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Dr. Navneet Verma
Oral and Maxillofacial Surgery, PAHER, Udaipur, Rajasthan, India

Dr. A Bhagvandas Rai
Oral and Maxillofacial Surgery, PAHER, Udaipur, Rajasthan, India

Dr. Himanshu Gupta
Oral and Maxillofacial Surgery, PAHER, Udaipur, Rajasthan, India

Divya Rajpurohit
Pediatric and Preventive Dentistry, PAHER, Udaipur, Rajasthan, India

Corresponding Author:
Dr. Navneet Verma
Oral and Maxillofacial Surgery, PAHER, Udaipur, Rajasthan, India

Comparative evaluation of pain perception in inferior alveolar nerve block using conventional local anesthetic technique and computer-controlled delivery system (Star Pen®)

Navneet Verma, A Bhagvandas Rai, Himanshu Gupta and Divya Rajpurohit

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Abstract
Background: Pain management remains an essential aspect of effective dental treatment, especially during the administration of local anesthesia. Fear of dental pain often leads to avoidance of dental care, thereby exacerbating oral health issues. Inferior Alveolar Nerve Block (IANB) is a commonly used technique for achieving local anesthesia in the mandibular region.
Aim: To evaluate and compare pain of inferior alveolar nerve block with conventional local anesthetic technique and electronic assisted time and pressure control system.
Method: This prospective, split-mouth study evaluates and compares the pain perception associated with conventional local anesthetic technique and CCLAD system (Star Pen®) during IANB. The study was conducted on 40 patients requiring bilateral mandibular posterior tooth extractions. Pain perception was recorded using a 10-point Visual Analog Scale (VAS).
Result: The findings demonstrate a significant reduction in pain with the Star Pen® compared to the conventional technique, underlining its efficacy in improving patient comfort and compliance in dental procedures.
Conclusion: Considerable discomfort due to the deep tissue penetration and pressure exerted during the injection. The advent of Computer-Controlled Local Anesthetic Delivery (CCLAD) systems like the Star Pen® has revolutionized pain management strategies by offering precision in anesthetic delivery.

Keywords: Inferior alveolar nerve block, computer-controlled local anesthetic delivery star pen®, pain perception, visual analog scale

Introduction
Dental fear is one of the most common reasons patients avoid dental visits. Several factors contribute to dental anxiety, including the sound and vibration of tooth-cutting devices, the smell of medications or dental supplies, discomfort during procedures, and an unfounded fear of local anesthetics. Regional anesthesia is a fundamental aspect of dentistry and is essential before performing operative dental procedures [1].
The extraction of mandibular third molars is one of the most commonly performed procedures in dentistry. Pain control is a crucial aspect of dental extractions. The inferior alveolar nerve block (IANB) caused more discomfort compared to infiltration, intraligamentary injection, and mental nerve block. Therefore, reducing injection pain associated with the IANB remains necessary [2].
The inferior alveolar nerve block involves injecting a local anesthetic solution near the mandibular foramen, where the nerve enters the inferior alveolar canal. This anesthetic technique is widely used in routine dental practice as it facilitates multiple surgical procedures [3].
Despite careful anesthetic techniques, the inferior alveolar nerve block (IANB) can cause pain for various reasons, including soft tissue damage during mucosal penetration, pressure from the spread of the anesthetic solution, the temperature and low pH of the solution, and

discomfort associated with the drug's characteristics [4].
To minimize injection pain, the use of topical anesthesia, low-pressure injection, narrow sharp needles, a slow injection rate, and solutions that are warmed and buffered have been suggested. However, achieving a completely painless injection under all circumstances remains impossible [5].
The sensation of pain during an injection can be categorized into three primary components:

- **Needle Insertion Pain:** This occurs when the needle penetrates the mucosa and underlying tissues. The degree of pain is influenced by the needle gauge, insertion technique, and patient sensitivity.
- **Anesthetic Solution Deposition Pain:** The rate and pressure at which the anesthetic solution is deposited affect patient comfort. Rapid injection can cause increased tissue distension, leading to greater discomfort.
- **Post-Injection Pain:** Some patients experience lingering discomfort after the anesthetic has been administered, which may be due to tissue irritation or inflammation [6].

