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Review Article

Controlled Flow of Dental Anesthesia Solution to Reduce Pain and Anxiety

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Abstract

Local anesthetic injection remains as one of the most anxiety-provoking aspects for both children and adult patients in dentistry, although anesthesia infiltration is needed for almost all dental procedures. Computerized anesthetic injection has been suggested as an alternative to classic dental anesthesia. This review set out to describe current available devices for a controlled flow of dental anesthesia solution to reduce pain and anxiety during its administration and address the supported evidence. Although few studies analyze the topic in detail so far, computer-controlled anesthetic delivery seemed to be statistically superior to traditional dental injections in terms of patient comfort. The use of computer controlled anesthetic may be considered a strategy to reduce patient´s fear and create a positive attitude towards dental treatment in the future. More randomized clinical trials are needed to draw more precise conclusions.

ABBREVIATIONS

STA: Single Tooth Anesthesia; CCS: Comfort Control Syringe; CNR: Computer-controlled Anesthetic Delivery System; CCLAD: Computer Controlled Local Anesthetic Delivery System

INTRODUCTION

The perception of pain is subjective and strongly dependent on the cultural, individual and economic background of the patient. Specifically, dental pain management is still one of the most critical aspects in modern dentistry because it is not entirely under the operator´s control, but depends on the patient's "level of anxiety, trust, personality and perceived control over the painful stimulus" [1].

Anesthetic needles and drills have been ranked as the most unpleasant or anxiety-arousing stimuli in dental fear research. Specifically, injections for dental treatments is usually ranked first or second in a hierarchy of specific dental fears [2]. Local anesthetic injection has been defined as one of the most anxiety-provoking procedure for both children and adult patients in dentistry [1]. Le Claire showed that local anesthetic injection caused the highest level of anxiety [3]. On the other hand, while most patients encounter fear of pain and anxiety during local anesthetic injections [4], anesthesia infiltration is needed for almost all dental procedures.

It seems wise to search for devices and techniques that minimize patient´s sensation of pain and anxietyin order to obtain greater satisfaction during dental procedures without reducing the numbing effect.Several methods have been clasically used to minimize the discomfort produced by traditional dental anesthesia; for example, the slow delivery of anesthesia with narrow needles and after topical anesthesia application [1]. However, the injection procedure depends on the operator´s dexterity, strength and experience when traditional anesthesic techniques are used since the flow rate and fluid pressure is difficult to control with metalic cartridge-based syringes [5].

COMPUTER CONTROLLED DEVICES FOR DENTAL ANESTHESIA ADMINISTRATION

Recent developments have allowed introducing computerized anesthetic injection as an alternative method to classic dental anesthesia. Innovative computerized systems might be a possible solution to reduce the pain during the local anesthetic injection by automatically controling the slow delivery of local anesthetic solution [1]. Furthermore, the use of computer controlled devices for local dental anesthesia administration has become an important topic for clinical scientific research in the dental field.

THEORETICAL ADVANTAGES AND DRAWBACKS

There are theoretically three possible advantages of these devices that may have an impact in reducing pain during anesthetic administration:

1. A better control of the volume delivered: a controlled volume might be better tolerated by the tissue.

2. A more precise flow rate delivery: a controlled flow rate seems to be associated to a faster effect and a decrease in pain perception and patient anxiety levels [2,5,6].

3. A more controlled speed of injection is supposed to prevent

the subsequent swelling of the tissue [7].

At the same time, two drawbacks have been described:

1. Highercost than traditional anesthesia.

2. Longer time required for the complete delivery of the cartridge [6].

MARKETED DEVICES

The first computerized anesthetic delivery system was introduced in the dental market in the last quarter of 1997 [5,7,8]. Several electronic pre-programmed computerized local anesthetic injection devices have been marketed later. All of them basically consist on an electronic unit that connects to a handpiece that includes a syringe and needle. The computer is activated by an operator controlled foot pedal or switch button.

The devices currently available are: The Wand Single Tooth Anesthesia (STA) System (Milestone Scientific, Livingstone, NJ), the Comfort control syringe (CCS) (Midwest-Dentsply, Des Plaines, IL), Quicksleeper and SleeperOne (Dental Hitech, ZI Champ Blanc, France) , Anaeject (Septodont, Sallanches, France) and Calaject (Ronvig, Daugaard, Denmark).

