

Comparative study of the anesthetic efficacy of 4% articaine versus 2% lidocaine in inferior alveolar nerve block during surgical extraction of impacted lower third molars

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ABSTRACT

Background: A comparative study is made of the anesthetic efficacy of 4% articaine versus 2% lidocaine, both with epinephrine 1:100,000, in truncal block of the inferior alveolar nerve during the surgical extraction of impacted lower third molars.

Study design: A randomized double-blind clinical trial was conducted of 30 patients programmed for the bilateral surgical extraction of symmetrical lower third molars in the context of the Master of Oral Surgery and Implantology (University of Barcelona, Barcelona, Spain). Following the obtainment of informed consent, two operators performed surgery on an extemporaneous basis, using as local anesthetic 4% articaine or 2% lidocaine with the same concentration of vasoconstrictor (epinephrine 1:100,000). The study variables for each anesthetic were: latency (time to action) and duration of anesthetic effect, the amount of anesthetic solution used, and the need of re-anesthetize the surgical zone. A visual analog scale was used to assess pain during surgery, and thus subjectively evaluate the anesthetic efficacy of the two solutions.

Results: Statistically significant differences ($p = 0.003$) were observed in the mean duration of anesthetic effect (220.86 min. for 4% articaine vs. 168.20 min. for 2% lidocaine). Latency, the amount of anesthetic solution and the need to re-anesthetize the surgical field showed clinical differences in favor of articaine, though statistical significance was not reached. The pain scores indicated similar anesthetic efficacy with both solutions.

Conclusions: The results obtained suggest that 4% articaine offers better clinical performance than 2% lidocaine, particularly in terms of latency and duration of the anesthetic effect. However, no statistically significant differences in anesthetic efficacy were recorded between the two solutions.

Key words: *Articaine, Lidocaine, anesthetic efficacy, impacted lower third molar.*

RESUMEN

Objetivo: Valorar y comparar la eficacia anestésica de la Articaína al 4% respecto a la Lidocaína al 2%, ambas con una concentración de 1:100.000 de epinefrina en el bloqueo troncal del nervio alveolar inferior durante la extracción quirúrgica de terceros molares inferiores incluidos.

Diseño del estudio: Se realizó un ensayo clínico aleatorio a doble ciego en una muestra de 30 pacientes programados para las extracciones quirúrgicas bilaterales de terceros molares inferiores simétricos en el Servicio de Cirugía Bucal del Máster de Cirugía e Implantología Bucal de la Universidad de Barcelona. Previo consentimiento del paciente, dos operadores efectuaron las intervenciones quirúrgicas de forma extemporánea, utilizando como anestésico local la Articaína al 4% o la Lidocaína al 2% con la misma concentración de vasoconstrictor (epinefrina 1:100.000). Las variables estudiadas para cada anestésico fueron: tiempo de latencia (o de inicio del efecto anestésico), duración del efecto anestésico, cantidad de solución anestésica utilizada y la necesidad de reanestesiarse la zona operatoria. Se utilizó una escala analógica visual para valorar la cantidad de dolor experimentado durante el acto quirúrgico y, así, evaluar subjetivamente la profundidad anestésica de las dos soluciones.

Resultados: Se observaron diferencias estadísticamente significativas ($p = .003$) en cuanto a la duración del efecto anestésico, que fue mayor para la articaína al 4% (220,8 minutos), respecto a la lidocaína al 2% (168,20 minutos). En las variables tiempo de latencia, cantidad de solución anestésica utilizada y necesidad de reanestesiarse el campo operatorio se evidenciaron diferencias clínicas a favor de la articaína, aunque estas diferencias no fueron estadísticamente significativas. La valoración cualitativa de los anestésicos mediante la escala analógica visual mostró similitud en el dolor experimentado por los pacientes con ambos anestésicos.

Conclusiones: De acuerdo con los resultados obtenidos se puede afirmar que la articaína al 4% muestra mejores características clínicas que la lidocaína al 2%, especialmente en cuanto al tiempo de latencia y duración del efecto anestésico. Sin embargo, no hubieron diferencias estadísticamente significativas que confirmen la superioridad de una solución respecto a la otra, al valorar la eficacia anestésica.

