ORIGINAL RESEARCH PAPER

Dentistry

CONVENTIONAL ANAESTHESIA VS COMPUTER CONTROLLED ANAESTHESIA FOR PREVENTING PAIN IN ADULTS UNDERGOING DENTAL TREATMENT- A SYSTEMATIC REVIEW AND META-ANALYSIS

KEY WORDS: dental treatment, endodontics, systematic review, smartjet, VAS

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ABSTRACT

Aim: To assess and summarize effect of computerized anesthesia techniques in reducing pain as compared to conventional technique in adult patients undergoing dental treatment. **Methods:** We conducted a comprehensive literature search on four electronic databases, PubMed, net of information, google scholar, and Cochrane library for this systematic review after registering with Prospero. The inclusion and exclusion was stringent to conduct the filtering and select the Randomised Control Trial/ Clinical Trial which were eligible for qualitative and subsequent quantitative analysis. The heterogeneity was analyzed with the I2 values and risk of bias was conducted with appropriate tool form Cochrane. Review Manager 5.3 was used for meta-analysis. **Results:** Out of 24 studies, 08 studies were further included for quantitative analysis and the meta-analysis was interpreted with the forest plot. The outcome which we assessed was the pain outcome after anaesthesia. The mean cumulative difference was -1.73 (CI: -3.01to -0.45). The heterogeneity was I2=91%, hence we applied the random effects model for analysis. **Conclusion:** The CCLAD seems to be a promising device, offering a less painful method of anaesthesia administration; which showed that the pain was higher in conventional group when compared to other interventional techniques.

INTRODUCTION

Pain is an unpleasant emotional and sensory experience that is caused by actual or potential tissue damage.[1] Local anaesthesia and pain control is one of the most important elements of dentistry.[2]

The public and professional acceptance of contemporary dental treatment is indebted to the refinement of the hypodermic syringe and to the introduction of first Novocain and subsequently of Lidocaine amide as anaesthetic agents in the early twentieth century. However, despite continued advances in anaesthetic devices, agents, techniques, scientific and behavioral research, and the training and education of dentists, complete and predictable control of pain and anxiety associated with the injection for local anaesthesia is not always an absolute certainty.[3]

Traditional injection systems that use metallic syringe do not allow the control of flow rate in a constant way and consequently, fluid pressure varies depending on manual force used by the practitioner during the injection procedure.[4,5] An injection into some areas in oral cavity, such as the palate that requires harder force, causes difficulty in syringe control and does not provide a comfortable injection.[6] Although reducing the speed and pressure of the injection is the most effective method to reduce pain, manual control is quite laborious

Throughout history, dentists have taken different measures to mitigate the discomfort associated with injections and increase patient satisfaction[7], such as the use of topical anaesthesia[8], warming anaesthesia solution to body temperature[9] , adoption of alternative local anaesthesia technique[10] , or increasing injection time by the administration of local anaesthesia[8] , use of thinner needles, cartridge syringe injections, jet injections and Computer Controlled Local Anaesthesia devices. When flow and pressure are accurately controlled during injection of local anaesthetic, pain can be significantly reduced. It was revealed that injecting 0.3ml of local anaesthetic solution at a slow rate with a constant flow (161s/ml) is less painful than a faster infiltration (29s/ml)[11,2]

Other authors reported that to minimise pain and anxiety it is important to start injecting anaesthesia at a pressure below 306mmHg. Nonetheless they also indicated that some other variables such as the injected volume and tissue integrity could also have an impact on pain perception[12] Many studies have compared pain levels between conventional techniques and CCLAD [29,30]. However, results are still unclear, and the differences between these results may be related to several factors, such as the patients' anxiety levels, injection technique, and tactile skill in syringe injections. Low-pressure, slow-delivery apparatus, such as the CCLAD, should be evaluated as a possible means of alleviating the perceived pain on injection. This systematic review of cross-over studies focuses on the question whether CCLAD is "less painful" than conventional anaesthesia in adults.

