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Crestal Anesthesia: An Efficient, Fast and Reliable Technique in Posterior Mandibular Exodontia; a Case-Control Clinical and CT Scan Assessment

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Abstract: Performing an efficient and safe anesthesia is a basic principle in nearly all of the dental procedures. In posterior mandible current infiltration techniques, as in the upper jaw, are not applicable because of dense cortical bone so dentists necessarily use Inferior Alveolar Nerve Block (IANB) which has many potential side effects like trismus, temporary paralysis of facial nerve. In this study, the Crestal Anesthesia (CA) was assessed both clinically and by CT scan for its efficacy and side effects. A combination of an opaque material (Ultravist®) and lidocaine 2% was used to study the route of anesthetic solution. The combination was primarily injected in rabbit gingival tissue and was followed up regularly for 2 weeks to assess any possible injury. After confirming its safety, a combination of these materials was injected to volunteers to assess efficacy and diffusion route. A total of 69 patients (37 female, 32 male) with matched bilateral posterior teeth in mandible were selected randomly and an IANB and CA was performed randomly and separately in different sessions for the contralateral teeth. The onset of anesthesia, anesthesia duration, pain, blood pressure and pulse rate, bleeding quantity and consumed anesthetic solution was recorded for each technique and data were analyzed using paired t-test with SPSS 10.0 for Windows. CA had a significant advantage over the IANB in pain, onset of anesthesia, bleeding quantity, pulse rate and the consumed anesthetic solution ($p<0.05$). Instead, IANB produced significantly longer anesthesia ($p<0.05$). CA could be considered as a reliable and safe primary injection for mandibular exodontia.

Key words: Crestal anesthesia, case-control clinic, CT scan, IANB, CA

INTRODUCTION

In modern dentistry, providing an efficient and localized anesthesia is of utmost importance in gaining patient's trust and convenience. In public opinion, a successful dentist is the one who is able to perform dental procedures with the least pain and discomfort. The reality is that without a through anesthesia, one can not perform a safe practice for patient. Although in today's modern dentistry, we are often able to control the pain but in some occasions the anesthetizing techniques are accompanied by some drawbacks especially in mandibular block anesthesia such as: difficulty in achieving anesthesia because of anatomic variations (Reams and Tinkle, 1989); deep and invasive needle penetration (Gow-Gates, 1973; Watson and Gow-Gates, 1992); paresthesia (Reams and Tinkle, 1989); muscle trismus (Kafalias *et al*., 1987); paralysis (Fish *et al*., 1989); transportation of oral microbial flora to anatomic spaces (Malamed, 2005); delayed onset of anesthesia (Malamed, 1981; Khedari, 1982); hematom formation (Watson, 1973); high incidence of positive aspiration (Watson, 1973); undesired soft and/or hard tissue anesthesia with possible patient-induced injury (Khedari, 1982; Malamed, 1982) and difficulty in hemostasis in patients with bleeding disorders (Malamed, 1982).

Some supplementary anesthetic injection methods have been evolved to circumvent above disadvantages. These include intrapulpal, intraosseous, intraseptal and intraligamentary injections (Goebel, 1983; Reams and Tinkle, 1989; Walton and Abbott, 1981). Giffin (1994), introduced a new variation of intraosseous anesthesia Crestal Anesthesia (CA), which he claimed was tested on more than 6000 teeth for different dental procedures ranging from simple restorations to extractions. The technique relies on alveolar crestal perforations formed by foramina of Zuckerkandl and Hirshfielf (Schroeder and Page, 1990), which provide gingiva with innervation and circulation (Fig. 1). Since, then some have commented on the technique and approved it (Karna, 1994). But to our