A computerized injection system was developed as an alternative to the conventional syringe to alleviate pain and anxiety during intraoral injections [7]. The first of these devices was introduced in 1997. This device is a computer-controlled system that maintains constant pressure and volume ratios, delivering local anesthetic solutions at a steady rate regardless of tissue resistance [8]. When advanced slowly, the drops of solution anesthetize the tissue ahead of the needle, resulting in a virtually painless needle insertion [9].
The system provides both audible and visual feedback mechanisms [10]. The visual indicators display the injection speed [11]. The Woodpecker Star Pen is a wireless electronic anesthesia delivery device designed to enhance patient comfort during dental procedures [12]. Utilizing an intelligent algorithm with automatic pressure feedback technology, it ensures consistent and precise anesthetic administration, reducing discomfort associated with traditional manual injections [13].
As an innovative computer-controlled local anaesthetic delivery (CCLAD) system, aims to address concerns related to injection discomfort by offering precise control over injection speed and pressure [14]. This technology enhances the patient's experience by minimizing the discomfort associated with local anesthetic administration [15].
Hence, the present split-mouth prospective study aims to evaluate and compare the pain experienced during inferior alveolar nerve block (IANB) using the conventional local anesthetic technique versus an electronically assisted time- and pressure-controlled system, STAR Pen® [16]. The findings from this study could provide valuable insights into optimizing local anesthesia administration in clinical practice, promoting more patient-friendly anesthetic techniques, and ultimately enhancing the overall dental experience [17].

Materials and Methods

The present study is a split-mouth comparative study. It was approved by the Institutional Scientific and Ethical Review Board, and prior approval (IEC approval) was obtained before the commencement of the study. Additionally, written informed consent was secured from all participants.
The study aimed to evaluate and compare the pain associated with the inferior alveolar nerve block (IANB) using the conventional local anesthetic technique versus an electronically assisted time- and pressure-controlled system (Star Pen®).
The inferior alveolar nerve block (IANB) has the potential to be a painful injection [19]. One method to reduce this pain is the use of a slow injection technique. Fowler [19] measured the injection pressures of dental injections and found that administering anesthesia at low pressures (slow injection) significantly reduced pain and anxiety. Therefore, a slow injection during the deposition of anesthetic solution helps decrease pressure and patient discomfort. Kanaa *et al*. [19]
A coin toss was used to randomly determine the side for each injection technique:
Group 1 received the conventional local anesthetic injection technique.
Group 2 received the electronically assisted time- and pressure-controlled system (Star Pen®).

Study Design: An *in vivo* prospective comparative study.

Study Duration: 18 months

Study Sample: The present study was conducted on 40 patients with informed consent in the Department of Oral and Maxillofacial Surgery, Pacific Dental College and Hospital, Udaipur, Rajasthan, India.

Sample size: 40 patients
Sample size was calculated using the formula:

$n= [z^2p (1-p)]/d^2$

Where: Z = table value of alpha error from Standard Normal Distribution table (0.95)
Power (p) = 80%
Precision error of estimation (d) = 0.06

n= [0.95 x 0.95 x 0.8 (0.2)] / 0.06 x 0.06 = 40.11

Hence a sample size of 40 patients was considered adequate for our study.

Method of Collection of Data

The patients in this bilateral split mouth study were given anesthesia:

- **One side:** conventional technique
- **On contralateral side:** Electronic assisted time and pressure control system delivery system (star-pen by woodpecker).

Inclusion Criteria

- Patients requiring bilateral removal of mandibular lower teeth requiring IANB.
- Age of the patients chosen as subjects will be above 18 years.
- Un-restorable mandibular teeth.
- Impacted teeth.
- Patient should be free of any co-morbidity and under classification ASA 1 and ASA 2.