Methodology

Protocol And Registration:

The research protocol is designed according to the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) guidelines 2009. (D Moher et al. 2009)

Population: Patients undergoing dental treatment requiring anesthesia

Intervention: Computer controlled anesthesia devices

Comparison: Control (Patients who received conventional anesthesia)

Ourcome- Postoperative Pain by VAS Scale

Study Design- Randomised Control Trial/ Clinical Trial

Focused Question:

Is there any effect of Computerised anesthesia techniques in reducing pain as compared to conventional technique in adult patients undergoing dental treatment?

Study Design

All studies known were screened for by reading the printed title and abstract. Choice of articles for inclusion into the systematic review was created by applying the inclusion and exclusion criteria mentioned above Then full texts of those studies were known, and reference lists contained in this were also reviewed to appear for different probably relevant articles which may are incomprehensible throughout the initial search

Inclusion Criteria	Exclusion Criteria
1.Studies with patients who have undergone dental treatment 2. Involved tooth was in the permanent dentition. 3. Pain outcomes and clinical examination findings were available at follow up, with outcome determined with clearly defined criteria. 4. Publications were in English or foreign language, with full text available in either soft or hard copy.	1. Follow up period was less than 1 year 2. Study did not involve patient treatment (eg, studies on cell cultures or animal study). 3. Publications were in the form of letters, commentaries, or narratives. 4. No specified criteria were provided for evaluating the outcome of treatment, or there was no mention of how to determine the healing outcome.

Study Selection:
A title identified from the search was screened by one reviewer with a subsequent duplicate independent checking of their abstracts/full-texts retrieved by the electronic search against the eligibility criteria by another reviewer. (kappa=0.84)

Substantial agreement between reviewers in the study selection process was obtained. After the same reviewers independently reviewed the full-text articles of the previous included studies, and studies which did not present any of the exclusion criteria were selected. Additionally, all references of the selected studies were manually screened for potentially relevant additional studies. Any possible discrepancies encountered during this process that is, inclusion or exclusion criteria, were resolved by discussion between the reviewers who selected the included studies. If a disagreement persisted, the judgment of a third reviewer was considered decisive.

Literature Search:
A comprehensive search was conducted on electronic databases, additionally as by manual search, to spot all relevant studies associated with intra-orifice barriers. Four electronic databases, PubMed, net of information, google scholar, and Cochrane library, were consulted by looking for the key words "(dental therapy OR root canal treatment OR endodontic treatment OR endodontic therapy OR endodontic retreatment OR root canal retreatment) AND (pain OR discomfort OR analgesia) AND (anaesthesia OR STA/WAND/CCLAD/ Caljet). The search lined all articles printed from **2000** to July **2021.**

Duplicate records were removed. Another search of the four electronic databases for reports of outcome of medical procedure passageway retreatment was conjointly performed within the hope to not miss any potential reports that will be relevant to the present topic. Each prospective and retrospective clinical studies printed in Chinese or English language were enclosed.

Data Collection:
Characteristics of included trials and numerical data were extracted in duplicate by two reviewers using predetermined and piloted extraction forms. Piloting of the forms was performed during the protocol stage until over 90% agreement was reached. Missing or unclear information was requested by the researchers

Data Extraction And Management:
Information on authors' names, year of publications, study design, sample, inclusion criteria, groups of intervention, type of intervention type of treatment, follow-up period, method of dentin hypersensitivity stimulation and method of pain assessment and result was independently extracted by two reviewers. Data regarding the included studies was also independently extracted by the reviewers based on a previously defined protocol in a specific form in the Microsoft Office Excel 2007 software (Microsoft Corporation, Redmond, WA, USA).

