The Efficacy of 4% Articaine Versus 2% Lidocaine in Inducing Palatal Anesthesia for Tooth Extraction in Different Maxillary Regions

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Purpose: This study was conducted to ascertain the efficacy of buccal injection of articaine compared to lidocaine in inducing palatal anesthesia in different maxillary regions.

Materials and methods: This double-blinded, randomized clinical trial included 300 patients who referred for extraction of 1 maxillary tooth. The patients were categorized into 3 strata according to the extraction area (anterior, premolar, molar), and then randomly assigned to 2 groups based on the administered medication. The first group received buccal infiltration by 0.6 mL of 2% lidocaine, whereas the second group was buccally administered using 0.6 mL of 4% articaine. After a waiting period of 2 minutes, the failure or success in achieving palatal anesthesia was assessed by the instrumentation technique. In cases of failed anesthesia, an additional 0.6 mL of the same anesthetic was given, and the procedure was repeated if palatal anesthesia was not attained after a 2-minute delay. If pain remained 2 minutes after the third injection, a supplemental palatal infiltration was administered and the extraction was attempted.

Results: The success rate of buccal infiltration in achieving palatal anesthesia was 82.7% in the articaine group and 1.3% in the lidocaine group. There was a significant difference in the success rate and drug volume required to induce palatal anesthesia between the 2 groups ($P < .001$), but no significant difference was found between different maxillary regions, using either of the medications ($P > .05$).

Conclusions: Articaine can be considered as a suitable alternative to lidocaine for eliminating painful palatal infiltration in the extraction of maxillary teeth.

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The experience of pain is a major concern for patients undergoing dental treatments. Palatal injection is among the most painful procedures in the clinical practice and surface anesthesia is unable to alleviate its accompanying discomfort.[1-3] The pain of palatal injection is assumed to occur as a result of tight adherence of the palatal soft tissues to the underlying bone as well as to the abundant nervous supply in the palate.[3,4] Eliminating palatal infiltration can remarkably increase patients' comfort and

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treatment acceptance and thus reducing the stress level imposed to the clinician during treatment.[3] One way to remove direct injection to the palatal gingiva is the alteration in the type and volume of the local anesthetic solution or the use of different concentrations of vasoconstrictors.

Dental anesthetics fall into 2 categories, including ester and amide types. The amides are more popular due to the observed cases of allergic reactions by the ester group of drugs. Lidocaine is an amide derivate of diethylamino acetic acid. Within a few years of its introduction by Löfgren in 1943, lidocaine was recognized as the safest and most commonly used local anesthetic agent in clinical usage, and it is still considered as the gold standard in dental anesthesia.[5,6]

In 1969, Muschaweck synthesized articaine hydrochloride, another amide drug with unique biochemical properties.[6] Several studies indicated the safety and effectiveness of articaine as an anesthetic agent for use in dental procedures.[6-10] Generally, amide drugs are metabolized by the liver. Articaine is the only amide-type local anesthetic that could be inactivated by nonspecific plasma esterases as well as by the liver, and thus, it has a short half-life and is cleared quickly from the body.[9-13] It has been claimed that maxillary buccal infiltration of articaine can provide sufficient anesthesia in palatal gingiva due to the better diffusion properties of the drug as compared to other anesthetics, thus surpassing the need for painful palatal injection.[3,4,9-11,13-15]

Previous studies reported controversial results regarding the effect of single buccal infiltration of lidocaine or articaine on palatal anesthesia during extraction of maxillary teeth. Although the majority of studies demonstrated that buccal administration of lidocaine is not adequate to achieve optimum palatal anesthesia for tooth extraction,[6,10,11,16] Yadav et al[17] and Badcock et al[18] indicated successful removal of maxillary third molars using lidocaine without the need for an additional palatal infiltration. Several investigations found that the use of articaine obviated the need for painful palatal injection.[3,4,6,13,19] However, other studies reported the experience of pain during extraction of permanent maxillary teeth following sole buccal infiltration of articaine.[2,20]

It should be noted that the thickness and density of the alveolar bone is different in the anterior, premolar and molar regions of the maxilla; therefore, the efficacy of buccal infiltration and the drug volume required to anesthetize palatal soft tissue may differ per maxillary tooth. This prospective, randomized clinical trial was conducted to ascertain the efficacy of single buccal injection of 4% articaine in comparison with that of 2% lidocaine in inducing palatal anesthesia for extracting teeth in the anterior, middle, and posterior regions of the maxilla. The second aim of this study was to determine the least volume of medications required for pain control in the palatal gingiva of different maxillary teeth.

