

Preventive treatment of ectopically erupting maxillary permanent canines by extraction of deciduous canines and first molars: A randomized clinical trial

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Introduction: In this research project, we aimed to compare the effectiveness of single (1 deciduous canine) and double (deciduous canine and first molar) extractions in subjects with retained maxillary permanent canines positioned palatally or centrally in the alveolar crest, at risk for root resorption of adjacent permanent teeth.

Methods: Subjects at risk for canine impaction or resorptive situations were randomly assigned to 1 of 2 treatment modalities: single extraction (17 patients, 28 canines) or double extraction (20 patients, 37 canines). Thirty-one patients with 53 canines judged to be not at risk constituted the untreated control group. Panoramic radiographs were taken at the initial observation and after 18 months on average. Between-group statistical comparisons were carried out on the changes in canine inclination and sector location (measured on panoramic radiographs) and on the percentages of successful permanent canine eruptions. **Results:** The double-extraction group showed significant improvements in the success rate and the intrabony position of the permanent canine, in terms of uprighting the canine's long axis with a crown movement in a distal direction. **Conclusions:** Concomitant deciduous canine and first molar extractions proved to be more effective as a preventive approach to promote eruption of retained maxillary permanent canines positioned palatally or centrally. (Am J Orthod Dentofacial Orthop 2011;139:316-23)

Maxillary canine impaction is often encountered in orthodontic clinical practice¹⁻³; the frequency ranges from 1.7% in the general population² to 4.3% in the population of subjects referred to oral surgery or orthodontics departments.⁴

Ectopically or nonerupting canines can lead to resorption of the roots of the adjacent permanent teeth.⁵⁻⁸ For this reason, great emphasis should be given to the early detection of ectopic eruption and potential resorptive situations, when preventive measures could reduce the

severity of the impaction and, if possible, encourage the eruption of the canine, thus avoiding possible detrimental effects.^{5,7,9-13}

For early diagnosis of ectopically erupting maxillary canines, both clinical (digital palpation screening method) and radiographic (eruption angle and position measured on panoramic radiograph) examinations should be used.^{1,3,5,6,9,10,14-17}

Extraction of the corresponding deciduous canines has been recommended as a preventive treatment to promote the eruption of malposed canines.^{1,7,9,11-14} Previous studies found that between 50% and 78% of palatally displaced maxillary canines reverted to a normal eruption path after this procedure.^{7,9,11,12} The additional use of headgear to maintain space in the maxillary dental arch resulted in an increase in terms of successful eruption of up to 80% of the canines,¹¹ or 87.5% of the subjects treated,¹² with a significant improvement in the intraosseous canine position.

The purpose of this study was to evaluate the effectiveness of concomitant extraction of the deciduous canine and first molar as a preventive procedure for corresponding retained maxillary permanent canines