Risk Of Bias Within Studies:
The risk of bias was assessed for RCTs using Cochrane collaboration tool and performed using the RevMan software. Risk of bias was assessed by the two independent reviews for RCTs included in the review and discrepancies were resolved by discussion and appropriate consultation with a third reviewer. The domains for risk assessment were graded as high, uncertain or low risk, based on selection bias (random sequence generation and allocation concealment), performance bias (blinding), detection bias (assessor blinding), attrition bias (incomplete outcome data), and reporting bias (selective reporting). Thus, the overall risk for individual studies were assessed as low, moderate or high risk based on the domains and criteria. The study was assessed to have a low overall risk only if all domains were found to have low risk, and high overall risk if one or more of the six domains were found to be at high risk. A moderate risk assessment was provided to the studies when one or more domains were found to be uncertain, with none at high risk.

RESULTS
We followed the PRISMA guidelines for the methodology. The study selection process is summarized in Supplementary F1 (PRISMA flow chart). All the titles and abstracts were screened based on the stringent selection criteria. Subsequently the full texts the assessed independently by the two reviewers. A total of 24 studies over the past two decades met the inclusion criteria for full text reading and all 24 were included for further analysis. All the statistical analyses were performed using the statistical software Review Manager version 5.3 (The Nordic Cochrane Centre, Denmark)

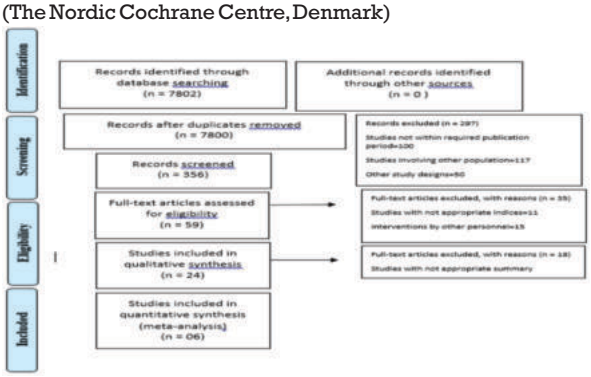

Figure 1: Prisma flow diagram showing the studies exclusion and final inclusion with reasons

Study Selection-
Twenty-four articles were selected from screening of the above-mentioned number of articles by two independent reviewers. Following careful examination and discussion was conducted depending on the selection criteria by the reviewers. Any discrepancies in opinion were resolved by the third reviewer. Ultimately twenty-four articles were finalised for qualitative synthesis. Studies meeting the inclusion criteria underwent validity assessment and data extraction. The studies that did not meet the inclusion criteria were excluded. The data provided in the selected studies should contain author, year of study, journal, region, age, sample size, gender, treatment, control, outcome, and conclusion. The data was extracted and recorded under the same headings as mentioned along with the outcomes.

Study Characteristics-
The publication year of studies varied from 2004 to 2020. A cumulative total of 1256 patients were included in the nine studies. The male and females were in varying sample size. The sample size ranged from 10-60 patients per group. All the studies exclusively mention the sample size. The studies were conducted all over the globe, most studies took place in Asia, Brazil, Europe, USA, Saudi Arabia/Middle East and Turkey. The study design was randomized controlled trials and clinical trials. The age of the patients ranged from 18-70 years.

Majority of the patients were females. The anaesthesia systems used varied from individual studies. The intervention group involved delivery of anaesthesia with WAND, Caljet, Anaject, Smartjet, Quicksleeper, iCT. The control group was consistent with conventional anesthesia technique for all the included studies.