Materials and Methods

STUDY SAMPLE AND DESIGN

This prospective, double-blinded, randomized clinical trial included 300 patients aged between 16 and 70 years who attended the Department of Oral and Maxillofacial Surgery at the Faculty of Dentistry of Mashhad University of Medical Sciences for extraction of a permanent maxillary tooth. Patients with a severe systemic disease that might contraindicate tooth extraction and those with allergies to sulphites or amide type local anesthetics, as well as those having intraoral infection at the site of extraction were excluded from the sample. The exclusion criteria also involved subjects who used analgesics within 24 hours prior to the administration of local anesthetic, pregnant women, and mentally disabled cases. The protocol of the study was approved by the ethics committee of Mashhad University of Medical Sciences (IR.mums.sd.REC.1394.311) and it was also registered in the Iranian Registry of Clinical Trials (IRCT) website under the identification number IRCT20180710040413N1. The study purpose and procedures were explained thoroughly to the participants and informed consent forms were signed by them before the study commencement.

The participants were assigned to the treatment groups using a stratified random sampling model. For this purpose, the patients who met the inclusion/exclusion criteria were classified into 3 strata according to the area of extraction including anterior (canine to canine), premolar, and molar regions (100 patients per stratum). The patients assigned to each stratum were then randomly allocated to 1 of the 2 treatment groups of equal size based on the anesthetic drug deposited (lidocaine or articaine). The randomization was performed by a table of random numbers and the allocations were done by an individual who was not involved in the study process.

The first group was given buccal infiltration (submucosal) along the axis of the tooth to be extracted, using 0.6 mL of 2% lidocaine with epinephrine 1:100000 (2% Persocaine-E; Daroupakhsh, Tehran, Iran). In the second group, 0.6 mL of 4% articaine hydrochloride with epinephrine 1:100,000 (Septanest; Ivoclar Vivadent Ltd., Rosedale Auckland, New Zealand) was buccally administered adjacent to the corresponding tooth. All injections were deposited at a slow rate and over a period of 20 seconds.

After a waiting period of 2 minutes to allow for an anesthetic effect, the failure or success of the initial

infiltration in achieving optimal palatal anesthesia was assessed using palatal instrumentation by the sharp end of a periosteal elevator. The test response was recorded positive if the patient perceived a sharp pain on palatal instrumentation (failure of anesthesia), whereas a negative result implied that there was no pain in palatal gingiva during the test (success of anesthesia).

In cases where adequate palatal anesthesia was not attained after 2 minutes, an additional 0.6 mL of the same anesthetic was given in the buccal vestibule. Following an interval of 2 minutes, the palatal gingiva was checked and if pain or discomfort was experienced by the patient, the last 0.6 mL of the cartridge was injected buccally. If pain remained after an additional 2-minute delay, a supplemental palatal injection was administered to anesthetize the palatal gingiva using 0.3 mL of 2% lidocaine or 4% articaine, and the extraction was attempted.

The demographic data (age and gender), the area of extraction, the volume of anesthetic solution administered, and the need to palatal infiltration were recorded for all patients. The study was considered double-blinded, as the patient and the outcome assessor were blinded to the type of the local anesthetic solution injected.

STATISTICAL ANALYSIS

The data were entered into the SPSS 16.0 software (SPSS Inc, Chicago, IL, USA) for statistical analysis. The demographic (age and gender) and dependent variables were analyzed by the Student t-test and chi-square test. The significance level was set at $P < .05$.