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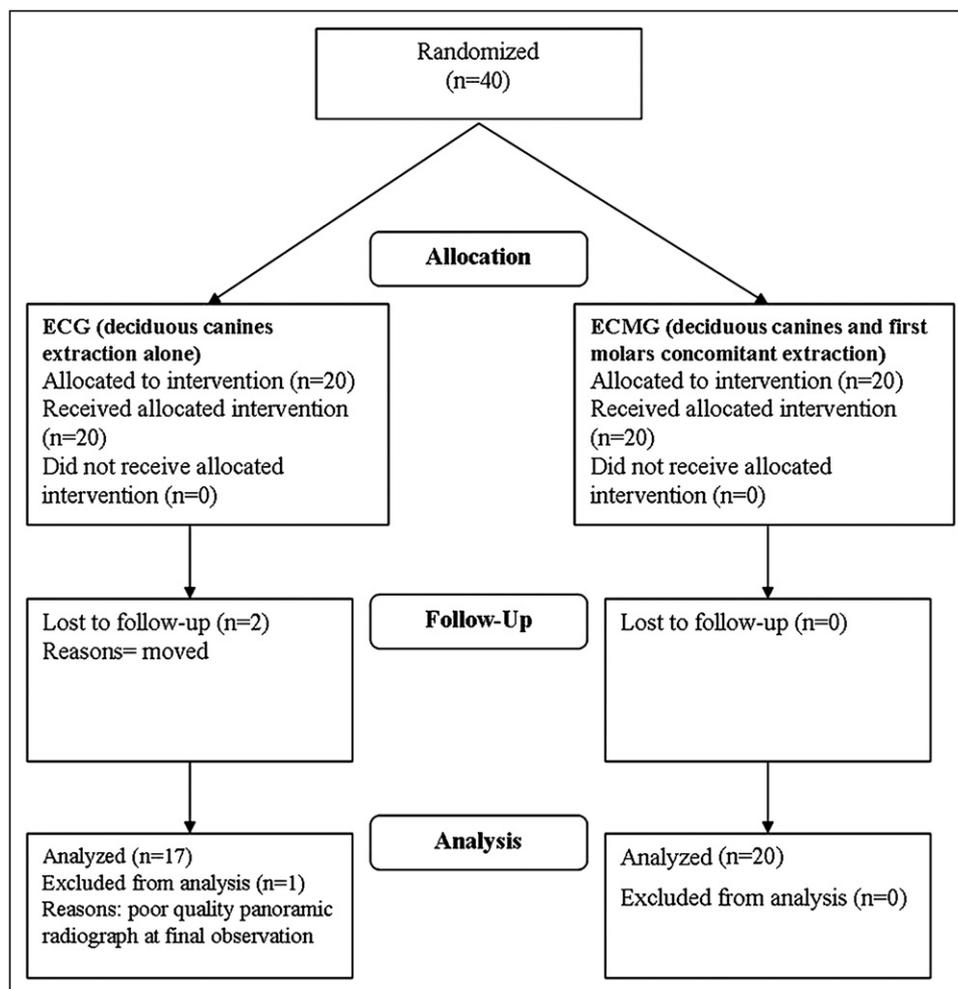


Fig 1. CONSORT flow chart of participants of the ECG and the ECMG through each stage of the trial (n, number of patients).

positioned palatally or centrally in the alveolar crest, compared with extraction of only the deciduous canine. The outcome of this preventive measure was evaluated in terms of improvement of the intraosseous position of the displaced canine and successful eruption.

MATERIAL AND METHODS

In this randomized clinical trial, we analyzed patient records collected from the Department of Orthodontics, University of Bologna, in Italy.

Inclusion criteria were nonorthodontic patients, white ancestry, age between 8 and 13 years, maxillary deciduous canines and first molars in the dental arch, and good-quality panoramic radiographs. Exclusion criteria were previous orthodontic treatment, premature loss of the maxillary deciduous canines and first molars,

labially retained maxillary permanent canines, aplasia or severe hypoplasia of the crown of the maxillary permanent lateral incisors, craniofacial syndromes, odontomas, cysts, cleft lip or palate (or both), evidence of traumatic injuries to the permanent incisors or to the face, and multiple or advanced caries. Seventy-one subjects, with 123 canines, fulfilled all criteria and were included in this study, after informed consent was obtained from them or their parents or guardians. All the patients were examined identically, both clinically and radiographically.

Because we considered it unethical not to treat patients at risk for ectopically erupting canines or potentially resorptive situations, canines were diagnosed to be at risk by at least 1 of the following clinical and radiographic criteria, which are widely accepted in the international literature and among practitioners.^{1,3,5,6,9,10,14-17}

Table I. Sample distribution by sex and age

	ECG	ECMG	CG	Total
Subjects (n)	17	20	31	68
Male	9	9	16	34
Female	8	11	15	34
Mean age (y)	9.8	10.2	9.0	

The clinical criteria were absence of palpation of the canine bulge, canine bulge palpable palatally, and no abnormal inclination or rotation of the adjacent lateral incisor crown. The radiographic criteria were inclination of the canine to a vertical line passing through the midline exceeding 25° and overlapping of the canine crown with the root of the permanent lateral incisor.

Among the 71 subjects (123 canines), 31 patients (53 canines) were judged to be at no risk. They had no treatment and constituted the control group (CG).

The remaining 40 patients (70 canines), diagnosed as at risk, were randomly assigned to 1 of 2 groups: ECG (20 patients, 33 canines), having extraction of only the deciduous canine corresponding to the ectopically erupting maxillary permanent canine; and ECMG (20 patients, 37 canines), having concomitant extraction of the deciduous canine and first molar corresponding to the ectopically erupting maxillary permanent canine.