Exclusion Criteria

- Known mentally challenged patients and patients unable to communicate.
- Patient allergic to Lignocaine.
- Patient unwilling to be a part of the study.
- Patient with known systemic co-morbidity up to ASA 3

Procedure

Each patient underwent bilateral IANB, with one side administered using the conventional 2cc syringe and 26-gauge needle, and the other using the Star Pen® with a 30-gauge needle. The sequence of administration was randomized using a coin toss. The anesthetic solution used in both techniques was lignocaine with adrenaline (1:80,000). Pain perception was recorded immediately after injection using the Visual Analog Scale (VAS).

Results

Demographics

- **Age Distribution:** Majority (70%) aged 21-30 years (Table 1, Graph 1)
- **Gender:** Equal male (50%) and female (50%) Distribution
- **BMI:** 52.5% normal, 35% overweight, 12.5% obese **(**Table 2, Graph 2)
- **Clinical Findings:** 90% with chronic pulpitis, 10% with chronic periodontitis (Table 3, Graph 3)

Pain Perception (VAS score)

- **Conventional Technique**: Mean VAS: 7.90 ± 0.81, 62.5% reported severe pain, 37.5% moderate pain (Table 4, Graph 4)
- **Star Pen® Technique:** Mean VAS: 1.80 ± 0.88, 100% reported mild pain (Table 5,)
- Graph 5)

Figures

Fig 1: Chronic irreversible pulpitis and mesio-proximal decay irt 46

Fig 2: Conventional local anesthetic technique

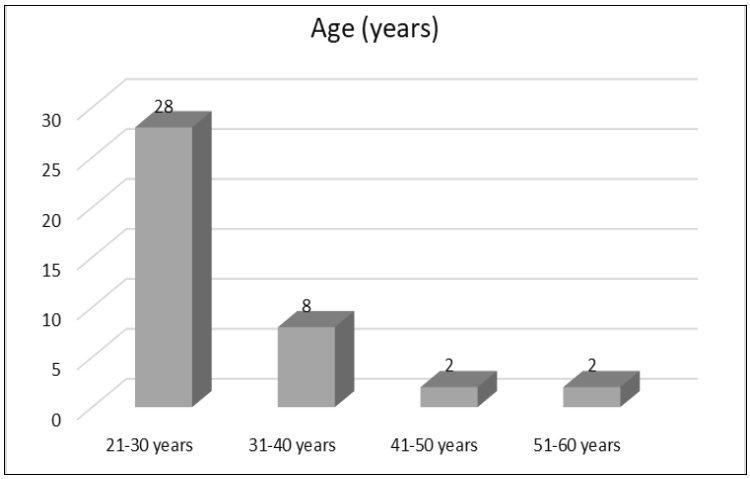
Fig 3: Chronic irreversible pulpitis and disto-proximal decay irt 36

Figure 4: star pen® computer controlled anesthetic injection technique

Tables & Graphs

Table 1: Distribution of patients according to Age

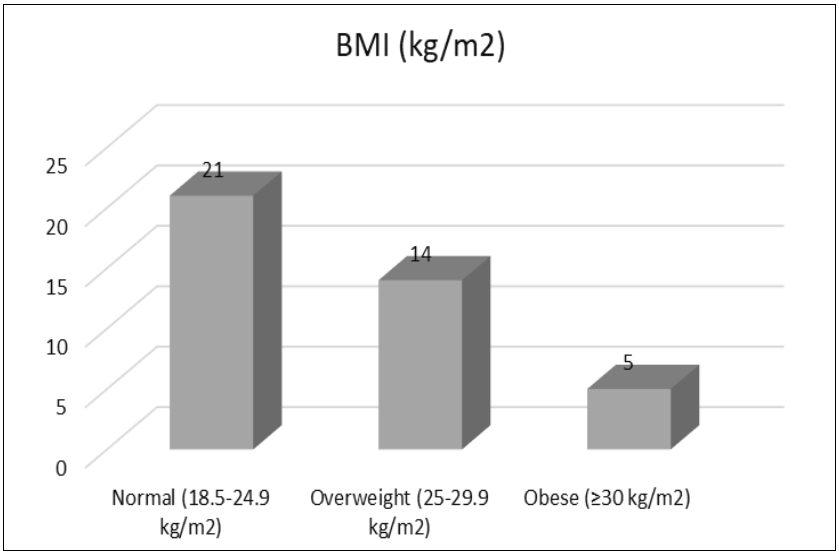
Age (years)	N	%
21-30 years	28	70%
31-40 years	8	20%
41-50 years	2	5%
51-60 years	2	5%
Total	40	100%
Mean ± SD	30.28 ± 7.44	



