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Comparative study between the digital anesthesia technique *vs* the conventional local anesthesia technique

Estudio comparativo entre la técnica de anestesia digital y la técnica de anestesia local convencional

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ABSTRACT: The aim of this study was to compare the conventional local anesthesia technique with digital local anesthesia in adults. A prospective, single-blind, randomized clinical trial was conducted with 30 adult patients scheduled for extraction of upper molars or premolars. Participants had no medical conditions that could influence the results. A 2% lidocaine solution with 1:100,000 epinephrine was administered on one side using two digital anesthesia devices (Soga Smart III, Denops, and Geni Dental) and on the contralateral side using a conventional syringe. Pain was assessed immediately after anesthesia using a visual analog scale (0–10). All data were tabulated for statistical analysis, and all patients provided informed consent. The study included 30 patients (14 men and 16 women) with a mean age of 34.9 years. On the experimental side, the mean pain score was 2.67, higher in men (3.86) than in women (2.69). Results by device were: Coxo (3.0), Soga (3.2), and Denops (2.8). On the control side, the mean pain score was 6.07, with men reporting 7.14 and women 6.31. No complications were observed during the procedures. Regarding professional satisfaction, 40% of practitioners considered the digital anesthesia technique easier, while 60% preferred the conventional technique. The comparison between conventional and digital anesthesia in dentistry reveals significant differences in efficacy, comfort, and patient experience. Digital anesthesia is perceived as less invasive, increasing patient confidence and comfort, allowing for more precise administration of anesthetic, and reducing anxiety and pain. However, its application and onset time are longer, which may limit its effectiveness in complex procedures where conventional anesthesia is preferred. Digital anesthesia is recommended for simple procedures, particularly for patients with low pain thresholds or previous negative experiences. Overall, combining both techniques may optimize outcomes in dental treatments.

KEY WORDS: Local anesthesia, digital anesthesia, pain control.

INTRODUCTION

Pain management is one of the most critical factors in fostering a positive attitude among patients during dental consultations. Local anesthesia involves the administration of a suitable chemical agent near nerves, thereby blocking the conduction of nerve impulses. This procedure poses a significant challenge for oral and maxillofacial surgeons, particularly when treating anxious patients or those with prior unpleasant dental experiences. Studies have shown that the administration of local anesthesia often leads many patients to avoid dental treatment (Gibson *et al*., 2000; Barros *et al*., 2013; Berrendero *et al*., 2021; Coari Diaz *et al*., 2024).

The use of local anesthetics is essential for effective

pain control during dental procedures, as pain, fear, or anxiety can significantly increase non cooperative behavior, thereby hindering the execution of dental treatments and clinical practice. Literature indicates that local anesthesia is among the primary dental procedures reported by patients as a negative experience due to associated pain, which can adversely affect treatment outcomes and may even lead patients to avoid seeking dental care altogether (Silveira *et al*., 2023).

Controlling injection flow in local anesthesia can be challenging due to the limitations of the traditional syringe system. Conventional syringes deliver anesthetic at a rate determined by the operator's muscular control, technique, and the resistance of the tissue at the injection site. With this type of syringe, it is not possible to precisely control either the pressure or the volume of the anesthetic administered (Barros *et al*., 2013).

Patient pain perception during the administration of local anesthesia in dentistry can be significantly influenced by factors such as injection speed, anesthetic volume, and temperature. Research has shown that slower injection rates can reduce pain perception, as tissues gradually adapt to the fluid, thereby decreasing pressure and discomfort. Additionally, the volume of anesthetic is critical; an appropriate amount ensures optimal diffusion of the agent, which may further reduce pain sensation. The temperature of the anesthetic solution also plays a role: using solutions at body temperature has been shown to decrease discomfort during injection compared to cold solutions (Sultan, 2007). Controlling the pressure and volume of the anesthetic solution during local anesthesia is critical for the success of the technique. Additionally, the use of a narrow-gauge needle and a slow administration rate helps reduce the tissue distension pressure experienced by the patient (Barros *et al*., 2013).