Randomization was carried out by using a block design and computer-generated random numbers. The allocations were concealed in consecutively numbered, sealed envelopes.

Three patients (5 canines) in the ECG did not complete the clinical trial: 2 were lost to follow-up because they moved, and 1 was not analyzed because of a poor-quality panoramic radiograph at follow-up. Consequently, the final ECG consisted of 17 patients and 28 canines. A CONSORT flow chart of participants in the ECG and the ECMG through each stage of the trial is shown in Figure 1. Patient distribution by sex and age is shown in Table I.

Panoramic radiographs were taken at initial observation (T0) and after an average period of 18 months (T1)—a duration that has already proven to be appropriate.^{7,12} No subject in either treated group received any additional orthodontic or surgical therapy beyond the extraction of the deciduous canine (ECG) or the concomitant extraction of the deciduous canine and first molar (ECMG) between T0 and T1. For all patients, the panoramic radiographs were taken with the same radiologic apparatus at both T0 and T1, under standardized conditions. Since different studies have already confirmed the reliability of angular measurements in panoramic radiographs, each panoramic radiograph was digitized with a scanner (Expression 1680 Pro, Epson, Cinisello

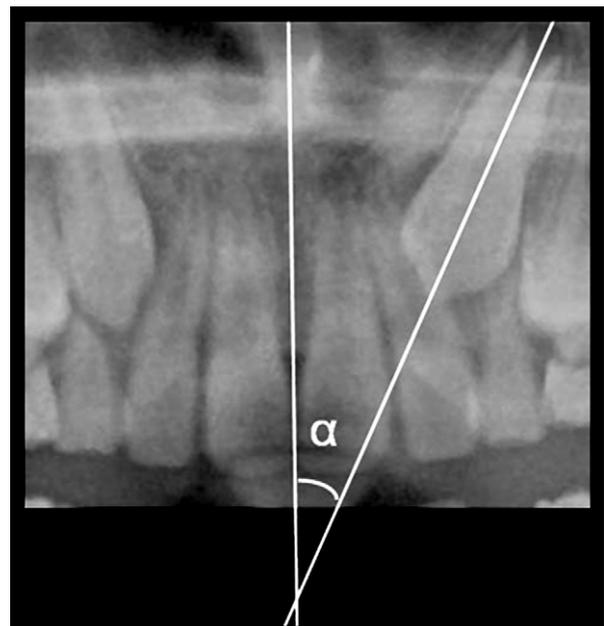


Fig 2. Inclination of the maxillary permanent canine (angle α) is measured by the internal angle formed by the major axis of the canine and the midline, according to the method of Ericson and Kuroi.⁷

Balsamo, Milano, Italy), and the angular values were calculated with measurement software (LightningPlant 1.0.0, ElleSoft, Chieti, Italy).¹⁸⁻²¹ Two radiographic parameters were analyzed to assess the canine eruption pattern: (1) the mesial inclination of the crown to the midline, according to Ericson and Kuroi⁷ (angle α , Fig 2); and (2) the medial crown position in sectors 1-5, according to Ericson and Kuroi⁷ (s1-s5, Fig 3). Radiographic measurements were made at both T0 and T1 by the same operator (S.I.P.), who underwent an intraexaminer reliability check. Additionally, the development of the permanent canine (measuring the length of the root) was evaluated at T0 according to 2 stages, according to the method of Ericson and Kuroi⁸: (1) the root was longer than the canine crown, and (2) the root was shorter than the canine crown (Table II).

The between-group statistical comparison was carried out on the T0-T1 changes in the radiographic measurements. The successful outcome was defined, according to Leonardi et al,¹¹ as the complete eruption of the permanent canine into the dental arch within 48 months from the initial observation, thus permitting bracket positioning for final arch alignment when needed.