The Wand Single Tooth Anesthesia (STA) System (Milestone Scientific, Livingstone, NJ) is a computer controlled device that maintains a constant ratio among pressure, rate and volume [9,10]. The Comfort control syringe (CCS) (Midwest-Dentsply, Des Plaines, IL) is a computer controlled device with 5 pre-programmed speeds for different injection techniques. Three independent buttons control: (a) start/stop of the injection, (b) aspiration, (c) speed (by pressing this third button flow rate doubles). Three digital readouts (rate of injection, time elapsed and injected cumulative volume) provide feedback during the injection procedure [11]. The Quicksleeper and SleeperOne (Dental Hitech, ZI Champ Blanc, France) are computer controlled devices that also allow rotation and were designed to be used with the Trancrt-S® needle (Diameter: 0.4 mm, Length: 12 mm), which is supposed to ensure a painless penetration due to the two characteristic asymmetrical bevels [12- 14]. Anaeject (Septodont, Sallanches, France) is a cordless and rechargeable electric injection syringe that allows a gradual acceleration of injection to the preset speed (low, medium or high) [15,16] .Calaject (Ronvig, Daugaard, Denmark) is the latest marketed device that is supposed to provide a painless injection in a virtual way by "an intelligent and gentle administration" of the solution with several flow rate programs. Apart from the cord handpiece that holds the cartridge and needle and the footswitch, it contains a stand for the handpiece with an integrated needle recapping. Last, a controlled-volume sound helps the operator for a better control of the procedure [7,17].

All described devices allow to perform maxillary and mandibular infiltration, mandibular blocks and intraligamentary injections [1]. However, intraosseus anesthesia can only be used with CCS, Quick sleeper and Sleeper One [18,19].

METHODS & RESULTS

A literature search was performed in Medline and Cochrane databases. Table 1 includes all the *in vivo* studies retrieved from the literature search that compared pain perception and/or anxiety during injection with any of the computer-controlled anesthetic delivery systems and traditional anesthesia. Eight studies were found for Wand STA, three for CCS, two for Quick sleeper and only one for CNR and Calaject.

The major difference in the methodology used in the different studies was the pain scale used to measure the pain experiences. Pain is such a subjective sensation that different authors suggested a variety of strategies for the study of pain.

In this review, most of the studies used a VAS scale ranging from 0-100 mm with "no pain" to "maximum pain imaginable" (or similar labels) anchored at each extreme of the line to measure pain experiences [1,4, 11,20,21]. Gibson et al. [20], and Smaïl-Faugeron et al. [21], did not find significant differences between computerized techniques and traditional injection. However, the rest of the studies suing VAS scales did. Romero-Galvez [4] found that the use of Calaject allowed significantly less painful experiences when compared to traditional techniques.

Some of the studies combined the VAS with a descriptive scale [1,22,23]. As an example of the combination of a VAS and a descriptive scale, Mittal et al. [1], combined the VAS scale with a SEM scale with 4 categories (comfort, mild discomfort, moderately painful, and painful) for each of the Sound, Eye and Motor pain code. Computerized anesthesia was found to be significantly less painful for palatal anesthesia; however, there were no significant differences in the pain experienced during buccal infiltration either with traditional or computerized anesthesia. At the same time, the heart rate did not vary significantly when traditional or computerized methods were used. Re [22] did not find any significant difference either with a VAS scale or with a qualitative pain perception questionnaire where the patient could choose "I felt more, the same or less discomfort". On the contrary, Chang [23] combined a VAS scale with a 4-category Dental anxiety scale (DAS) and 14 items to rate psychologic stress level and found relief of injection pain during computer controlled anesthetic delivery.

Other studies used exclusively a simple descriptive scale [12,24]. For example, Beneito [12] observed patient´s preferences for intraosseous anesthesia when compared to conventional techniques with a 4-category scale (none, mild, moderate, intense). Alamoudi [24] recorded pain reaction and behavior with the same scale but did not find significant differences.

Other studies used Facial Image scales (FIS) for the subjective evaluation of pain perceived during injection; and most importantly in children. Among them, Thoppe-Dhamodhara et al. [25], analyzed the effect of traditional versus CCLAD injections in children using different scales easier to manage for this specific group of patients. The FIS included 3 faces indicating no discomfort, mild discomfort or severe discomfort. At the same time, objective evaluation of disruptive behavior was evaluated using 5 categories (facial expression, leg movement, activity, cry, consol ability (FLAC)). Curiously there were no significant difference when comparing FIS (P=0,164) and FLACC (p=0,120) scores after cartridge-based syringe techniques or CCLAD injections in children during first visits; however, there was a significant increase in both FIS (p=0,004) and FLACC (p=0,006) scores in posterior visits. They also found that heart rate increased significantly (p=0,0007) when using cartridge syringe in comparison to CCLAD. Langthasa [11] combined a VAS and a Faces Rating Scale (FRS) consisting on six drawings with different expressions ranging from a child smiling to a child crying. Both

Table 1: *In vivo* studies comparing pain perception and/or anxiety during injection with any of the computer-controlled flow and traditional anesthesia (general characteristics).