Palabras clave: Articaína, Lidocaína, eficacia anestésica, tercer molar inferior incluido.

INTRODUCTION

Pain control through truncal block of the inferior alveolar nerve is one of the locoregional anesthetic techniques most widely used in oral surgery, affording comfort and safety for both the patient and operator when used correctly. The choice of anesthetic solution should be based on three main clinical considerations: anesthetic potency, latency (time to onset of anesthesia), and duration of the anesthetic effect (1). Other important considerations are the pharmacokinetics (absorption, distribution, metabolism and excretion) and toxicity of the drug. Lidocaine, synthesized by Löfgren in 1943, was the first amide anesthetic prepared for local application, and the only marketed representative of this drug group with topical action. Its potency is presently regarded as the standard for comparison with other local anesthetics (2). The latency of lidocaine varies from 2-3 minutes, with an approximate duration of anesthetic effect for 2% solutions with epinephrine 1:100,000 as vasoconstrictor of 85 minutes at pulp level, and 190 minutes in soft tissues (3). Lidocaine is the local anesthetic most widely used for pain control, since its pharmacokinetic characteristics and low toxicity compared with other ester-type anesthetics make it safe for use in dental practice (1,2,4,5).

Articaine hydrochloride (HCl), or 4-methyl-3-[1-oxo-2-(propylamino)-propionamido]-2-thiophene-carboxylic acid methyl ester hydrochloride, was synthesized by Rusching et al. in 1969 with the name of carticaïne, and was first marketed in Germany in 1976. By 1983 the drug was available in practically all of Europe and Canada, though it was not approved in the United States until March 2000, and only in

its presentation as a 4% solution with epinephrine 1:100,000 (6). The pharmacological characteristics of this anesthetic are responsible for its main advantages with respect to other local anesthetics, and include substitution of the aromatic ring with a thiophenic ring that increases the liposolubility of the drug as well as its potency (1.5 times greater than that of lidocaine). Moreover, articaine is the only amide local anesthetic containing an ester group in its molecular structure – thus allowing metabolism of the drug both by plasma esterases and by liver microsomal enzymes (7). The clinical advantages of articaine include the duration of its anesthetic effect – only surpassed by ultra-long acting anesthetics such as bupivacaine, etidocaine and ropivacaine – and its superior diffusion through bony tissue (8,9). Lemay et al. (10) found the mean latency of articaine to be 2.01 minutes. In comparison, Martínez et al. (11) recorded 2.9 minutes, while other authors such as Berini and Gay-Escoda (1) and Malamed (2) reported times to anesthesia onset of 1-2 minutes. The duration of the anesthetic effect varies according to the amount of vasoconstrictor added to the commercial formulation. Thus, in Europe 4% articaine with epinephrine 1:100,000 is usually used, yielding approximate durations of anesthesia of 75 and 240 minutes at pulp and soft tissue level, respectively. Another common presentation is 4% articaine with epinephrine 1:200,000, yielding anesthetic durations of 45 and 180 minutes at pulp and soft tissue level, respectively (5,12).

Since the introduction of articaine on the market, a number of studies have evaluated its advantages with respect to other local anesthetics. In this sense, many authors have been

unable to demonstrate superior anesthetic efficacy versus other agents such as 4% prilocaine (13) or 2% lidocaine with epinephrine 1:80,000 (14). Nevertheless, Malamed et al. (7,15), after comparing the drug with 2% lidocaine and epinephrine 1:100,000, reported articaine to be a safe local anesthetic that can be used in both adults and children, with an anesthetic latency and duration that makes it adequate for clinical use and comparable to the rest of local anesthetics (7, 15).

The present study compares the anesthetic efficacy of 4% articaine versus 2% lidocaine, both with epinephrine 1:100,000, in application to truncal block of the inferior alveolar nerve during the surgical extraction of impacted lower third molars.