Statistical analysis

On the basis of the results obtained in a pilot sampling of canines, a normal distribution of the main

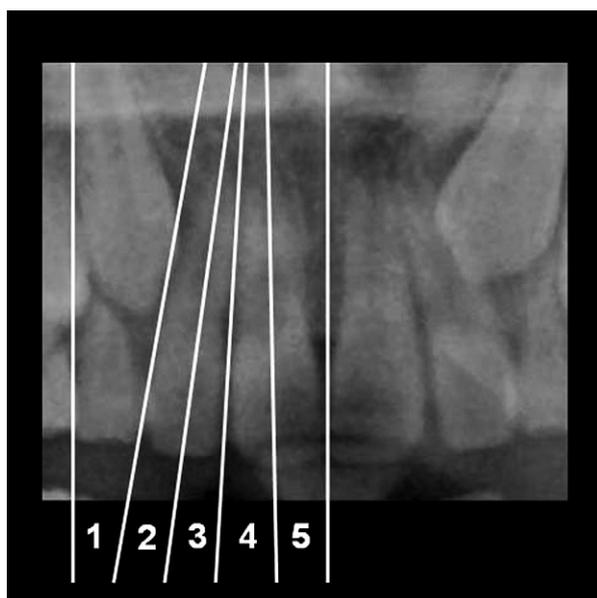


Fig 3. Sector of mesiodistal crown position of the maxillary permanent canine (s1-s5) was located in accordance with the sector designation used by Ericson and Kuroi.⁷

variable—the absolute difference of the α -angle of the canine—was hypothesized; similarly, a standard deviation of 13° was estimated. A minimum of 26 canines was required for each group, when the true value of the absolute difference of the α -angle between the ECG and the ECMG was 10° , at an α -level of 0.05 and with a power of 80%.

The Kolmogorov-Smirnov test with the Lilliefors level of significance was carried out to verify the normality of the distribution of the α -angle of the canines in each group. In addition, skewness and kurtosis coefficients (\pm SE) and cumulative normal plots were used to confirm the Gaussian form of distribution of the α -angles. A generalized linear model was applied to verify the significance of the differences of the α -angles. The values of the α -angles among the 3 groups at T0 were always significantly different. Consequently, to control for the influence of the severity of canine displacement on the final results, the inclination at T0 was used as the covariate; also, the stage of root development of the permanent canines was controlled for. The chi-square test was used to highlight an association of a group with variations of sector. The *t* test for independent samples was used for comparison between each pair of groups. The Fisher exact test was carried out to compare the percentages of favorable outcomes between the ECG and the ECMG.

An α -level of 0.05 was set and adjusted by the Bonferroni correction at 0.016 for multiple comparisons.

Table II. Canine distribution by root development

	ECG	ECMG	CG
Canines (n)	28	37	53
Stage 1	17	20	15
Stage 2	11	17	38

To evaluate the method error, an intraobserver reliability check was carried out for both angular values and sectors. Fifteen randomly selected panoramic radiographs (15 subjects; 30 canines) were measured by the same operator (S.I.P.) twice, on 2 days, with 15 days separating the measurement sessions. The intraclass correlation coefficient (ICC)²² was 0.968 (95% CI, 0.934–0.985; $P = 0.0001$) for angulation of the canines, thus confirming high intraobserver reliability for the method used. The ICC was 1.00 for the sector designation, indicating no differences between measurement sessions. To evaluate whether clinical experience affects the accuracy of the measurements, 20 randomly selected panoramic radiographs (20 subjects; 20 right and 20 left canines) were independently measured by 5 orthodontists. The ICC values were 0.955 for the angular measurements and 1.000 for the sector designation for both right and left canines. These coefficients show high interobserver reliability of the measurement method, which has proved not to be influenced by clinical experience.

RESULTS

The T0-T1 changes in the radiographic measurements relative to the canines' intraosseous position on the panoramic radiographs are shown in Table III. The variable α -angle exhibited statistically significant changes between T0 and T1 in the ECMG when compared with both the ECG ($P = 0.0001$) and the CG ($P = 0.0001$). The variable sectors (s1-s5) showed a statistically significant change between T0 and T1 in the ECMG when compared with both the ECG ($P = 0.0009$) and the CG ($P = 0.003$). Neither the α -angle nor the sectors (s1-s5) showed significant differences in T0-T1 changes in the ECG compared with the CG. Positive values (+1, +2) relative to the T0-T1 changes in the sectors—ie, significant improvement in the mesiodistal canine crown position—prevailed in the ECMG. In the ECMG, 51% of the canines (19 of 37) showed improvement by 1 sector, and 13% of the canines (5 of 37) had improvement by 2 sectors. In the ECG, 32% of the canines (9 of 28) exhibited improvement by 1 sector, but no canines improved by 2 sectors.