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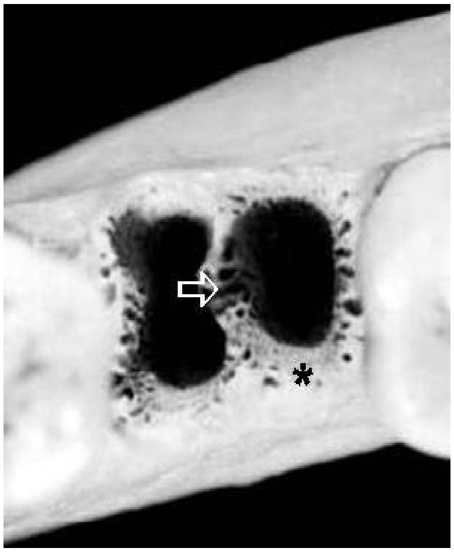

Fig. 1: Alveoli of mandibular teeth. Note that the foramina of the nutrient canals are greater both in number and size in the interdental bone (arrow) comparing to marginal bone (*)

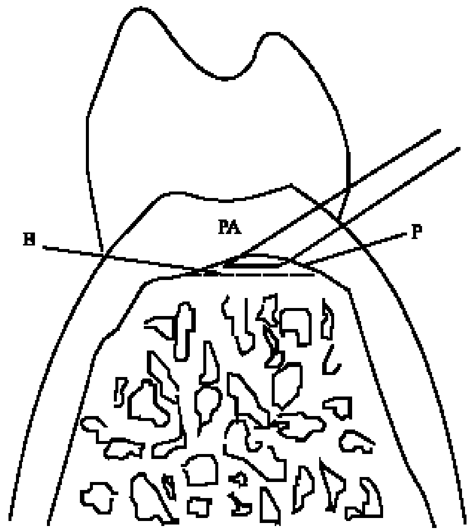

Fig. 2: CA technique. Note the pooling of the injectate in subperiosteal area (P). B = alveolar bone, PA = interdental papilla

knowledge no systematically designed case-controlled study has been proposed to evaluate its benefits and disadvantages. In this article, we have tried to show the time dependent route and diffused area of anesthetic agent and finally compared some clinically related specifications of Inferior Alveolar Nerve Block (IANB) and CA to determine their efficiency.

MATERIALS AND METHODS

Sixty nine systemically and mentally healthy individuals between 18 and 47 were randomly selected from patients referring to department of oral and maxillofacial surgery in Tabriz dental faculty during four educational semesters in 2003-2005. The subjects were not taking any medication that would alter pain perception. The medical ethic committee of Tabriz University of Medical Sciences approved the study and a written informed consent form was obtained from each subject.

Before participation in this study, full medical histories were obtained from all patients and all were physically examined. This study was a split-mouth case-control clinical trial. Data were analyzed using paired t-test with SPSS 10.0 for Windows. At the 0.05 level of significance and with a power of 90%, the sample was quite enough to be statistically reliable.

Animal study: The animal study was performed regarding to NIH guidelines for the care and use of laboratory animals. To determine the route of anesthetic agent we used a combination of 1^{cc} Lidocaine 2% with 1:100, 000 epinephrine (Darou Pakhsh, Tehran, Iran) and 1^{cc} of an injectable radiopaque material (Ultravist ®, Shering AG 13342 Berlin, Germany). As pH for both of these materials was measured almost the same (Lidocaine pH = 6.39, Ultravist pH = 6.54), no undesirable reactions would actually happen. In order to prevent any potential hazard of this combination, it was initially injected to the anterior gingiva of rabbit (*Oryctolagus cuniculli*) in 2 different sites (interdental papilla and attached gingiva). The injection sites were followed up regularly everyday for 2 weeks to determine any possible desquamation and/or soft/hard tissue necrosis. By the end of the follow up period it was judged that no potential hazard threatens the gingiva.