Results

Three hundred patients requiring extraction of 1 permanent tooth in different maxillary areas (100 anterior teeth, 100 premolars, and 100 molars) were included in the study and received anesthesia with either 2% lidocaine or 4% articaine (n = 150 per group). Table 1 presents the demographic variables in the study groups. The participants were 162 women (54%) and 138 men (46%) with the mean age of 38.5 ± 11.7 years in the lidocaine group and 39.9 ± 11.8 years in the articaine group. No significant difference was found in the mean age and gender distribution between the 2 groups ($P = .806$ and $P = .376$, respectively; Table 1).

Table 1. THE MEAN AGE (STANDARD DEVIATION) AND GENDER DISTRIBUTION (%) OF THE PARTICIPANTS IN THE STUDY GROUPS

	Lidocaine	Articaine	Significance
Age (year)	38.5 (11.7)	39.9 (11.8)	0.806
Gender			
Female	84 (56)	78 (52)	0.376
Male	66 (44)	72 (48)	

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THE SUCCESS RATE OF BUCCAL INFILTRATION IN ACHIEVING PALATAL ANESTHESIA IN THE STUDY GROUPS

Figure 1 illustrates the number of patients who reported the absence or presence of pain on palatal instrumentation after buccal infiltration in the 2 study groups. The buccal infiltration provided palatal anesthesia in 124 patients (82.7%) of the articaine group, whereas 26 cases (17.3%) required an additional palatal injection. In the lidocaine group, only 2 patients (1.3%) reported the absence of pain after buccal injection and 148 cases (98.7%) underwent supplemental palatal anesthesia. The success rate of buccal infiltration in achieving palatal anesthesia was significantly greater in the articaine group (82.7%) than in the lidocaine group (1.3%) ($P < .001$).

THE VOLUME OF MEDICATION REQUIRED TO INDUCE PALATAL ANESTHESIA IN THE STUDY GROUPS

Table 2 and Figure 2 indicate the incidence of palatal anesthesia after injection of different volumes of the anesthetic solutions. The frequencies of subjects with no pain on palatal instrumentation after buccal infiltration of 0.6, 1.2, and 1.8 mL articaine were 36 (24%), 62 (41.4%), and 26 (17.3%), respectively. In the lidocaine group, the successful results were observed in only 2 cases, 1 received 0.6 mL and another received 1.8 mL anesthetic solution. Twenty-six patients in the articaine group and 148 cases in the lidocaine group required palatal injection of 0.3 mL anesthetic solution. The statistical analysis revealed a significant difference in the drug volume required to induce palatal anesthesia between the 2 groups ($P < .001$; Table 2).

THE SUCCESS RATES OF BUCCAL INFILTRATION IN ACHIEVING PALATAL ANESTHESIA IN DIFFERENT MAXILLARY REGIONS

The buccal infiltration of lidocaine caused palatal anesthesia in 1 anterior and 1 premolar tooth. Following buccal infiltration of articaine, the successful outcome was observed in 43 anterior, 39 premolar, and 42 molar teeth (Table 3). When the success of palatal anesthesia after buccal injection was compared between the 3 tooth extraction areas, the difference was statistically insignificant with either of the 2 anesthetic drugs ($P = .593$ for lidocaine and $P = .463$ for articaine; Table 3).

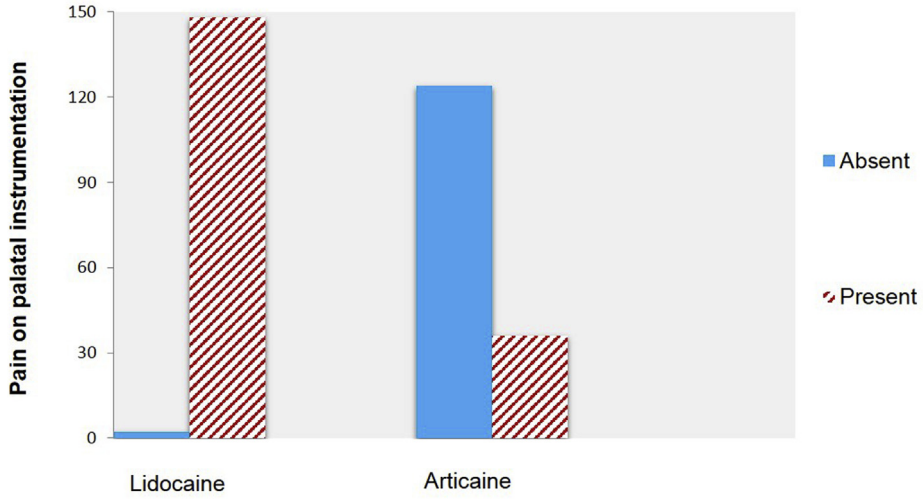

FIGURE 1. Comparison of patients with absence or presence of pain on palatal instrumentation after buccal infiltration of lidocaine or articaine.