Graph 1: Distribution of patients according to Age

Table 2: Distribution of patients according to BMI

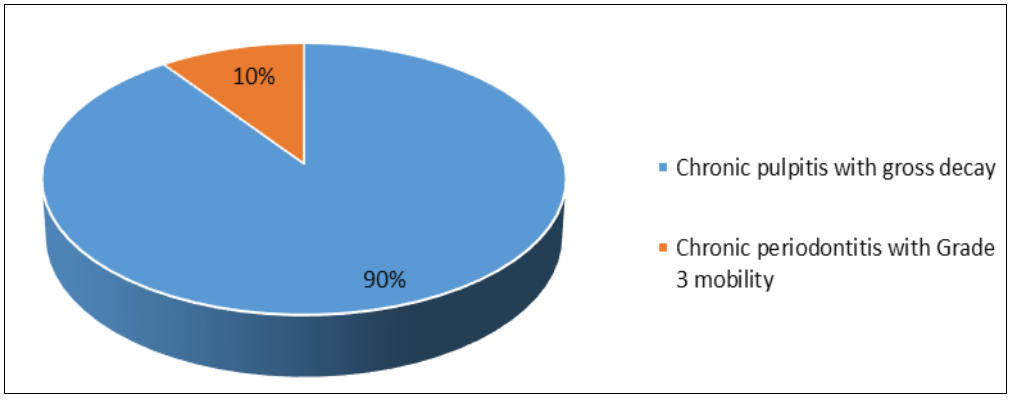
BMI (kg/m^2)	N	%
Normal (18.5-24.9 kg/m^2)	21	52.5%
Overweight (25-29.9 kg/m^2)	14	35%
Obese (≥30 kg/m^2)	5	12.5%
Total	40	100%
Mean ± SD	24.45 ± 4.02	



Graph 2: Distribution of patients according to BMI

Table 3: Distribution of patients according to Clinical Findings

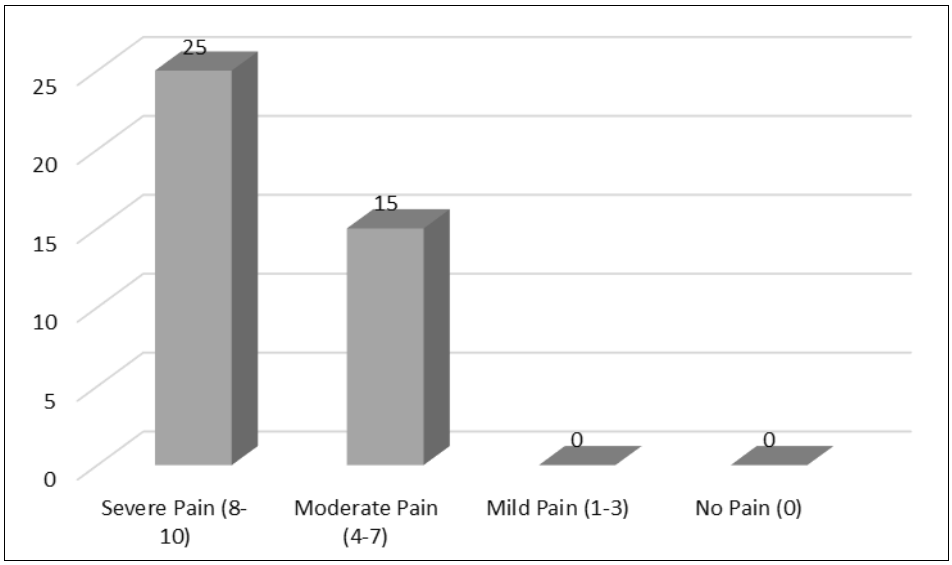
Clinical Findings	N	%
Chronic pulpitis with gross decay	36	90%
Chronic periodontitis with Grade 3 mobility	4	10%
Total	40	100%



