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Minimally-invasive dental anesthesia: Patients' preferences and analysis of the willingness-to-pay index

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Abstract

Aim: The aim of the present prospective study was to evaluate the impact of a computer-controlled anesthesia on patients' comfort and to investigate, through the willingness-to-pay (WTP) index, and patients' acceptance of this new technology.

Methods: Fifty patients undergoing a class I or II restorative procedure were enrolled. A computer-controlled device for anesthetic delivery was utilized, and a questionnaire on the level of discomfort and WTP was given to all patients.

Results: A total of 86% of participants declared less discomfort than that perceived during their last traditional procedure for pain control; 58% of patients were willing to pay an additional fee for a modern anesthesia technique, with a median WTP value of 20$.

Conclusions: Computer-controlled systems for local anesthesia represent a relevant tool for reducing patients' discomfort during dental treatment. The WTP index helps to quantify its relevance.

KEYWORDS

anesthesia, patients' preferences, restorative procedure, willingness to pay

1 | INTRODUCTION

Pain management during dental procedures is a cornerstone for successful everyday practice. Recently, computer-controlled delivery of local anesthetics has been proposed as an alternative to the traditional injection technique. Several studies have shown that this new approach is as effective as the traditional one in a variety of clinical scenarios, including endodontic procedures[1-4] and dento-alveolar surgery.[5] Moreover, other studies have investigated the level of patients' anxiety and pain perception (during both needle insertion and anesthetic delivery), and reported better outcomes in cases performed with computerized devices.[4,6,7]

However, the introduction of a new medical device must undergo a validation process that should focus not only on its efficacy or clinical outcomes but on patient domain as well.[8] Today's medical approach demands a patient-oriented evaluation of treatment options, which takes into consideration patients' expectations and their degree of acceptance or satisfaction.[9] In order to better understand patients' inclination toward a new injection technique and/or device, a methodological approach could be implemented, inviting the patient to indicate the amount of money he/she would be willing to pay (WTP) for a specific medical procedure. In this regard, the WTP index could be a useful tool, as it expresses the strength/magnitude of preference for a specific treatment or the economic value that patients attribute to its benefits, and the maximum amount of money they are willing to spend in order to receive it.[10] In medicine, WTP is a well-established index, and it has been used to evaluate pharmacological therapies (ie administration of anticoagulants in cardiovascular diseases),[11] interventions for lifestyle modifications in patients affected by diabetes mellitus,[12] or recovery programs in cases of drug abuse.[13] WTP has also been applied extensively to evaluate the preference of patients for treatment options in infective diseases (ie HIV)[14] or malignancies (eg pulmonary

cancer).[15] The measurement of patient preferences by the WTP index might be helpful when dealing with decisions in health economics.[16]

The aim of the present study was to evaluate the impact of a computer-controlled device for dental anesthesia on a population of adult patients. In particular, the main objective was to analyze the strength of preference, expressed according to the WTP method, compared to an alternative technique for delivering anesthetic injections. At the same time, discomfort levels produced by the automatic device were recorded and were correlated to sociodemographic variables.

2 | MATERIALS AND METHODS

Fifty consecutive patients attending a private dental clinic were recruited for this prospective study. The sample included 30 men and 20 women (age range: 25-60 years). Patients presenting with two distinguished carious cavities of the same class (I or II) in the upper jaw, that were to be treated in two consecutive sessions no more than 1 week apart, were included. The first cavity was treated using traditional injection for intraoral anaesthetic, and the second using a computer-assisted device. The anesthetic of choice was Articaine (1:100 000; Weimer Pharma, Rastat, Germany), and half a cartridge was used for each cavity. The time required to perform the injection in both cases was registered.

All patients received a thorough explanation of the study protocol, and provided written consent to participate to the study. All patients were treated according to the principles contained in the Declaration of Helsinki of 1980 for biomedical research involving human participants, as revised in 2000.

Patients with systemic diseases directly or indirectly afflicting the neurological condition or altering pain perception were excluded from the study.

Patients were divided in two groups depending on the type of dental treatment received: the first group of 25 patients receiving two class I composite restorations with a standard treatment time of 20 m each, and the second group of 25 patients receiving two mesio-occlusal or disto-occlusal class II composite restorations with 35 minutes of standard treatment time.