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THE VOLUME OF MEDICATION REQUIRED TO INDUCE PALATAL ANESTHESIA IN DIFFERENT MAXILLARY REGIONS

In the lidocaine group, palatal anesthesia was observed in 1 premolar injected with 0.6 mL and 1 anterior tooth infiltrated with 1.8 mL of the drug. The highest frequency of palatal anesthesia after buccal infiltration of articaine pertained to the 1.2 mL volume of the medication, which caused successful outcomes in 22 anterior, 20 premolar, and 21 molar teeth. The statistical analysis revealed no significant difference in the medication volume required to anesthetize palatal mucosa between the different maxillary regions with either of the 2 anesthetic drugs (P = .396 for lidocaine and P = .843 for articaine).

Discussion

The present study evaluated palatal anesthesia following deposition of 2 anesthetic drugs, namely 2% lidocaine and 4% articaine, in the buccal vestibule of the upper anterior, premolar, and molar teeth. The volume of local anesthetics required for pain control in the palatal gingiva was also investigated. The 2 groups were similar in terms of age and gender to eliminate the effect of these factors on bone composition and drug diffusion in the maxilla. A volume of 0.6 mL of 4% articaine or 2% lidocaine was deposited 3 times at the depth of the buccal vestibule with an interval of 2 minutes between them. The pain sensation was assessed during palatal instrumentation by a periosteal elevator, and the result was recorded as the dichotomous outcome including the presence (failure) or absence (success) of sharp pain.

Table 2. THE DRUG VOLUMES REQUIRED TO CAUSE PALATAL ANESTHESIA IN DIFFERENT GROUPS

	Lidocaine		Articaine	
Drug volume	Number	%	Number	%
0.6 mL	1	0.65	36	24
1.2 mL	0	0	62	41.4
1.8 mL	1	0.65	26	17.3
1.8 mL + 0.3 mL palatal injection	148	98.7	26	17.3
Significance	P < .001			

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In the present study, the buccal infiltration of 1.8 mL articaine caused palatal anesthesia in 124 out of 150 patients (82.7%) after an interval of 6 minutes, whereas the remaining 26 cases (17.3%) required palatal infiltration. In the lidocaine group, the vast majority of cases (98.7%) reported a sharp pain on palatal instrumentation following buccal infiltration. The success rate of 4% articaine was significantly greater than that of 2% lidocaine in desensitizing the nerve endings in the palatal mucosa. The outcomes of this study indicated that the administration of 4% articaine into the upper teeth buccal mucosa could eliminate the need for painful palatal injection in most patients. However, an additional palatal infiltration would be mandatory to attain painless extraction of maxillary teeth when 2% lidocaine is used.

The molecular structure of articaine makes it a unique anesthetic solution in the dental practice. Articaine contains a thiophene group instead of the benzene ring of lidocaine. The thiophene group enhances diffusion properties and lipid solubility of