Device	*In vivo* study	Randomization	Sample size	Age of participants	Anesthetic solution	Epinephrine dose	Technique	Pain scale	Significant effect
WAND STA	[1]	Yes	100	8 to 12	Lidocaine (2%)	1/800000	Palatal	VAS / SEM	Yes
							Buccal		No
	[25]	Yes	120	7 to11		1/100000	Buccal	FLACC, FIS	
	[9]	Yes	20	19 to 43			Palatal	VAS, Gracely scale	Yes
	[5]	Yes	150	13 to 80	____	____	Different techniques	No info	
	[20]	Yes	62	5 to 13	Lidocaine (2%)	1/100000	Palatal & buccal	VAS	No
	[23]	No info	50	25 to 60	Articaine	1/100000	No info	VAS, Verbal	No
	[24]	Yes	100	5 to 9	Lidocaine (2%)	1/100000	IANB, ILA	SEM	No
	[26]	Yes	91	5 to 9	Lidocaine (2%)	1/100000	IANB,ILA	WBFACES	Yes
CALAJECT	[4]	Yes	25	20 to 30	Mepivacaine (3%)	No	Palatal	VAS	Yes
CCS	[2]	No info	260	no info	Lidocaine (2 %)	1/100000	Different techniques	Verbal	No
	[11]	Yes	50	6 to 14			Dental arch bilateral	VAS, FRS	Yes
	[27]	No info	72	no info			Different techniques	Verbal	
CNR	[23]	Yes	31	34 to 66			Buccal & palatal	VAS,DAS,PSS	
QUICKSLEEPER	[12]	No info	30	18 to 65	Articaine (4 %)		Intraosseous	Verbal	
	[22]	Yes	160	7 to 15		1/200000	Intraosseous	Verbal, VAS	__

Abbreviations: VAS: Visual Analog Scale; SEM: Sound Eje Motor; FLACC: Face, Legs, Activity Cry Consolability Scale; FIS: Facial Image Scale; FRS: Faces Pain Rating Scale; DAS: Dental Anxiety Scale; PSS: Perceived Stress Scale; IANB: Inferior Alveolar Nerve Block; ILA: Intraligamental Anesthesia; WBFACES: The Wong-Baker Faces Scale; ISA: Intraseptal Anesthesia; PLA: Periodontal Ligament Anesthesia.

scales detected significant differences in favor of computer controlled techniques. Baghl of [26] used the Wong-Baker FACES scale and associated CCLAD with the least pain-related behavior.

Other authors preferred to survey the patient´s opinion verbally. Rosenberg [5] used a different technique to rate subjective pain experiences. By recording verbatim opinions about the injection experience and later classifying them into four responses (superlative, positive, somewhat positive, and negative), it was reported that patients preferred the use of the computer controlled anesthetic delivery system than traditional techniques. Grace [27] interviewed both patient and dentists using seven questions with 4 possible answers for each and found a higher satisfaction for both with computerized local anesthetic injection system.

Other studies have analyzed different rates of injection using computerized devices. Prismoch et al. [9], observed statistically lower VAS score (100mm) when using slow rate delivery compared to fast injections rate. Same results were found using Gracely pain intensity score (a verbal descriptor scale evaluating pain intensity (weak/mild, moderate, strong/intense) and unpleasantness (slightly unpleasant, unpleasant/annoying, very unpleasant)).

DISCUSSION AND CONCLUSION

Studies on pain perception and anxiety should be read with caution since these are difficult outcomes to analyze due to patient´s variability. Studies must be well designed in order to include and control all possible confounding factors that may have an effect in pain sensation and anxiety.The information included in Table 1 aims to provide further understanding on the validity of the studies: randomization, sample size, age of participants, the anesthetic solution and epinephrine dose used, technique, pain scale and lastly if the results showed a significant effect when compared to traditional anesthesia.

In general, there are more studies showing that the injection with any of these devices is effective in reducing pain and anxiety when compared to traditional anesthesia than not; except for buccal infiltrative techniques where it seems to be no differences when compared to traditional anesthetic techniques [1,20, 25].

Therefore, despite the use of such a great variety of different subjective scales in the different studies that limits further comparisons; it seems that the constant volume, rate and pressure that these devices control during the anesthetic delivery have potential benefits for most of the techniques. At the same time, a more rapid onset with a reduced volume of anesthetic solution and fewer “missed” mandibular block injections have been reported [28].

The major limitation of this review was the small number of studies on the topic. Because computer-controlled local

anesthesia remains an innovation rather than the norm in dentistry, additional studies in the topic should be encouraged. Specifically, more research using controlled trials is needed to assess the real benefits of current computerized controlled-flow anesthesia delivery devices.

This review set out to describe current devices for a controlled flow of dental anesthesia solution to reduce pain and anxiety during its administration and address the supported evidence. Although few studies analyze the topic in detail so far, the present review found some support to the use of computerized anesthetic delivery systems to reduce the anxiety and pain during anesthetic injections. Computer-controlled anesthetic delivery seemed to be statistically superior to traditional dental injections in terms of patient comfort. The use of computer controlled anesthetic may be considered a strategy to reduce patient´s fear and create a positive attitude towards dental treatment in the future.

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