MATERIAL AND METHODS

Two operators enrolled in the second and third course of the Master of Oral Surgery and Implantology (Service of Oral and Maxillofacial Surgery, University of Barcelona Dental School, Spain) conducted a randomized double-blind clinical trial of 30 patients (13 males and 17 females; mean age 23.72 years (standard deviation (SD): 0.71), range 18-36 years) programmed for bilateral surgical extraction of the lower third molars. The inclusion criteria were: subjects over age 18, without systemic disorders or antecedents of complications associated with local anesthetics, and presenting impacted symmetrical lower third molars requiring ostectomy and tooth sectioning for extraction. The exclusion criteria were: the existence of acute infection and/or swelling at the time of surgery, and interventions in which anesthetic latency exceeded 5 minutes. Operations lasting more than 60 minutes were also excluded, as were those patients presenting intra- or postoperative complications such as paresthesia or dysesthesia of the inferior alveolar nerve.

After obtaining informed consent, surgery was performed on an extemporaneous basis, with a minimum washout period of one month between operations, and using 4% articaine (Articaine 4% Inibsa®, Inibsa, Barcelona, Spain) or 2% lidocaine (Xylonibsa®, Inibsa, Barcelona, Spain) as anesthetic solution, with the same concentration of vasoconstrictor (epinephrine 1:100,000) in both cases. The patients were randomly assigned to one of the two anesthetic groups.

Direct truncal block of the inferior alveolar nerve was performed, complemented with vestibular and retromolar trigone infiltration for anesthetic block of the buccal nerve, using a 25G needle 35 mm in length (Nissho Nipro, Zaventem, Belgium) for truncal block, and a 27G needle 25 mm in length (Nissho Nipro, Zaventem, Belgium) for infiltration block. A 1.8-ml cartridge of anesthetic solution was injected in 60 seconds for inferior alveolar nerve block, while another 1.8-ml cartridge was used for buccal nerve anesthesia. The anesthetic techniques were performed on a random basis by one of the two operators. Each operator performed the two extractions in the same patient - each with one type of anesthesia. After injection of the anesthetic solution, the time to anesthetic effect was recorded (defined as the

time elapsed from full needle withdrawal until the patient referred the first evidence of Vincent's sign). The duration of anesthesia was in turn recorded as the time from initial patient perception of the anesthetic effect to the moment in which the effect began to fade.

Evaluation was also made of the need to re-anesthetize the surgical zone, specifying the technique and amount of anesthetic injected. The anesthetic techniques used to re-anesthetize the surgical field comprised the intraligamentous and intrapulpal approaches – the latter only being used when anesthetic reinforcement proved necessary at the time of tooth sectioning. A visual analog scale (VAS) from 0 to 100 millimeters was used to subjectively assess the depth of anesthesia – each patient scoring pain intensity during surgery and after the operation.

The statistical analysis of the results was carried out with the Student t- and chi-square tests, using the SPSS version 11.0 statistical package throughout.

RESULTS

Of the 30 patients, three were excluded from the study: one due to the development of transient inferior alveolar nerve paresthesia, another because of transient paresthesia of the lingual nerve, and the third as a result of voluntary dropout from the study. A total of 54 interventions were included in the study: 24 performed with 2% lidocaine, and 30 with 4% articaine (with epinephrine 1:100,000 in both cases). In most cases extraction was decided for prophylactic reasons (33% of cases), followed by orthodontic indications (27.8%), a history of pericoronaritis (25.9%), anterior crowding (5.6%), pain alone (5.6%), and periodontal lesion of the lower second molar (1.9%). The mean duration of surgery was 22.57 minutes (SD: 1.27), without significant differences between the two groups. The mean anesthetic latency for lidocaine was 75.04 seconds (SD: 14.8), versus 56.03 seconds (SD: 9.76) for articaine – no statistically significant differences being observed between the two anesthetic solutions. In turn, the mean duration of the anesthetic effect was 220.86 minutes (SD: 13.81) for articaine and 168.20 minutes (SD: 10.77) for lidocaine – the difference in this case being statistically significant ($p = 0.003$) (Table 1).