The primary outcome assessed was pain after the injection techniques using the Visual Analogue Scale score. (mean/sd) Out of 24 studies, 08 studies were further included for quantitative analysis and the meta-analysis was interpreted with the forest plot. The outcome which we assessed was the pain outcome after anaesthesia. (Table 1 and Table 2)

Table 1: Demographic Details Of Included Individual Studies

Sr. no	Author Name	Year of study	Region of study	Age of patients (years)	No. Of patients
1	Obaida M13	2019	Saudi Arabia	18-64	40 per group
2	Araujo G14	2015	Brazil	18-40	30 per group
3	Benito-B15	2012	France	18-65	30 per group
4	Campanella16	2018	Rome	18-70	40 per group
5	Fowler17	2018	Ohio	20-36	55 per group
6	Gajendragadkar18	2019	India	18-75	50 per group
7	Ghaderi F19	2017	Iran	23-28	25 per group
8	Galvez J11	2016	Barcelona	23.6	25 per group
9	Nusstein20	2004	Ohio	18-65	40 per group
10	Agrawal K21	2018	India	18-65	50 per group
11	Kammaer P22	2014	Palate	18 and above	30 per group
12	Loomer23	2004	San Fransico	18 and above	10 per group
13	Shah et al24	2011	India	30-65	5 per group
14	Nicholson J3	2014	India	23-54	30 per group
15	Ozer S25	2012	Istanbul	18-40	20 per group
16	Rizzo-Lorenzo26	2019	Spain	28.8	34 per group
17	Berrendero 7	2020	Madrid	45.65	40 per group
18	Saloum F27	2000	Oregon	21-36	40 per group
19	Saoji H28	2019	India	20-40	30 per group
20	Shirani G29	2017	Tehran	38	35 per group
21	Singh S30	2013	India	20-64	50 per group
22	Sumer M31	2006	India	18-63	26 per group
23	Yenisey2	2009	Mayis	27-64	16 per group
24	Yesilyrut C32	2008	Turkey	18-30	40 per group

Table 2: Characteristic Details Of Included Individual Studies

Sr. No	Study ID	Study design	Treatment	Control	Outcomes assessment	Conclusion
1	Obaida M,2019	RCT	WAND	Conventional syringe	WB Faces pain	WAND system can provide less painful and more comfo-rtable restorative treatment proceduresin comparison to the traditional infiltration technique.
2	Arauji G,2015	RCT	WAND	Conventional Syringe	Pain VAS	The computed anesthetic technique showed lower mean pain perception, but did not show statistically significant differences when contrasted to the conventional technique.
3	Benito-B,2012	CT	Quicksleeper	Conventional Syringe	Pain	The described anesthetic system is effective, with a much shorter latency than the conventional technique, sufficient duration of anesthesia to perform the required dental treatments, and with a much lesser soft tissue anesthetic effect.
4	Campanella,2018	RCT	WAND	Conventional Syringe	VAS	The computerised technique resulted in lower pain, dis-comfort, and lower intensity of physio-logical parameters
5	Fowler, 2018	CT	WAND	Conventional Syringe	VAS	Needle placement was the most painful phase of the injection. Solution deposition pain was less with the CCLAD when compared to other studies of the IANB using a traditional syringe.
6	Gajendragadkar, 2019	CT	WAND	Conventional Syringe	VAS	A significant difference was observed in the pain perception of the patients during CCLAD. The patient comfort was grossly equal for both techniques.
7	Ghaderi F.2017	RCT	Smartjet	Conventional Syringe	VAS	It is suggested, needle penetration is not the main reason of pain during injection. Inconsistent fluid pressure created by injected anesthetic solution on nerve fibers is more impressive in pain evelopment. Hence, Smartject as a CCLAD can be considered as an appropriate device for dental injection.