No significant influence of the stage of root development of the permanent canines was seen. A statistically significant difference ($P = 0.036$) was observed in the

Table III. Comparison of the changes between T0 (initial observation) and T1 (18 months after T0) for canine inclination (α -angle) and sector location (s1-s5) on the panoramic radiographs

	ECG (28 canines)				ECMG (37 canines)				CG (53 canines)				Significance		
	Mean	Interval	Min	Max	Mean	Interval	Min	Max	Mean	Interval	Min	Max	ECG-ECMG	ECMG-CG	ECG-CG
α -angle (°)	5.7	40.9	-16.9	24.0	16.4	32.98	2.6	30.38	0.60	62.8	-27.6	35.2	$P = 0.0001$	$P = 0.0001$	NS
s1-s5	0.0	1.0	0.0	1.0	1.0	3.0	-1.0	2.0	0.0	3.0	-2.0	1.0	$P = 0.0009$	$P = 0.003$	NS

Min, Minimum; *Max*, maximum; *NS*, not significant.

percentages of favorable clinical outcomes between the ECG (78.6%) and the ECMG (97.3%).

DISCUSSION

During its normal eruption pathway, the maxillary permanent canine moves down between the distal aspect of the permanent lateral incisor and the mesial aspect of the first premolar in close contact with these neighboring teeth and the apex of the deciduous canine.¹⁴ Canine inclination to the midline increases mesially until the maximum angle is reached at approximately 9 years of age; then it straightens again with horizontal movement of the cusp in a distal direction.²³⁻²⁵ When the tooth shows an excessive mesial inclination to the midline or overlaps with the root of the adjacent incisors based on clinical and radiographic criteria, it is suspected to follow an incorrect eruption pathway. Therefore, preventive approaches to reestablish the physiologic eruption process might be considered, thus decreasing the risk of canine impaction or adjacent root resorption of permanent teeth.

Deciduous tooth removal has been shown to be successful in inducing eruption and, in some cases, even uprighting succedaneous teeth.^{14,26-28} Similarly, several authors have proposed the extraction of deciduous canines to return ectopically erupting canines to a normal eruption pathway, if the persistence of the deciduous tooth would represent a mechanical obstacle for the emergence of the permanent tooth.^{7,9,11,12,14,23} However, the exact mechanism behind this phenomenon has not yet been scientifically explained.^{11,12} In this study, we suggest combining preventive deciduous canine extraction with deciduous first molar extraction (Fig 4, 5, and 6) to maximize the advantages of these 2 procedures. In addition to the positive effects derived from deciduous canine extraction, it may be that the removal of the deciduous first molar accelerates eruption and promotes uprighting of the first premolar, thus stimulating the correct eruption of the permanent canine by providing more space for the physiologic uprighting movement of the tooth crown in a distal direction into alveolar bone.^{7,14}



Fig 4. Patient in the ECMG who underwent bilateral concomitant extraction of the maxillary deciduous canines and first molars (before and after extractions).

In this research project, we aimed to compare the effectiveness of these 2 treatment modalities in subjects with retained maxillary permanent canines positioned palatally or centrally in the alveolar crest, at risk for root resorption of adjacent permanent teeth. To this end, patients were randomized between the ECG and the ECMG. Previous studies demonstrated that incisor



Fig 5. Patient in the ECMG who underwent bilateral concomitant extraction of the maxillary deciduous canines and first molars (before and after extractions).

root resorption occurs in almost 50% of patients with ectopically positioned maxillary canines,^{29,30} and that the risk of such a serious complication might be decreased by early intervention, aiming to eliminate canine crown superimposition over the adjacent incisor root as early as possible.^{6,7} For these reasons, we considered it unethical to design a study with a randomized, untreated control group. Therefore, only patients with no risk for ectopically erupting canines or potential resorptive situations constituted the untreated, nonrandomized CG. Because of the limitations of a nonrandomized CG, it was used for comparison to test only the effects in terms of permanent canine intraosseous positional changes of both the extraction of 1 deciduous canine and the concomitant extraction of the deciduous canine and first molar. Since the severity of canine displacement at



Fig 6. Patient in the ECMG who underwent concomitant extraction of the maxillary deciduous canines and first molars on the left side (before and after extractions).