In recent years, several companies have developed digital anesthesia systems that enable precise control over the speed and volume of local anesthetic injections, which has been shown to improve the patient experience during dental procedures. For example, the Wand System, also known as the Magic Wand, has been extensively studied and found to provide a more controlled and less painful anesthetic delivery through low-pressure injections at a consistent flow rate (Sumer *et al*., 2006). Similarly, the Comfort Control Syringe has demonstrated positive outcomes in reducing injection pain by regulating the delivery speed of the anesthetic (Tirupathi *et al*., 2020). These technological advancements not only optimize the effectiveness of anesthesia but also help reduce patient anxiety and discomfort, highlighting the relevance of innovation in modern dental practice.

The analysis of new technologies in comparison with traditional procedures enables the evaluation of their efficiency and the consideration of potential changes in treatment protocols, an area in which anesthesia is no exception. Accordingly, the objective of this study was to compare conventional local anesthesia techniques with digital local anesthesia techniques in adult patients.

MATERIAL AND METHOD

A randomized, single-blind, split-mouth prospective clinical study was carried out with 30 adult volunteer patients aged between 18 and 60 years. Eligible participants, regardless of gender, required the extraction of bilateral maxillary molars or premolars and presented no history of systemic conditions that could influence the study outcomes.

The procedures were performed by Oral and Maxillofacial Surgeons. Randomization was carried out to assign the experimental side (right or left) using the software random.org (Randomness and Integrity Services Ltd). The anesthetic administered was 2% lidocaine with epinephrine 1:100,000, supplied in 1.8 mL glass cartridges (New Stetic, C.A., Colombia). Patients with contraindications to this medication were excluded from the study.

On the experimental side, three digital anesthesia devices were employed for the administration of the anesthetic solution, using the programs most comparable to the conventional procedure (Fig. 1):

- Soga Smart III, set to a flow rate of 1.62 mL/min.
- Denops (Dentis) in Stage full mode: 1.8 mL/3rd Stage: 48 seconds.
- Geni Dental Anesthesia Booster (Coxo) in mode: High 1 mL/about 89 seconds.

All three devices are equipped with preprogrammed flow rates ranging from 0.1 to 1.0 mL/min (Tabla I). Each consists of a mobile unit with an interactive display, provides auditory feedback, and features an ergonomic design that facilitates anesthetic administration. In addition, these systems are compatible with conventional universal anesthetic cartridges and needles.

Fig. 1. Caharcateristics of the equipaments. 1a. Dentis Denops, 1b. Coxo, Deni dental, 1c. Soga smart III.

Table I. Characteristics of the equipment and procedures.

Dentis (denops)	Coxo Geni Dental Anesthesia Booster	Soga Smart III
-Cold-sterilizable plastic case -Charging unit with plug -Options for the amount of injectable medication: 1/16, 1/8, 1/4, 1/2, Full. -Speed: Step 1, 2, 3. (Low / Mid / High) Manual: l: 320 s. 2: 160 s. 3: 30 s. Automatic: 1: 320 s. 2: 170 s. 3: 48 s.	-Cold-sterilizable plastic case -Rechargeable wireless charging unit. -Speed: • High (about 89 s) • Mid (about 130 s) • Low (about 285 s) - Projection adjustment for a single injection: 0.1 ml, 0.3 ml, 0.6 ml, 0.9 ml, 1.8 ml.	-Sterilizable metal case -Case-type wireless charging unit. -Injection Flow rate: • High speed mode: 1.62 mL/min (±10 %). • Low-speed mode: 1.02 mL/min (±10 %). • PDL mode: 0.42 mL/min (±10 %).

Fig. 2. Digital anesthesia application.

In contrast, the control side was anesthetized using a conventional dental syringe, with an approximate flow rate and injection time of 1 minute, simulating the duration required for the digital devices. Following administration, participants were asked to rate their pain perception using a visual analog scale (VAS) ranging from 0 to 10, where 0 indicated the absence of pain and 10 represented the maximum level of pain.