Graph 3: Distribution of patients according to Clinical Findings

Table 4: Distribution of patients according to Pain Felt during Needle Insertion in Group 1 (Conventional technique)

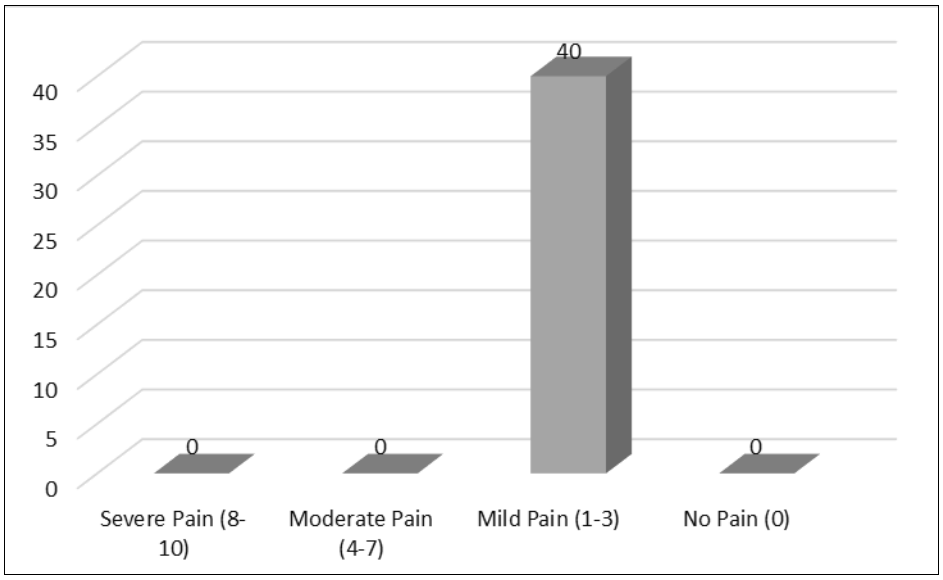
VAS Score	N	%
Severe Pain (8-10)	25	62.5%
Moderate Pain (4-7)	15	37.5%
Mild Pain (1-3)	0	-
No Pain (0)	0	-
Total	40	100%
Mean ± SD	7.90 ± 0.81	



Graph 4: Distribution of patients according to Pain Felt during Needle Insertion in Group 1 (Conventional technique)

Table 5: Distribution of patients according to Pain Felt during Needle Insertion in Group 2 (Star pen)

VAS Score	N	%
Severe Pain (8-10)	0	-
Moderate Pain (4-7)	0	-
Mild Pain (1-3)	40	100%
No Pain (0)	0	-
Total	40	100%
Mean ± SD	1.80 ± 0.88	



Graph 5: Distribution of patients according to Pain Felt during Needle Insertion in Group 2 (Star pen)

Discussion

In clinical dental practice, pain is considered a subjective sensation influenced by various psychological factors, such as a patient's stress level, trust, personality, and perceived control over a pain stimulus [12]. Various novel pharmacologic and non-pharmacologic methods are currently being used to manage trypanophobia [18]. Effective pain management during local anesthesia administration is crucial, as a painful injection can induce fear and anxiety, potentially leading to the refusal of dental treatment.

In the present study, the majority of patients (70%) were in the age group of 21-30 years, followed by 20% in the 31-40 age group, and 5% in the 41-50 and 51-60 age groups. The mean age of the patients was 30.28 ± 7.44 years. The study group consisted of 20 male (50%) and 20 female (50%) patients. These demographics are similar to those reported in studies by Singh S *et al.* [18]

Singh S *et al.* [18]. compared pain perception using a traditional syringe versus a computer-controlled "Anaeject" device for supraperiosteal injections in a sample of 90 patients (54 males and 36 females) aged between 20 and 65 years. Shetty S *et al.* [17]. evaluated pain perception using a computer-controlled local anesthesia delivery (CCLAD) system versus a conventional syringe for inferior alveolar nerve block (IANB) in children. Their study included 30 children (14 boys and 16 girls) aged between 6 and 12 years, with a mean age of 9 ± 1 years.