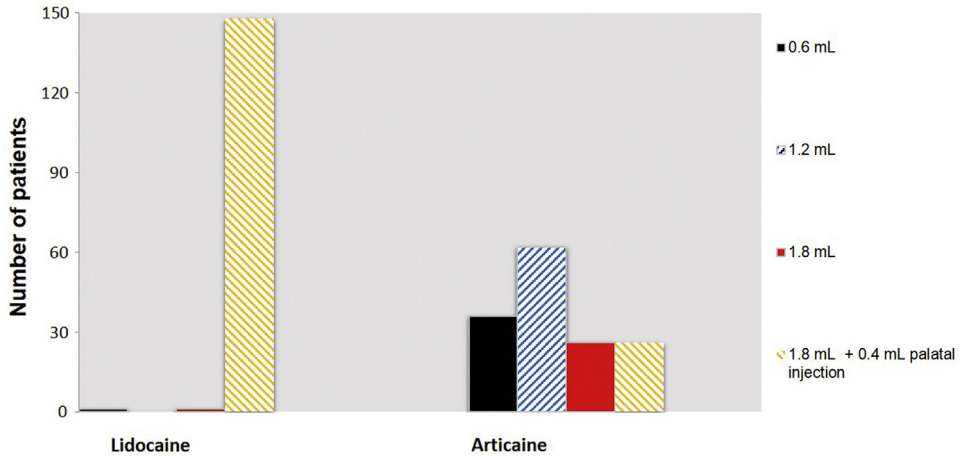

FIGURE 2. The frequency of successful palatal anesthesia after injecting different volumes of lidocaine or articaine.

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articaine and thus promotes the drug passage through soft and hard tissues and penetration into the nerve membranes.[9,12,14] The greater concentration of articaine (4%) as compared to lidocaine (2%) can also promote its diffusion properties, as the local concentration of the active drug at the site of injection would be nearly twice when using articaine compared with lidocaine at the same drug volume.[2,12,21]

According to the results of this study, the deposition of 0.6 mL articaine to the buccal vestibule caused palatal anesthesia in 24% of patients. By administration of another 0.6 ml articaine, palatal anesthesia was attained in an additional 41.4% of cases. In the clinical practice, it seems reasonable to recommend buccal injection of 1.2 mL articaine and expect palatal anesthesia in about two thirds of the patients after a 4-minute wait. The buccal administration of 1.8 mL articaine provided palatal anesthesia in about 83% of patients after a 6-minute latency period, whereas the other 17% required a supplemental palatal infiltration. In the lidocaine group, palatal anesthesia was observed in only 2 patients, 1 injected with 0.6 mL and another with 1.8 mL solution. The majority of cases in the lidocaine group required 0.3 mL palatal infiltration in addition to the buccal deposition of 1.8 mL drug to perceive palatal anesthesia. The outcomes of this study revealed that articaine could provide maxillary tooth removal at a lower drug volume than that of lidocaine.

The bone quality and innervation differ in the anterior versus posterior parts of the maxilla. This can influence the diffusion properties and anesthetic ability of the drugs when used without palatal supplementation. The anterior region has greater innervation; and denser but thinner bone than the molar region of the maxilla.[19] In the present study, the success rate of palatal anesthesia and the amount of medication used was not significantly different between the anterior, premolar, and molar teeth when either lidocaine or articaine was buccally administered. These findings imply that neither the success rate of buccal infiltration nor the drug volume required to induce palatal anesthesia have a significant association with the maxillary tooth region.

A factor that could affect the outcomes of this study is the time required for the onset of action of the 2 anesthetic drugs. In the present study, 3 buccal infiltrations were performed, and the palatal anesthesia was assessed after 2 minutes of each injection. The final conclusion regarding the success of buccal infiltration in attaining palatal anesthesia was made after a 6-minute interval. It is assumed that 2 to 3 minutes is sufficient to achieve anesthesia by buccal infiltration of lidocaine.[2] However, a longer latency

Table 3. THE FREQUENCY OF SUBJECTS WITH ABSENCE OR PRESENCE OF PAIN ON PALATAL INSTRUMENTATION AFTER BUCCAL INFILTRATION IN DIFFERENT MAXILLARY REGIONS

Drug	Pain on Palatal Instrumentation	Anterior	Premolar	Molar	Total	Significance
Lidocaine	Absent (Success)	1	1	0	2	$P = .593$
	Present (Failure)	49	49	50	148	
Articaine	Absent (Success)	43	39	42	124	$P = .463$
	Present (Failure)	7	11	8	26	