Finally, all data were tabulated and processed for analytical statistics. Each patient signed an informed consent form authorizing the collection of data related to their procedure.

This research was approved by the Research-bioethics Committee of La Floresta Clinical Institute, Caracas. (RDE-2025-1)

RESULTS

A total of 30 patients were included in the study, comprising 14 men (46.67 %) and 16 women (53.33 %). The mean age of participants was 34.9 ± 7.71years, with ages ranging from 18 to 60 years. On the experimental side, the mean pain score reported was 2.67 ± 0.93. When stratified by gender, men presented a higher mean score of 3.86 compared to 2.69 in women.

Regarding the digital devices used on the experimental side, the mean pain scores were as follows: Soga device, 3.2 ± 1.36; Coxo device 3.0 ± 0.71; and Denops device (Dentis), 2.8 ± 0.60. On the control side, the mean pain score was 6.07 ± 1.00. Stratified by gender, men reported a higher mean score of 7.14, whereas women reported a mean of 6.31. No complications were reported during any of the procedures.

Professional satisfaction with the anesthesia techniques was also assessed. No difficulties were reported with either approach; however, 40 % of the professionals found the digital anesthesia technique easier to use, whereas the remaining 60 % preferred the conventional technique.

Table II. Distribution of patients according to age, sex, level of pain expressed by the patient on both sides, equipment used and complications.

PX.	AGE	SEX	CONTROL SIDE	EXPERIMENTAL SIDE	EXPERIMENTAL EQUIPMENT	COMPLICATIONS	EXTRACTED TEETH
1	18	M	8	5	Soga	No	14 - 24
2	50	M	7	3	Dentis	No	17 - 26
3	19	M	7	4	Coxo	No	14 - 24
4	48	M	7	3	Coxo	No	16 - 26
5	20	F	6	2	Soga	No	14 - 24
6	32	F	7	3	Dentis	No	16 - 26
7	21	F	6	2	Coxo	No	15 - 24
8	30	F	7	2	Dentis	No	17 - 27
9	55	F	5	2	Soga	No	16 - 26
10	52	F	6	3	Coxo	No	17 - 27
11	22	M	8	4	Soga	No	14 - 24
12	37	M	7	3	Dentis	No	17 - 26
13	24	M	8	2	Dentis	No	14 - 24
14	39	F	7	2	Coxo	No	16 - 27
15	29	F	5	3	Dentis	No	14 - 24
16	31	M	6	4	Soga	No	17 - 26
17	38	F	7	3	Coxo	No	17 - 27
18	26	M	8	4	Coxo	No	14 - 24
19	41	M	6	3	Dentis	No	17 - 26
20	55	F	6	2	Dentis	No	17 - 27
21	43	F	7	2	Soga	No	15 - 25
22	54	F	4	1	Soga	No	16 - 27
23	39	M	7	3	Coxo	No	16 - 26
24	52	M	5	2	Dentis	No	17 - 27
25	27	F	8	3	Soga	No	15 - 25
26	34	M	7	5	Soga	No	16 - 26
27	39	F	6	3	Dentis	No	17 - 27
28	40	F	5	3	Coxo	No	16 - 27
29	38	F	6	2	Soga	No	15 - 25
30	45	M	7	4	Coxo	No	16 - 27

DISCUSSION

The administration of local anesthesia, which blocks nerve impulse conduction, is one of the most frequently performed procedures in dental practice. Despite technological advancements and improvements in dental care, injection-

related pain remains a significant source of fear and anxiety for many patients. Discomfort during anesthetic administration can be influenced by various factors, including age, prior unpleasant experiences, emotional state, and anxiety (Barros *et al*., 2013).