8	Galvez J,2016	RCT	Caljet	Conventional Syringe	VAS	Within the limitations of the present study, a relief of injection pain during local anesthetizing was observed in utilizing the computer-controlled anesthetic delivery system.
9	Nusstein, 2004	RCT	WAND	Conventional Syringe	VAS	The AMSA, using either the Wand Plus or a conventional syringe, has the potential to be a painful injection. We found the incidence of postinjection pain and sequelae was low with both techniques.
10	Agrawal K,2018	RCT	WAND	Conventional Syringe	VAS	Lower pain perceived with CCLAD and higher preference for the system suggest that CCLAD should replace conventional syringes to allow pain-free dental treatment.
11	Kammaer P,2014	CT	WAND	Conventional Syringe	VAS	The mechanical PDL-S device showed a significant lower pain during treatment compared to the CCLAD system. Concerning the efficiency of anaesthesia, the injection pain, the need of a second injection, the amount of used local anaesthesia as well as the duration of soft tissue anaesthesia, no significant differences were seen. We recommend including specific trainings in intraligamentary anaesthesia in the dental curriculum.
12	Loomer, 2004	RCT	WAND	Conventional Syringe	VAS	Subjects reported having less pain with GP and NP injections delivered using the computer- controlled device,and total injection time was similar to that required for syringe injections. Both techniques provided adequate anesthesia for therapeutic scaling and root planing.
13	Shah et al,2011	RCT	WAND	Conventional Syringe	VAS	The WAND results in less painful injections; however, mean ratings of pain for both the groups, were mostly below the annoying level of pain. Also, the areas covered by the anesthetic effect of both the injections were comparatively similar.
14	Nicholson J,2014	CT	WAND	Conventional Syringe	VAS	Successful and painless local injections have greater import than patient compliance and practice efficacy. The WAND device, when compared to the syringe, for two major dental injections, has been shown to meet these criteria.
15	Ozer S, 2012	CT	Quicksleeper	Conventional Syringe	STAI VAS	IO injection with Quicksleeper is a less painful injection method compared with conventional IANB techniques.
16	Rizzo-Lorenzo, 2019	RCT	WAND	Conventional Syringe	STAI	Patients that received a detailed explanation of The Wand did not have a significant reduction of the anxiety degree and perceived pain during the anesthetic act compared to patients that received no information. The need of re-anesthesia was not related to the anxiety level but was significantly related to increasing operative time.
17	Berrenderro,2020	RCT	Caljet	Conventional Syringe	VAS	Computerized anesthesia system produces significantly less pain compared with a conventional anesthesia syringe. Although both obtained sufficient anesthetic depth to perform treatments, the majority of patients chose electronic anesthesia as the most satisfactory.

18	Saloum F,2000	CT	WAND	Conventional Syringe	VAS	The Wand generally seemed to provide less painful injections; however, the mean ratings of pain were mostly mild pain for both injections The operator technique and tactile skill in syringe injections and site of injection (right or left) could be important factors that were not evaluated in this study
19	Saoji H,2019	RCT	WAND	Conventional Syringe	VAS	CLADS can be an effective and pain-free alter native to conventional local anesthetic procedures.
20	Shirani G,2017	RCT	iCT	Conventional Syringe	FRS and WB VAS	Both FRS and VAS in iCT injection showed that frequency of severe pain during needle insertion and anesthetic delivery was noticeably lower than that in conventional injection method but findings revealed that there was no significant difference between these two techniques after 5 hours of injection.
21	Singh S,2013	RCT	Anajec t	Conventional Syringe	Heft Parker VAS	In this in vivo study it was found that subject's perception of pain was significantly low for supra-periosteal injections while using computerized anesthesia as compared to that of conventional disposable syringes.
22	Sumer M,2006	CT	WAND	Conventional Syringe	PRS and VAS	Under the conditions of this study, although the anxiety levels of patients were higher in Wand injection than conventional syringe injection, the Wand seemed to be less painful. However, the mean ratings of pain was mostly mild or no pain for both injections.
23	Yenisey, 2009	CT	WAND	Conventional Syringe	PRS and VAS	The AMSA technique using the Wand is recommended for prosthodontic treatment because it reduces pain during needle insertion and during delivery of local anaesthetic. However, these two techniques have the same pain levels for tooth preparation.
24	Yesilyrut C, 2008	RCT	WAND	Conventional Syringe	PRS and VAS	The Wand technique resulted in significantly lower pain scores during the IAN block injections. Most of the patients preferred the IAN injection with the Wand for future dental injections.