T0 could be assumed to be different among the treated and untreated subjects, radiographic variables at T0 were used as the covariate to prevent any possible influence of this difference on the final results, and the CG was not used to compare the percentages of spontaneous canine eruption, which is the ultimate criterion for a successful outcome.

The greatest mean value for α -angle change (16.4) and improvement in sector (+1) between T0 and T1 was found in the ECMG compared with both the ECG and the CG. In the ECMG, 19 of the 37 canines improved by 1 sector, and 5 canines improved by 2 sectors. On the other hand, 9 of the 28 canines in the ECG improved by 1 sector, but none improved by 2 sectors. No statistically significant difference was shown in terms of both α -angle and sector changes between the ECG and the CG. On the contrary, the ECMG proved to be superior to the CG:

a significant difference was found in the T0-T1 changes among all examined variables.

Clinical and radiographic follow-ups are indicated 12 to 18 months (or even more, depending on the patient's age at the initial observation) after removal of deciduous teeth to follow permanent canine eruption tendency over time. The possibility of space loss after tooth extractions is unlikely to be of enough clinical significance to warrant the use of a space maintainer. Orthodontic treatment might be needed later to create space for the canine or to correct its position in the dental arch, once the clinician has taken into proper account canine inclination, mesiodistal position, and their potential effect on incisor root resorption.³¹ Radiographic evidence of a decrease in canine inclination to the midline and a more distal canine crown position, meaning greater parallelism between the roots of those elements, enables clinicians to start the orthodontic treatment by moving permanent incisors with no risk of iatrogenic root resorption. A further advantage of the concomitant extraction of the deciduous canine and first molar is that the first premolars erupt early into the dental arch, thus allowing fixed orthodontic therapy to begin, if necessary, at an earlier stage.

This study showed uneventful canine eruption, the ultimate criterion for a successful outcome, in 97.3% of the subjects (36 of 37 canines) in the ECMG compared with 78.6% of subjects (22 of 28 canines) in the ECG, attesting to greater effectiveness of concomitant extraction of the deciduous canine and first molar in terms of canine impaction prevention.

It is reasonable to assume that concomitant extraction of the deciduous canine and first molar is no more technically difficult, biologically expensive, or traumatic, compared with extraction of only the deciduous canine. The procedure requires anesthetizing the 2 adjacent areas, and the 2 extractions can be done in the same appointment. Above all, this protocol could be intended as a real prevention procedure for patients with ectopically erupting permanent canines at risk of adjacent tooth root resorption, since it is not an early orthodontic treatment, because the patient is not asked to wear an orthodontic appliance. Therefore, successful outcome does not depend on patient cooperation. Deciduous tooth extractions would decrease the incidence of maxillary permanent canine impaction, thus beneficially reducing the need for active orthodontic treatment in a patient who might otherwise have an acceptable occlusion. The early detection and prevention of maxillary canine impaction is of fundamental importance to the orthodontist to avoid a more complicated, time-consuming, and biologically expensive procedure, including surgical uncovering followed by orthodontic repositioning of the unerupted tooth.

CONCLUSIONS

Based on the results of this randomized clinical trial, it seems appropriate to recommend concomitant early extraction of the deciduous canine and first molar as a preventive measure in patients with retained maxillary permanent canines positioned palatally or centrally in the alveolar crest, at risk for root resorption of adjacent permanent teeth.

The following conclusions can be drawn from this study.

1. Favorable and greater changes of the intrabony position of the maxillary permanent canine (in terms of uprighting the long axis of the canine and distal movement of the canine crown) attesting to a greater chance of spontaneous tooth eruption into the dental arch were observed with concomitant extraction of deciduous canines and first molars, than with extraction of only deciduous canines.
2. This procedure proved to be effective at increasing the rate of normal eruption of ectopic canines, compared with deciduous canine extraction alone.
3. Concomitant canine and first molar extractions seem to be a reasonable attempt to obtain greater parallelism between the roots of the permanent canine and the adjacent lateral incisor, thus improving the local condition for the displaced canine to erupt uneventfully.
4. This treatment modality allows successive fixed orthodontic therapy to start, if necessary, earlier and with no risk of incisor root resorption.

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