In our study, 21 patients (52.5%) had a normal BMI, while 14 (35%) were overweight, and 5 (12.5%) were classified as obese. The mean BMI was 24.45 ± 4.02 kg/m². Additionally,

36 patients (90%) were diagnosed with chronic pulpitis with gross decay, while 4 patients (10%) had chronic periodontitis with Grade 3 mobility.

In the present study, it was observed that the teeth scheduled for extraction in 22 patients (55%) were the lower left and lower right molars (37, 47). Additionally, in 15 patients (37.5%), the teeth extracted were the lower left and lower right molars (36, 46), while in 2 patients (5%), the lower left and lower right premolars (35, 45) were extracted. In one patient (2.5%), the extracted teeth were the lower left and lower right premolars (34, 44).

Regarding pain perception during needle insertion using the conventional local anesthetic injection technique, 25 patients (62.5%) reported experiencing severe pain, while 15 patients (37.5%) reported moderate pain. The mean Visual Analog Scale (VAS) score was 7.90 ± 0.81, which is comparable to findings from studies by Singh S *et al.* [18].

Singh S *et al.* [18]. reported mean pain scores during needle insertion for the conventional and computerized anesthesia groups as 19 ± 8.2 and 11.03 ± 7.26, respectively. The pain experienced during local anesthetic administration occurs in two phases: the first sensation is caused by the needle puncture, which induces a brief but intense pain, while the second phase involves activation of nociceptors responding to the chemicals in the infiltrated agent and the rapid distention of tissue, which results in a more intense and prolonged pain response.

In the present study, all patients (100%) reported only mild pain during needle insertion using the Star Pen® technique, with a mean VAS score of 1.80 ± 0.88. Singh S *et al.*[18] also reported mean scores for the anesthetic delivery phase as 22.9 ± 10.68 for conventional anesthesia and 13.17 ± 9.20 for computerized anesthesia. Additionally, Attia S *et al.* [19]. found that in the computer-controlled group, 22 patients (36.7%) reported no pain, 24 patients (40%) reported slight pain, 14 patients (23.3%) reported moderate pain, and none (0%) reported severe pain.

Pain perception during needle insertion was significantly lower when using the Star Pen® technique compared to the conventional local anesthetic injection technique, as indicated by the Student's t-test (7.90 ± 0.81 vs. 1.80 ± 0.88; $p < 0.05$). Furthermore, pain at the injection site five hours after treatment was lower in the computerized anesthesia group, although the difference was not statistically significant. Various factors, such as anxiety, fear, trust, and perceived control over the painful stimulus, may influence pain perception during local anesthesia administration.

The findings of this study are consistent with prior research highlighting the advantages of slow, controlled injections in minimizing pain and discomfort. The electronically assisted delivery system ensures a steady injection pressure, reducing the likelihood of tissue trauma and enhancing patient comfort. In contrast, the conventional syringe technique depends on manual pressure control, which can result in inconsistencies and potentially increased pain levels.

The significant reduction in pain observed with the Star Pen® suggests that its integration into clinical practice could be particularly beneficial for patients with dental anxiety, who often experience heightened sensitivity to pain and stress during procedures. By providing a more comfortable injection experience, this technology has the potential to improve overall patient compliance and satisfaction.

Further research could explore the broader applications of the Star Pen® in various dental procedures, such as periodontal treatments, endodontic therapy, and oral surgeries. Additionally, investigating its impact on clinician efficiency, procedural outcomes, and long-term patient perceptions could offer valuable insights into its role in modern dentistry. Understanding how this technology influences overall treatment experiences, including patient willingness to undergo necessary dental care, could further support its widespread adoption in clinical settings.

Conclusion

The Star Pen® system significantly reduces pain associated with inferior alveolar nerve block compared to conventional techniques. By ensuring a slow and consistent anesthetic flow, it minimizes tissue trauma and improves patient comfort. Incorporating CCLAD systems into routine dental practice can enhance patient satisfaction, reduce anxiety, and potentially increase acceptance of dental treatment.

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Conflict of Interest

Not Available

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