In recent decades, a technique known as digital anesthesia has emerged, aimed at controlling the administration of anesthetic solutions while enhancing patient comfort. Although serving the same purpose as conventional methods, this approach allows for preprogramming prior to application. Digital anesthesia enables precise control over the amount of anesthetic delivered, the timing, and the flow rate, depending on the anatomical area and whether the patient is an adult or a child. It can be employed in any infiltrative anesthetic technique, including areas such as the palate and periodontal ligament, thereby reducing discomfort in these denser tissues (Gibson *et al*., 2000; Barros *et al*., 2013; Berredero *et al*., 2021; Silveira *et al*., 2023).

A commonly cited explanation in the literature is that rapid injection of anesthetic solution can cause tissue distension and damage, resulting in heightened pain perception during administration (Bennett, 1989; Vieira *et al*., 2000; Primosch & Brooks, 2002). We concur with these findings and note that manual control of anesthetic flow can be challenging, particularly in denser tissues such as the palatal region. Consequently, excessive anesthetic may be delivered relative to the tissue's capacity, leading to increased internal pressure and discomfort.

The age range in our study was broad, spanning from 18 to 60 years, to capture diverse references regarding pain perception. In the literature, studies on digital anesthesia predominantly focus on pediatric populations (Silveira *et al*., 2023), as children often exhibit greater resistance to the procedure due to fear or anxiety. However, research indicates that there are no significant differences in pain perception between techniques in this population; rather, anxiety levels and pre-procedural behavior tend to improve markedly (Gibson *et al*., 2000; Berrendero *et al*., 2021; Silveira *et al*., 2023; Coari Díaz *et al*., 2024).

In contrast to the mentioned studies, our research was conducted with adult patients, yielding satisfactory results that align with findings from one of the analyzed studies. In that study, the equipment employed was a computer controlled anesthetic injector, specifically the Morpheus®. The authors reported that only 30 % of patients experienced any discomfort with the computerized technique, whereas 70 % reported no pain. By comparison, with the conventional technique, 60% of patients reported discomfort, while only 40 % experienced no pain (Barros *et al*., 2013).

Regarding pain perception, we observed that female patients reported lower pain intensity, with an average score of 2.69 in the experimental group, suggesting a less intense experience compared to male patients. This difference may be influenced by multiple factors, including biological variations such as endorphin release and hormonal effects, as well as psychological and social factors that shape how each gender perceives and expresses pain. Women appear to cope with pain differently, which may result in lower self-reported intensity. Similar findings were reported in a comparative study on anxiety and pain perception, which concluded that female patients experienced less pain during surgical procedures; however, the differences were not statistically significant (Bennett, 1989).

The relationship between pain perception and age demonstrates notable variability. Younger patients, specifically those aged 18 to 22 years, reported higher pain levels, with an average score of 8, whereas older patients, such as those aged 54 and 55 years, reported lower scores of 4 and 6 in the control group, respectively. These findings suggest that older adults may have a higher pain tolerance or reduced sensitivity to discomfort during medical procedures. Nonetheless, several individuals in the middle-age range reported pain levels comparable to those of the younger cohort. Overall, these results indicate that pain perception is influenced not only by age but also by individual factors, including prior experience with medical procedures, anxiety levels, and personal pain thresholds (Abad Silupu, 2019; Bishop *et al*., 2015).

The Coxo device yielded an average score of 3, suggesting a relatively comfortable experience, while the Soga device recorded a slightly higher average of 3.2. In contrast, Denops (Dentis) device the achieved the lowest average score of 2.8, indicating a marginally more effective reduction in pain perception than the other devices. Although these differences are modest, the results suggest that the Denops (Dentis) device may provide greater comfort during anesthesia administration without compromising anesthetic efficacy, particularly when compared to the control group, which demonstrated a significant difference between conventional and digital techniques. Notably, the devices

reported as easiest to handle and learn were Soga and Denops. Factors such as the injectiontechnique, the speed of anesthetic administration, and the ergonomic design of each device may have contributed to these results. Overall, all three devices demonstrated acceptable performance, suggesting that any of them could be preferred by clinicians aiming to optimize patient comfort and the overall experience during dental procedures.

