s minimalnim odstupanjima, precijenjenost se doista može protumačiti pozitivnim trendom rasta i razvoja djece u posljednjih 25 godina, dok se veći rezultati kod djevojčica mogu objasniti njihovim bržim razvojem. U našoj je studiji razlika između postignute dentalne i kronološke dobi metodom prema Demirjšanu, precijenjena za jednu godinu u obje skupine. Koristeći se metodom prema Haavikko, razlika između postignute i kronološke dobi bila je kod djevojčica i dječaka podcijenjena za jednu godinu. Tunc i Koyuturk (21) u svojoj su studiji dobili razliku između dobi određene prema Demirjšanu i kronološke dobi. Ona je iznosila od 0,36 do 1,43 godina za dječake, a za djevojčice od 0,50 do 1,44.

Bez obzira na rezultate, važno je znati da se razlike između kronološke dobi i dobivene dentalne dobi mogu pripisati mnogim čimbenicima, kao što je preciznost izvođenja metode, subjektivnost ispitivača, veličina uzorka, struktura uzorka (dob, spol, etnička i nacionalna pripadnost, socijalni status) te statistički pristup dobivenim rezultatima.

Za razliku od ispitivanih postupaka u ovom istraživanju, Cameriere i suradnici (22-24) objavili su matematičku formulu za izračun dentalne dobi na zubima nekih europskih zemalja kao što su: Italija, Španjolska, Slovenija i Hrvatska. Metoda se temelji na mjerenju završenosti razvoja vrhova korijena zuba računalnom metodom, a sva su dosadašnja istraživanja pokazala vrlo jaku korelaciju s kronološkom dobi.

the children's chronological age, and to compare these with the results from Haavikko's method (16). The Haavikko method proved most precise in 12-year-olds, while it yielded too small results for all patients above that age participating in this study.

Liversidge et al. (19) proved that the Demirjian method yields overestimated results and they consider this due to a positive trend in growth and development during the last 25 years. The results of this study confirm this fact.

Furthermore, in their study, Liversidge and Speechly compared the growth and development of 7 teeth on the left side of the mandible in both sexes and almost every stage of development showed faster tooth development in girls than in boys (20).

Our study showed greater overestimation of results for girls than for boys when using the Demirjian method. Assuming this method is accurate and reliable, with minimal deviation, overestimation can truly be attributed to a positive trend in children's growth and development over the last 25 years, whereas overestimated results for girls can be attributed to their faster development. The difference between dental age and chronological age according to Demirjian was overestimated by one year. For boys the difference was 11 months, and for girls it was 12 months. According to the Haavikko method, the difference between the obtained age and chronological age was also underestimated for one year in both groups. In their study, Tunc and Koyuturk (21) obtained a difference between Demirjian method values and chronological age. It was 0,36 to 1,43 years for boys and 0,50 to 1,44 years for girls.

Regardless of the obtained results, it is important to remember that the difference in chronological age and obtained dental ages can be attributed to numerous factors, such as the accuracy of the method's execution, the examiner's subjectivity, sample size, sample structure (age, sex, ethnicity and nationality, social status), and statistic approach to the obtained results.

Cameriere et al. (22-24) took a completely different approach and published a mathematical formula for calculating dental age on teeth for some European countries: Italy, Spain, Slovenia, Croatia. The method is based upon measuring the completeness of apical development via a computer method, and all studies to date show a very strong correlation to chronological age.

## Zaključak

Unatoč studijama koje daju prednost metodi prema Haavikku, ili onih koje ističu važnost metode prema Demirjjanu, ovo istraživanje na hrvatskoj djeci pokazalo je visok korelacijski koeficijent u objema metodama, dakle visoku korelaciju između kronološke i postignute dentalne dobi te je tako potvrdilo njihovu moguću primjenu u kliničkoj praksi i forenzičnoj stomatologiji.

## Zahvala

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## Conclusion

Despite the existence of studies in favour of the Haavikko method and those that emphasize the importance of the Demirjjan method, this study conducted on Croatian children demonstrates a high correlation coefficient for both methods, therefore a high correlation between chronological and obtained dental age, and confirms their potential applicability in clinical practice and forensic dentistry.

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## Abstract

Developing teeth are used to assess maturity and estimate age in a number of disciplines, such as pediatric and preventive dentistry, orthodontics, forensic odontology, etc. **Aim:** The accuracy of different methods has not been systematically investigated within the Croatian population, so the aim of this investigation was to determine the accuracy of two methods; Demirjjan's and Haavikko's. **Material and Methods:** Tooth formation was assessed from orthopantomograms (OPGs) belonging to healthy children, patients of the School of Dental Medicine, University of Zagreb. The sample consisted of 324 children (149 boys, 175 girls, ages 6–16 years). The OPGs were examined and seven mandibular teeth were staged according to Demirjjan's dental maturity scale and according to Haavikko. Descriptive statistics were used together with relation analysis (Spearman correlation) and tests (Lilliefors test for normality of distribution, t-test for significance of Spearman's rank-order correlation coefficient, and Mann-Whitney test for testing the difference between boys and girls). **Results:** Dental age and the difference between dental and actual chronological age was calculated for both methods. Results showed that Demirjjan's method overestimated the age while Haavikko's method underestimated the age. All data was subjected to both correlation and regression analysis, which showed that both applied methods gave results with significant correlation to the actual age (Demirjjan's method yielded a 0.93 coefficient of correlation, Haavikko's method yielded a correlation coefficient of 0.89,  $p < 0.05$ ). **Conclusion:** This study on Croatian children has shown high correlation coefficients for both methods and demonstrated their potential benefit in clinical and scientific use.

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## Key words

Age Determination by Teeth; Forensic Dentistry; Radiography, Panoramic

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