Meta-Analysis:

The meta-analysis was conducted on 08 studies which have data outcome that could be used for analysis. The other studies were excluded due the data reported that could not be analysed (which was not in mean +/- SD format).

The results as forest plot are depicted in figures. After that the meta-analysis conducted for the selected studies, the heterogeneity was analysed based on I2 values hence fixed or random effect model was applied.

Intervention vs Control

For meta-analysis we assessed for comparison between Intervention (different injection techniques) vs control, the mean cumulative difference was -1.73 (CI: -3.01to -0.45) which showed that the pain was higher in conventional group when compared to other interventional techniques.

The heterogeneity was I2=91%, hence we applied the random effects model for analysis. (Figure 1)

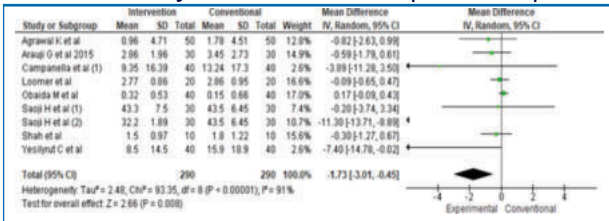

Figure 1-Forest plot depicting the meta-analysis

Publication bias-

Publication bias was assessed for these outcomes. The funnel plots were derived according to the effect model applied. The overall publication bias was low, indicating that the studies had an acceptable methodology that could be followed for future studies

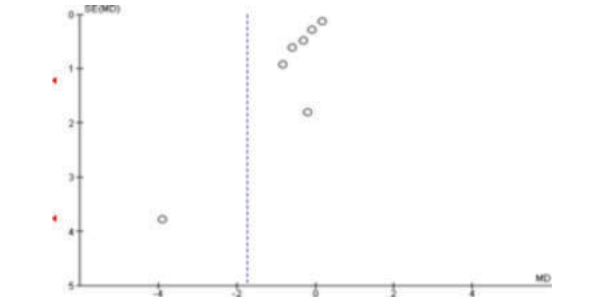

Figure 2-Funnel plot depicting the publication bias

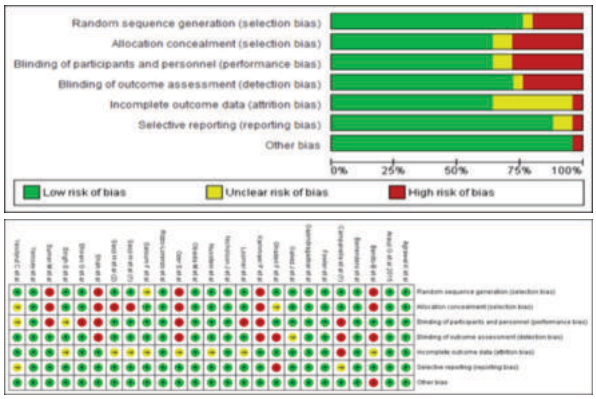

Figure 3-Risk of bias graph and summary: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Majority of studies reported performance and detection bias in their methodology. Studies conducted by Agrawal et al.[21], Araujo et al.[14], Berrendero et al[7], Fowler et al[17], Gajendra et al[18], Nicholson et al.[3], Rizzo-Lorenzo et al[26] and Yenisey et al[5] had methodology that could be followed in future studies.