Crestal anesthesia technique: A regular dental anesthetic syringe and a standard short 27 gauge needle are used. Then an interdental gingival papilla is selected adjacent to the tooth or area to be anesthetized. A topical anesthetic agent (in this study benzocaine) is applied with a cotton-tipped applicator and the syringe is positioned so that as the papilla is penetrated, needle bevel and orifice will be eventually positioned subperiosteally adjacent to bone and crestal nutrient canals (Fig. 2). Then, using a significant pressure initially the anesthetic agent is injected. This procedure should last at least 20 sec. Usually 1.8-1.4th of a standard anesthetic cartridge suffices per papilla. One or both of the papilla (in case of inadequate numbness) can be used for the procedure. In this study, we used both papillae to get adequate anesthesia required for extraction.

A classic direct Inferior Alveolar Nerve Block (IANB) plus long buccal nerve block was performed in the contralateral side for purpose of comparison.

Standardized extraction technique: Three surgeons participated in this study. They rigidly adhered to a standardized technique for mandibular posterior exodontia in patient and surgeon position, soft tissue detachment, luxation, tooth removal if needed suturing technique. In cases, where an individual needed an open technique exodontia or other supplementary actions were necessary, he or she was excluded from the study. All of the extractions were completed in less than 10 min.

Extractions were performed in the morning and completed before noon. Perioperative antimicrobial therapy was standardized for all patients. Chlorhexidine gluconate 0.2% mouthwashes were prescribed twice daily for all patients.

Study design: Using a crossover design, we randomly performed CA and IANB techniques at 2 separate appointments. Assigned random numbers determined the order of the anesthetic techniques. The appointments at least 2 weeks apart were scheduled for each of the 69 subjects. Mentioned outpatients had 2 bilateral posterior teeth (premolars, first and second molars) to be extracted. After clinical and radiographic observations, these teeth were judged to need uncomplicated exodontia with similar difficulty. Patients were prepared for the extraction by blind skilled hygienists and the CA or IANB techniques were performed by the principal investigator (KTT). In few cases (n = 6), in which there was no interdental bone in the contralateral side because of adjacent tooth/teeth extraction or a periodontal disease was present, an intraseptal anesthesia was administered instead of CA and the tooth was extracted. In this case, we utilized four line angles of tooth to perform intraseptal anesthesia. The patients were followed up for three months and were told to report any probable problem encountered.

Using a written questionnaire, all patients were asked to rate the injection pain based on a scale of 0-5, where 0 represented no pain, 1 mild pain, 2 moderate pain, 3 moderate to sever pain, 4 severe and 5 intolerable pain.

Contralateral canine was used as the unanesthtized control to ensure that the pulp tester was operating properly and that the subject was responding appropriately during the experiment. At the beginning of each appointment and before any anesthetic administration, trained blinded hygienists tested the experimental tooth and the control canine 3 times using a pulp tester (Gentle-Pulse, Parkell, Farmingdale, NY, USA) to record baseline vitality. After the tooth to be tested was isolated with cotton rolls and dried with gauze, tooth paste was applied to the probe tip, which was then placed midway between the gingival margin and the occlusal edge of the tooth.

The criterion for pulpal anesthesia was an absence of response by the patient to the maximum output (10). The current rate was set at 25 sec. to increase from no output (0) to the maximum output (10). In order to determine the onset of anesthesia we tested the pulp after the patient's lip in the injection side was numb in IANB or immediately after second papillary injection in CA. Along with this, we tested the contralateral canine to become sure of the testing reliability. We considered anesthesia successful when a subject had two consecutive maximum readings (10). Anesthesia was also not successful if no signs of tissue numbness were observed in IANB within 10 min.or any supplemental injections (such as mental) was required to gain anesthesia. In order to determine, the effective duration of anesthesia, we instructed the patients to raise their hands during or after the operation whenever they sensed any pain, which in this situation they were administered by a second injection of the primary anesthesia technique.