For the current study, a computer-assisted anesthesia system was utilized for the second conservative treatment (The Wand; Milestone Scientific, Livingston, NJ, USA). Introduced in 1997, it represents the first computer-controlled local anesthetic delivery system. It has the advantage of controlling flow rate and pressure of the anesthetic solution during the injection. Furthermore, it allows accurate identification of the periodontal ligament tissue and accurate aspiration at the exact location of the needle. It is also credited for introducing a disposable pen-like handpiece that increases tactile control during injection.

Injections and solution delivery were always performed by the same dentist, who had extensive previous experience with the device. Manufacturers' recommendations were followed to obtain proper pain control.

Five minutes after the administration of the anesthetic solution for the second treatment, a questionnaire-based survey was carried out and patients were asked to: (a) objectively evaluate the perceived discomfort through a pain visual analog scale (VAS) (0-10); (b) qualitatively specify their feelings about the computerized injection technique when compared to the last traditional injection they received ("I felt more/the same/less discomfort than the last time"); and (c) determine the maximum amount of money they would be WTP to receive a computerized anesthetic technique. The WTP questions were framed in the form of a bidding game (or system of the offer).[8] Starting from a basis of 10$, each patient was invited to raise or drop the price to a $10 currency unit. Minimum and maximum economic limits were set, corresponding to 0$ and 50$, respectively. For each new figure given, an increase or reduction in price was offered to better determine the amount of money that was judged appropriate by the patient.

The data collected underwent descriptive statistical analysis using a professional software (SPSS Statistics version 19; IBM, Novegro-Tregarezzo, MI, Italy). The median WTP values, expressed in US$, were calculated in relation to sociodemographic parameters. Variations of WTP values associated with categorical variables were analyzed using the Mann-Whitney *U*-test (dummy variables) and Kruskal-Wallis (multiple variables). Medians were also calculated for the obtained VAS scores, and their potential associations with clinical- (ie upper/lower arch, tooth type) or patient-related variables were assessed (Mann-Whitney *U*-test). Significance was considered at $P<.05$.

3 | RESULTS

The demographic profile of the respondents is provided in Table 1. The participants declared to have visited their dentist regularly. All patients received a traditional injection and a computer-controlled anesthesia for either a class I or II restorative procedure. The mean VAS score was 1.6/10 and 1.7/10 for women and men, respectively ($P=.80$). No significant difference was found between treatment categories ($P=.60$).

Positive feelings about the computer-delivered anesthesia were reported: 86% of participants declared less discomfort than that perceived during their last traditional procedure for pain control. More than half of our sample (58% of patients) would be WTP an additional fee for a modern anesthesia technique; in particular, a median WTP value of 20$ (first quartile: 20$; second quartile: 30$) as an additional sum of money to the standard cost of the therapy was found (Figure 1).

4 | DISCUSSION

4.1 | Computerized device and needle phobia

A number of studies investigating the origin of dental fear have been published,[17-19] with most of them indicating needle phobia as the primary etiological factor, potentially leading to avoidance of dental treatment. While some authors have proposed inherited genetic vulnerability factors as possible causes for needle phobia,[20] the fear of injections frequently arises after a negative experience at a dental office. According to Ost, 56% of patients who had injection phobia could trace their fear back to negative conditioning from a health-care