DISCUSSION

Anxiety and fear form the mainstay of deferral in patients undergoing dental treatment, especially involving the injection of local anaesthetics.[33,34] Automatic injection systems as an alternative to conventional syringe injection are easy to use and decrease the level of pain and anxiety experienced by patients during anaesthetic injection.[29,35] This novel modality has revolutionized dental anaesthesia since it greatly decreases dental fear and stress experienced by patients.[35]

This systematic review and meta-analysis aimed to assess the effect of alternative anesthesia techniques in reducing pain as compared to conventional technique in patients undergoing dental treatment or retreatment. With a stringent inclusion and exclusion criteria search was conducted with the 3 databases by the two reviewers and data was then extracted under recommended headings. Titles and abstracts were screened to finalize twenty-four articles for systematic review and eight for meta-analysis. The intervention group involved delivery of anaesthesia with WAND, Caljet/Anaject/Smartjet. The intervention varied from each individual studies and most of the studies involved the WAND technique which was most commonly employed followed by Caljet. Mean VAS score in WAND group was less than the conventional technique. Thus, concluding that the adults had experienced less pain with the computerized techniques. No difference was generally found between the two techniques when compared through objective physiological parameters indicating pain (e.g., heart rate and pressure)[14,20,36,37]

In theory, the pain perception with CCLAD systems is supposed to be less than that in the traditional technique, because of the larger gauge needle, the pre-puncture technique[34,38], and the pen-like grasp tool. This tool allows users to easily rotate the needle - while it is introduced into tissues - producing a coring penetration that minimises needle deflection, allowing a slow rate of anaesthetic flow, thereby maintaining a constant pressure and controlled volume of solution, regardless of the tissue resistance[39]. With traditional anaesthesia, it is difficult - although not impossible - to achieve the same result, because the manual control of a syringe is objectively more difficult, owing to the wide variance in soft tissue elasticity, that unavoidably influences injection pressures (especially in the palatal area) which may require pressures as high as 660 psi.[34,40]

This results in a practical advantage for CCLAD, for which the pressure control is computerised. The comparative forest plot of the meta-analysis between CCLAD vs conventional systems shows over 4 points and 0.48 points of difference between the two systems. [52] These findings are relevant for clinicians, who must consider the fact that the use of CCLAD does not always guarantee less painful anaesthesia than the traditional technique. There is a noticeable proportion of clinical cases for which the two techniques are equivalent, in terms of pain, during the injection. In addition, data about anxiety associated with the two techniques are inconsistent and warrant further investigations.

Dr. Mark Hochman and coworkers were the first to demonstrate a marked reduction in pain perception for injections using a CCLAD system.[39,41] Fifty blindfolded dentists participated in a controlled clinical study (they received the injection) comparing the standard manual syringe to a CCLAD system (the Wand) for palatal injections. Forty-eight (96%) preferred the CCLAD injections. Liberman et al.[42] in their study found that the Wand was the most comfortable method, and it was a good tool for building positive dentist-patient relationships.[24,42] In contrast, The overall result of study by Shah et al[24] ,Asarch et al[43], Fodi et al[27], and Koyuturk et al[44] .Gibson et al.[45] did not show a significant difference between pain perception following conventional injection and the Wand® system.

The review had a few limitations that we encountered namely small number of articles included in the systematic review and the restricted access to online libraries, journals and database, which restricted in having more full text articles. We encourage future studies to conduct a wider data search and access more literature.

From a practical point of view, the commercial CCLAD systems analysed in the 08 reports eligible for the meta-analysis are WAND system (used in 07 studies) [Loomer et al[23], Campanella et al[16], Shah et al[24] ,Yesilyurt et al[32] , Arauji et al[14] , Obaida et al[13] , Agrawal et al[21] and Comfort control Syringe [Saoji et al[28]] This observation could be useful for clinicians, as they need to be aware from which device come the most robust data in the literature. This finding could guide clinicians on the type of instrument to follow in the literature; moreover, it can be useful for researchers to implement clinical studies on these systems.

CONCLUSION

A computerized system of anaesthetic injection results in significantly less pain perception (VAS score) when compared with the conventional injection during solution deposition, both on adult patients The CCLAD seems to be a promising device, offering a less painful method of anaesthesia administration; thus, helping and providing the clinicians a way to better evaluate anxiety associated with anaesthesia

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