In 16 interventions (29.6% of cases) re-anesthesia of the surgical zone proved necessary. The frequency of the techniques used, differentiated by anesthetic solutions, is reflected in Table 2. The nonparametric chi-square test revealed no significant differences between the need for re-anesthesia with articaine or lidocaine ($p = 0.128$). However, in terms of the amount of anesthetic solution used (including the cases of re-anesthesia) during the operation to achieve the desired anesthetic effect, larger volumes of 2% lidocaine with epinephrine 1:100,000 were required, administering an average of 4.20 ml (SD = 0.19) per operation (equivalent to 2.3 standard carpules), versus 3.86 ml (SD = 0.09) in the case of 4% articaine with epinephrine 1:100,000 (equivalent to 2.1 standard carpules). This differences did not quite reach statistical significance, however ($p = 0.052$).

Table 1. Duration of impacted third molar surgical extraction, anesthetic latency and duration, and intraoperative pain with 4% articaine and 2% lidocaine (both with epinephrine 1:100,000 as vasoconstrictor).

		N	Mean	SD	Range
Duration of surgery (min.) (<i>p</i> = 0.468)	L	24	22.0	1.85	12 - 50
	A	30	22.2	1.64	10 - 40
Latency (sec.) (<i>p</i> = 0.137)	L	24	75.0	14.02	17 - 300
	A	30	56.0	09.43	10 - 250
Duration of anesthesia (min.) (<i>p</i> = 0.003)	L	24	168.2	10.77	74 - 336
	A	30	220.8	13.81	57 - 416
Intraoperative pain (mm) (VAS) (<i>p</i> = 0.411)	L	24	12.8	3.19	0 - 48
	A	29	13.8	3.01	0 - 49

L: 2% lidocaine; A: 4% articaine (with epinephrine 1:100.000 as vasoconstrictor in all cases).

Table 2. Frequency of re-anesthesia according to the local anesthetic solution used and the anesthetic reinforcement technique involved.

Re-anesthesia technique	Local anesthetic			
	Lidocaine		Articaine	
	N	%	N	%
No re-anesthesia	15	62.5	23	76.7
Intraligamentous	8	33.3	4	13.3
Intrapulpal	1	4.2	3	10
Total	24	100	30	100

Lastly, subjective intraoperative pain scoring by the patients showed no differences between the two anesthetic solutions, with mean VAS scores of 13.81 mm (SD: 3.012) and 12.83 mm (SD: 3.186) for articaine and lidocaine, respectively (Table 1). A value reported by one of the patients for articaine was excluded, since scoring proved erroneous because the patient failed to understand the pain-evaluating instructions provided.

DISCUSSION

The diversity of anesthetic substances currently available on the market requires dental professionals to assess both the pharmacokinetic and clinical characteristics of each drug solution, in adaptation to the needs of each individual

dental intervention. Since its introduction in 1969, articaine has gradually become implanted in Europe. Its chemical structure, different to that of other local anesthetics due to substitution of the aromatic ring with a thiophenic ring, and the presence of an additional ester ring, provides articaine with increased liposolubility and intrinsic potency, as well as greater plasma protein binding versus other commonly used local anesthetic such as prilocaine or mepivacaine. These differential characteristics are in turn clinically reflected by a shorter latency and increased duration of anesthesia, as well as superior bony tissue diffusion (1,7,8,9).

The latency of an anesthetic depends on a number of factors, such as the intrinsic properties of the drug substance used,

and the anesthetic technique employed. On the other hand, latency is directly influenced by the corresponding pKa value - smaller pKa values being associated to shorter latency. Accordingly, 4% articaine (pKa = 7.8) would at least in theory present a shorter latency than 2% lidocaine (pKa = 7.9). Our results coincide with this assumption, since the latency was 1.3 times shorter for articaine versus lidocaine.