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period may be required in the clinical practice to allow diffusion of the anesthetic drug from the buccal vestibule to the palatal mucosa. The greater success rate of articaine as compared to lidocaine may be related to its shorter onset of action due to its superior bone and soft tissue penetration.[13,22] There is a great variation between the studies concerning the optimal interval between the administration of local anesthesia and tooth extraction. Sekhar et al[23] reported successful tooth extraction after 8 min of depositing lidocaine into the buccal vestibule. Kumaresan et al[24] indicated that the time spent to achieve palatal anesthesia after single buccal infiltration of lidocaine was 7-9 min in maxilla. Bataineh and Al-Sabri[19] and Uckan et al[4] performed tooth extraction after injection of 4% articaine and a 5-minute wait. In the study by Sandilya et al,[13] articaine and lidocaine showed a similar onset of action, which was about 4-5 min. Bataineh et al[25] reported that the diffusion characteristics of lidocaine and articaine were not significantly different and both had the mean waiting time of 11.5 min for maxillary tooth extraction.

The results of our study are in agreement with the outcomes of several investigators[3,4,6,13,19,26-28] who demonstrated that the deposition of 4% articaine into the buccal vestibule allowed painless removal of permanent maxillary teeth without the need for palatal supplementation. Somuri et al[1] and Kumar et al[10] indicated that the efficacy of single buccal infiltration of articaine was comparable to the conventional buccal and palatal infiltration by lidocaine. Sharma et al[29] reported that buccal infiltration of articaine was associated with significantly lower pain scores on probing palatal mucosa than that of lidocaine. Bataineh and Al-Sabri[19] found no difference in pain perception during extraction between anterior and posterior regions of the maxilla, when using 4% articaine without palatal injection. Hassan et al[6] reported that the required volume of articaine (0.71 mL) was significantly less than that of lidocaine (1.8 mL) to achieve profound anesthesia for extracting bilateral maxillary premolars.

In contrast to the outcomes of this study, Evans et al[30] indicated that buccal infiltration of articaine caused a comparable anesthetic efficacy to lidocaine in the maxillary first molar region (78% vs 73%), although for the lateral incisors, articaine exhibited a significantly higher anesthetic success rate of 88% as compared to the 62% of lidocaine. Majid and Ahmed[2] showed that buccal infiltration with either lidocaine or articaine should not be considered as an effective substitute to the standard combined injection technique for extraction of maxillary molars. Sekhar et al[23] used buccal injection of 2% lidocaine with 1:80,000 epinephrine in the study group and buccal and palatal infiltration of the same solution in the control group. They found no significant difference in pain levels during maxillary tooth removal between the 2 groups, implying that the deposition of lidocaine to the buccal vestibule could provide favorable palatal anesthesia for tooth extraction.[23] Yadav et al[17] and Badcock et al[18] concluded that the deposition of 2% lidocaine to the buccal vestibule could allow removal of maxillary third molars without the need for a separate palatal injection. The difference between the results of this study and those of previous authors could be attributed to the different latency periods, different concentrations of vasoconstrictors or volumes of local anesthetics, or variations in the methodology and the type of tooth to be extracted in these studies.[2,25] For example, Yadav et al[17] used a greater concentration of epinephrine and included cases that required extraction of third molars, a tooth that could be easily removed on account of its thin buccal bone.

The strength of this study was the large number of included patients and double-blindness. The limitation was that the effect of drug volume could be influenced by the onset time to induce anesthesia, as the effect of larger volumes were assessed at longer intervals. Further clinical trials are warranted to assess the efficacy of articaine compared to other anesthetics and as a substitute to lidocaine using different drug volumes and latency periods. Future studies should also investigate the effect of giving a supplemental buccal infiltration of anesthetic drug before attempting palatal injection on pain perceived during the extraction procedure.

In conclusion, the success rate of buccal injection in achieving palatal anesthesia was significantly greater when using 4% articaine (82.7%) as compared to that of 2% lidocaine (1.3%), implying that articaine can be considered as a suitable alternative to conventional anesthesia by lidocaine to eliminate the need for painful palatal infiltration in the extraction of maxillary teeth. The buccal administration of 1.2 mL articaine caused palatal anesthesia in about two thirds of the patients after a 4-minute period, whereas 17% required palatal infiltration even after deposition of 1.8 mL articaine into the buccal vestibule. No significant difference was found in the success rate or the volume of medication required to induce palatal anesthesia between the anterior, premolar, and molar regions of the maxilla when either lidocaine 2% or articaine 4% was employed as buccal infiltration.

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