TABLE 1 Demographic profile of the respondents

Patient identification	Tooth[a]	Cavity type (class)	Age (y)	Sex	Income/y (US$)	Qualitative pain perception[b]	VAS score	WTP	Additional threshold cost (US$)
C.P	12/24	I	40	Male	>30 000	Less pain	0.8	No	
C.P	14/17	I	35	Male	>30 000	Less pain	0	No	
P.P	13/27	II	45	Male	15-30 000	More pain	10	No	
A.F	13/24	II	50	Male	>30 000	Less pain	2	No	
L.D	23/27	I	44	Male	>30 000	Less pain	1	No	
F.P	13/16	II	40	Male	>30 000	Less pain	4.5	No	
F.T	15/26	II	40	Male	>30 000	Same pain	5.7	No	
S.B	14/25	I	55	Male	>30 000	Less pain	0	No	
I.C	11/15	II	26	Male	15-30 000	Less pain	0	Yes	30$
L.M	13/22	I	35	Female	15-30 000	Less pain	0	Yes	50$
M.B	14/17	II	71	Female	15-30 000	Less pain	0	Yes	10$
C.B	14/25	II	36	Female	>30 000	Less pain	0.9	Yes	20$
S.T	15/26	I	48	Male	>30 000	Less pain	0	Yes	20$
L:M	14/26	II	69	Female	>30 000	Less pain	0	Yes	20$
G.T	16/14	I	18	Female	<15 000	Less pain	0	Yes	20$
L.C	14/27	II	38	Female	15-30 000	Less pain	0	Yes	20$
L.B	15/25	I	24	Female	<15 000	Less pain	0	Yes	30$
L.B	12/25	II	20	Female	<15 000	Less pain	0	Yes	30$
D.O	16/27	I	45	Female	>30 000	Less pain	0.5	Yes	10$
S.B	13/26	II	38	Female	>30 000	Less pain	0.4	No	
A.T	11/15	I	36	Male	>30 000	Less pain	0	Yes	20$
R.L	15/26	II	70	Male	15-30 000	Same pain	6	No	
P.M	14/26	II	39	Male	<15 000	More pain	5	No	
F.B	15/27	I	34	Male	>30 000	Less pain	0	Yes	10$
F.B	14/23	I	30	Male	>30 000	Less pain	0	Yes	10$
D.F	12/37	II	51	Female	15-30 000	Less pain	1.5	Yes	20$
B.D	17/25	II	64	Male	>30 000	Less pain	1.3	No	
A.G	17/26	I	53	Female	>30 000	Less pain	5	No	
M.R	16/26	II	41	Male	<15 000	Less pain	2	No	
D.T	15/24	II	32	Female	15-30 000	Less pain	1	Yes	25$
D.C	15/15	I	39	Female	15-30 000	Less pain	0.9	No	
L.R	13/26	II	40	Male	>30 000	Less pain	0.8	Yes	20$
G.T	14/26	I	32	Male	>30 000	Less pain	0.5	Yes	10/20$
P.B	14/14	I	39	Male	>30 000	Less pain	0.9	Yes	20$
U.L	14/17	II	42	Male	>30 000	Less pain	0.6	Yes	10$
L.R	16/25	I	52	Male	>30 000	Less pain	0.5	Yes	30$
S.Z	17/26	I	65	Male	<15 000	Less pain	0.8	Yes	20$
M.G	16/27	II	44	Female	>30 000	More pain	5	Yes	30$
E.T	15/26	I	49	Female	>30 000	Less pain	3.9	No	
E.T	12/23	I	49	Male	15-30 000	Less pain	4	No	
P.B	11/12	II	39	Male	>30 000	Less pain	0.7	Yes	20$
M.G	23/26	I	44	Female	>30 000	More pain	5	Yes	30$
R.B	16/22	II	73	Female	<15 000	Same pain	4.8	No	
F.A	13/17	I	45	Male	15-30 000	Less pain	0.4	No	

(continues)

TABLE 1 (Continued)

Patient identification	Tooth[a]	Cavity type (class)	Age (y)	Sex	Income/y (US$)	Qualitative pain perception[b]	VAS score	WTP	Additional threshold cost (US$)
O.F	14/21	II	46	Female	15-30 000	Less pain	5.7	Yes	20$
M.P	14/24	I	45	Female	>30 000	Less pain	0.6	Yes	10$
F.D	13/25	II	42	Male	>30 000	Less pain	0.7	No	
V.G	14/25	I	69	Male	15-30 000	Less pain	0	Yes	50$
F.B	24/26	II	45	Male	>30 000	Less pain	1	Yes	10$
F.A	25/26	I	37	Male	>30 000	Less pain	0.5	No	

VAS, visual analog scale; WTP, willingness to pay.
[a]Computer-aided anesthesia was used for the first tooth; traditional anesthesia was used for the second tooth.
[b]Pain perception of the computer-aided anesthesia compared to the traditional anesthesia.