Regarding professional satisfaction during anesthesia administration, although both techniques are considered effective and consistent with existing literature, this study reveals that many practitioners still prefer the conventional method. This preference may be related to limited familiarity or experience with the alternative digital devices. Furthermore, it is important to note that the benefits of digital anesthesia may vary depending on the type of procedure; for example, oral and maxillofacial surgeons might encounter increased procedure time or require multiple infiltrations in a single intervention. In contrast, for procedures such as single-implant placements, individual extractions, endodontic treatments, or aesthetic dental interventions, the precise targeting of the injection site makes these devices particularly well-suited.

As dental professionals, it is essential to implement techniques that enhance the patient experience. Such approaches not only foster a more positive attitude during treatment but also create an environment of greater calm and trust. By reducing pain perception and anxiety associated with anesthesia, patient well being is improved, which, in turn, positively influences the clinician's performance. However, it is important to acknowledge that the literature highlights potential drawbacks, including increased treatment time and a shorter duration of anesthetic effect factors that continue to lead many practitioners to favor conventional techniques.

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RESUMEN: Este estudio comparó la técnica convencional de anestesia local con la técnica de anestesia digital en adultos. Se trató de un ensayo clínico prospectivo, aleatorizado y simple ciego, realizado en 30 pacientes entre 18 y 60 años que requerían extracción de molares o premolares superiores. No presentaban antecedentes médicos relevantes. Se utilizó lidocaína al 2 % con epinefrina 1:100.000, administrada en un lado con dispositivos digitales (Soga Smart III, Denops y Geni Dental) y en el otro con jeringa convencional. El dolor se evaluó mediante una escala visual análoga de 0 a 10. En el lado digital, el dolor promedio fue de 2,67 (3,86 en hombres y 2,69 en mujeres); por dispositivo: Coxo (3,0), Soga (3,2) y Denops (2,8). En el lado convencional, el dolor fue de 6,07 (7,14 en hombres y 6,31 en mujeres). No se registraron complicaciones. En cuanto a la satisfacción profesional, el 40 % consideró más fácil la técnica digital, mientras que el 60 % prefirió la convencional. La anestesia digital se consideró menos invasiva, con mayor comodidad y precisión, y útil en pacientes con bajo umbral de dolor o experiencias negativas previas. No obstante, su aplicación y acción son más lentas, lo que limita su uso en procedimientos complejos, donde se prefiere la técnica convencional. Se concluye que la combinación de ambas técnicas podría optimizar los resultados en tratamientos odontológicos.

PALABRAS CLAVE: anestesia local, anestesia digital, control del dolor.

CONCLUSIONS

The comparison between conventional and digital anesthesia in dentistry highlights notable differences in efficacy, comfort, and patient experience. Digital anesthesia is perceived as less invasive by patients, fostering greater trust and comfort during treatment. This technique enables more precise and controlled administration of the anesthetic, which can reduce anxiety and pain, thereby enhancing the overall patient experience. However, the longer application and onset time associated with digital anesthesia may limit its effectiveness for more invasive or lengthy procedures, where conventional techniques remain the preferred choice for many practitioners.

Overall, digital anesthesia is recommended as an alternative for simpler dental procedures, particularly for patients with low pain tolerance or prior negative experiences. The technique has proven to be simple, effective, and safe, with patients reporting lower pain levels compared to conventional anesthesia.Consequently, integrating both conventional and digital anesthesia approaches may represent an optimal strategy to enhance patient comfort and clinical outcomes in dental treatment.

Data Availability: All data supporting the findings of this study are included in the article.

Authors' Contributions: The research was conducted with the equal participation of all authors, who contributed equally to data collection, analysis, and manuscript writing. All authors have read and approved the published version of the manuscript.

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Conflict of Interest: The authors declare no conflicts of interest.

Ethical Approval: The study was conducted in accordance with the Declaration of Helsinki. The research bioethics Committee of La Floresta Clinical Institute, Caracas: RDE-2025-1.

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