We used a portable digital pulse-oximeter (Onyx 9500, Nonin Medical Inc., Min, USA) to monitor the patients pulse rate during the injection. The instrument has an attachment that patient's forefinger is placed in it and the heart rate is recorded. An anxiety-reduction protocol was used for all patients to avoid any stress born undesired increase in heart rate/blood pressure that would create bios in recording these variables: 10 min before any recordings, the patient was guided to a rest position in a quiet operating room. Then he/she was asked if he feels ok and whether he feels his heart is beating faster. We tried to reduce the anxiety in our patients by explaining the operation furthermore and answering their questions. Otherwise, they were excluded from pulse rate study. The pulse rate was recorded 5 sec prior the penetration of syringe's needle and 5 after the injection was terminated. An average of 2 recordings was used to compare the difference of pulse in 2 techniques.

To record the changes (increase) of blood pressure an automatic digital blood pressure monitor (Omron HEM-711AC, Omron Healthcare Inc, Bonnockbum, Il, USA) was utilized. The blood pressure was recorded 5 sec prior to the penetration of syringe's needle to record the base line blood pressure. Then we recorded the pressure immediately after the injection was initiated terminated

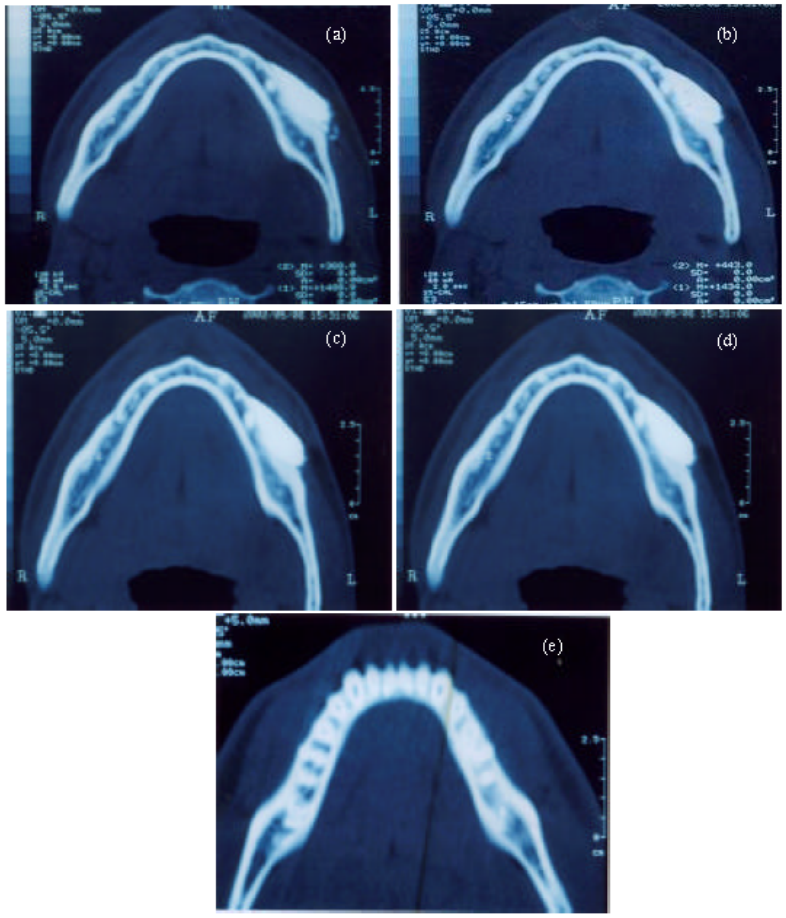

Fig. 3a-e: Penetration of radiopaque agent in cancelous bone was seen after the injection in axial CT scan

and immediately before it's termination. Again an average of 2 recordings was used to compare the difference of blood pressure in 2 techniques. A 2×2 cm gauze packs were used as a method to quantify the bleeding.

In order to compare, the administered volume of the anesthetic solution, anesthetic cartridges were stamped with milliliter marks and the consumed volume was recorded.