On the other hand, the recorded latencies for both anesthetic substances were shorter than reported by other authors. This may be because we measured latency from the moment of needle withdrawal from the patient soft tissues, while in contrast other investigators such as Cowan (16), in a comparative study of 4% articaine (the early name used for articaine) and the rest of amide local anesthetics, recorded latency from the moment of needle insertion and injection of the anesthetic. This author found the latency of articaine in application to mandibular block to be 1.48 minutes (16). According to other authors such as Malamed et al. (2), the latency of 4% articaine in mandibular block is 2-2.30 minutes, while Berini and Gay-Escoda (1) reported a latency of 2 minutes. In the case of lidocaine, both authors referred latencies in the range of 2-3 minutes. In our experience the latency of articaine was 56.03 seconds (0.93 minutes), versus 75.04 seconds (1.25 minutes) in the case of lidocaine. The difference between the two anesthetic solution was not significant.

The duration of the effect of an anesthetic is proportional to its degree of protein binding. However, the duration of the effect of the local anesthetic is also dependent on the injection site or concentration of vasoconstrictor present in the anesthetic solution, among other factors. Articaine presents one of the greatest protein binding percentages of all amide local anesthetics, comparable only to ultra-long action substances such as bupivacaine, ropivacaine and ethidocaine. This in turn implies a longer duration of the anesthetic effect (1). In our study, the duration of articaine anesthetic effect varied from 57-416 minutes (0.40-6.95 hours, respectively). These values are comparable to those reported in the literature (1,9,10,15), and are significantly longer than in the case of lidocaine. Nevertheless, considering the mean duration of the surgical interventions in our study, the 166.04 minutes of soft tissue anesthesia afforded by lidocaine are more than enough for the surgical extraction of an impacted lower third molar.

In this study a clinical evaluation of the efficacy of the two anesthetic solutions was made by comparing the need for re-anesthesia during dental surgery, in view of the impossibility of performing an electric pulp stimulus test for the objective assessment of anesthetic efficacy. In 16 interventions (29.62% of cases) another dose of anesthetic solution had to be administered via either the intrapulpal or intraligamentous technique. The number of repeat anesthetic procedures was greater when using 2% lidocaine. As a result, the total volume of anesthetic solution administered was 1.7 times greater than in the case of 4% articaine. On the other hand, this difference in the total amount of anesthetic solution used (0.31 ml) was similar to the value reported by

Malamed et al. (7) in their multicenter study of 1325 adult patients. However, the difference in both the mean frequency and amount of solution used for re-anesthesia of the surgical zone failed to reach statistical significance.

Subjective evaluation of the local anesthetics used in the present study (including those cases where re-anesthesia proved necessary) was made by means of a visual analog scale (VAS) in which the patient was instructed to score intraoperative pain intensity. The mean scores for 2% lidocaine and 4% articaine (both with epinephrine 1:100,000 as vasoconstrictor) were not significantly different. These results are comparable to those obtained in other studies contrasting the performance of these two local anesthetics (14,15,17,18).

Articaine was the anesthetic used in the two patients excluded from the study due to the appearance of transient paresthesia of the inferior alveolar nerve and lingual nerve. Haas and Lemmon (19), in a review of 143 paresthesias, found the latter to be more frequent when articaine and prilocaine were used. On the other hand, Malamed et al. (7) also reported an increased incidence of nerve alterations, paresthesias and hyperesthesias, when administering 4% articaine with epinephrine 1:100,000 versus 2% lidocaine at the same vasoconstrictor concentration - suggesting a possible greater neurotoxic effect on the part of articaine. In this sense, Peñarrocha et al. (20) documented 14 cases of eye problems when using this anesthetic for infraorbital nerve block. Among the causes for these complications, the authors mentioned the possibility of increased diffusion of this anesthetic within the soft tissues and bone - thus facilitating articaine penetration to the orbital cavity. In our experience, and despite the fact that the two cases presenting paresthesia were both anesthetized with articaine, there is insufficient evidence to believe the underlying cause to be the type of anesthetic used. We therefore consider that further studies are needed to establish such a possible relationship.

CONCLUSIONS

The results obtained suggest that 4% articaine offers better pharmacological performance than 2% lidocaine, particularly in terms of latency and duration of the anesthetic effect. However, no statistically significant differences in anesthetic efficacy were recorded between the two solutions.

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