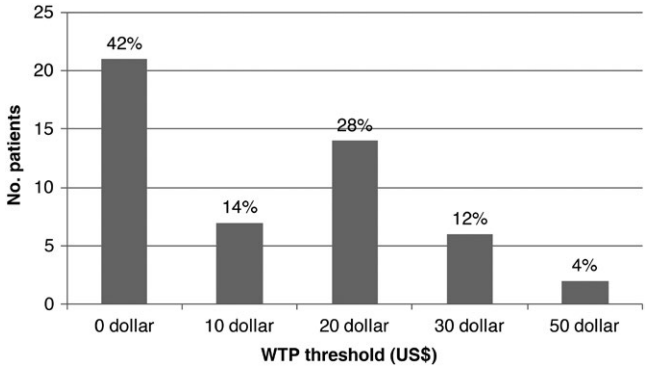

FIGURE 1 Distribution of the results of the willingness-to-pay questionnaire. Fifty-eight percent of patients were willing to pay an additional fee of approximately 20$ to receive a computer-driven anesthesia

experience.[21] Moreover, 24% of patients could trace their fear to having seen another child, often a sibling, experiencing a negative event (ie painful or traumatic) associated to needles. Based on these studies, the availability of a computerized device for delivering a minimally-invasive, less traumatic dental anesthesia, linked with less discomfort/pain during injection, might be extremely helpful for preventing needle phobia. In patients already suffering needle phobia, the computerized device could be a measure for re-education and desensitization through new positive exposures to dental injections.

4.2 | Visual analog scores

Our study substantially confirmed low levels of discomfort associated with the tested technology, as we found mean VAS scores in the range of 0.1-2.4/10 in 75% of cases.

For a comparison of values, using a 100-mm VAS scale, McPherson et al. reported scores of 38.9-38.7 mm/100 mm for larger and standard-bore needles, respectively, when using traditional syringes and injection techniques for the inferior alveolar nerve block.[6] In the same study, VAS scores of approximately 35 mm/100 mm were found for a traditional injection technique during anesthesia of the long buccal nerve.[6] In our study, 86% of patients declared less discomfort than that perceived during their last traditional procedure for pain control. This result, although nearly unanimous, should be interpreted with caution. Even though a restricted interval of 1 week was selected, the recall of an event might be influenced by time elapsed and/or complex memory elaborations. A factor involved in pain during traditional anesthesia is the pressure of the liquid injected into the tissues. An extremely slow, drop-by-drop, computer-controlled release of anesthetic solution might reduce the discomfort associated with the stretching of soft tissues. According to Nusstein et al., significantly more pain was found for solution deposition with a conventional syringe (42% on a Heft-Parker VAS scale) than that produced by the Wand Plus injection technique (25%) for anterior middle superior alveolar anesthesia.[7] The type of dental procedure to be carried out should not have direct influence on pain sensation at injection sites.

4.3 | Willingness-to-pay values and factors of influence

Even though it takes twice the time to perform a computer-assisted local anesthesia compared to the traditional one, more than half (58%) of the studied population agreed to pay an additional sum of money for the minimally-invasive anesthesia. This could confirm a positive patient experience with this new technique of pain control. Patients demonstrating no concern for an additional fee might have also recognized the technological value of the computerized device and the additional training/skills of the dentist related to the learning curve with a modern, non-traditional device. Furthermore, the trend found in our study is similar to that of other studies, where authors reported a significant positive correlation between the WTP index and the level of importance patients assigned to dental care.[8] In fact, patients who strictly followed recall programs and check-ups (every 3 months) paid large amounts of money in order to receive the computerized anesthesia. It is reasonable to believe that people who have a positive attitude toward their oral health are more inclined to pay more for a new pain control device, especially after having directly experienced it. As stated by Locker et al., the first barrier to a specific treatment, despite its proven effectiveness in restoring oral health and well-being, could be represented precisely by a high economic cost.[22] In the present

study, even though our initial offer was set to a small amount of money (10$), some patients refused to pay an additional cost to the therapy for the computerized anesthesia. In our analysis, the income variable was not related to WTP values. As expected, patients with higher incomes are capable of paying extra for their treatment of choice.

4.4 | Limitations of the study

More patients should be enrolled in future studies to further evaluate their feelings and clinical response to the computerized device. Moreover, correlations between anxiety/stress levels, as well as the psychological status of the patients and pain perception at injection site, should be explored. Finally, the best approach for WTP evaluation,[23] the proper amount of information that should be provided to participants about the tested technology (comprehensiveness of the scenario), or the potential influence of psychological variables on recorded WTP values are relevant topics that require further investigation.

5 | CONCLUSIONS

The computer-based device tested demonstrated low pain ratings during anesthesia. Most of the participants declared less discomfort with respect to their last traditional procedure for pain control. Most patients were also WTP an additional fee to receive a minimally-invasive computer-driven local anesthesia.

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