Finally CT scans were obtained from 2 volunteer's (x and y) lower jaw after the CA injection (using the mentioned combination of anesthetic solution and radiopaque agent previously tested on rabbit) to show the solution's rout (Fig. 3a-e).

RESULTS

Thirty seven female and 32 male patients with an average age of 32.5 years participated in this study. CT scan images are shown in Fig. 3a-h. About half of the patients in the CA group complained from a mild gingival soreness of no more than 1 day.

Table 1: Percentage (No.) of successful anesthesia gained by Crestal Anesthesia (CA) and Inferior Alveolar Nerve Block (IANB) techniques

Tooth	CA	IANB
1st premolar	94 (15)	81 (13)
2nd premolar	95 (21)	81 (18)
1st molar	100 (12)	83 (10)
2nd molar	100 (8)	87 (7)
3rd molar	100 (11)	91 (10)

The anesthetic success rates are presented in Table 1. Although not statistically, significant most of unsuccessful CA injections were in the first premolar region.

Regarding to the current study there was a statistically significant difference ($p<0.001$) in the onset of anesthesia between CA (7.00±0.71 sec) and IANB (3.30±0.67 min). A statistically significant difference was also present ($p<0.05$) between the duration of anesthesia in CA and IANB which, respectively lasted 23.10±2.13 min and 32.10±2.02 min. Thus, the anesthesia was virtually instantaneous for CA and more lasting in IANB for the extraction. It was interesting that in some cases with CA patients with a prior experience of IANB did not realize the completion of the injection.

An ooze was sensed during a successful CA injection that clinically guarantied the fast onset and a single administration of the anesthetic agent.

There were no significant differences in heart rate increase between CA (0.58±0.32 beat min^{-1}) and IANB (0.97±0.00 beat min^{-1}) ($p > 0.05$). Blood pressure increased 0.00±0.07 mmHg in CA and 0.97±0.00 mmHg in IANB. There was no statistically difference between them ($p > 0.05$). Only about a 5th of an anesthetic cartridge (0.40±0.07 mL) was consumed in CA. On the other hand, IANB needed about five times more of the anesthetic solution (1.99±0.06 mL) for initiating the anesthesia. Most of the pain ratings were in the moderate to severe and severe categories for IANB (3.44±0.22) and moderate to severe category for CA (1.45±0.18) and there was a statistically significant difference between them ($p < 0.001$). Consumed gauze packs in CA and IANB were 1.82±0.09 and 3.09±0.16, respectively and had a statistically significant difference. None of the studied variables showed a statistically significant difference for left and right of the mandible.

The rout of the anesthetic solution diffusion can be seen in Fig. 3a-h note the opaque area in the injection site that is a result of the instant diffusion of the injected media (anesthetic agent + opaque material).

A majority of patients receiving CA appreciated not having discomfort and incapacitation often experienced with IANB anesthesia.

One patient with IANB anesthesia developed dry socket she was not a smoker and no other reasonable rational found for this situation. By the end of three month follow up we found no problem that could be attributed to CA.

DISCUSSION

Although, the CA or any other kinds of similar methods of injection as intraseptal method (utilizing the alveolar bone nutritional canals) are traditionally considered as supplementary injections, they are successfully used by numerous clinicians as a primary route of anesthetic administration and high success rates of anesthesia and satisfaction both by patients and dentists were obtained. Due to these observations were conducted this study to systematically test the different aspects of this method.

CA can be placed in the midway of conventional intraosseous anesthesia and infiltration techniques. Karna (1994) called the technique intraosseous pressure anesthesia that although correctly describes its forceful nature but might mislead the hearer because it really does not penetrate the bone.

The benefits of conventional Intraosseous Injections (IOI) are clearly known. With the advances in this area and introduction of new instruments and techniques patients and dentists benefit from profound anesthesia without unnecessary lip and tongue anesthesia. Unfortunately above facts have not made IOI as popular as the infiltration and block techniques are Kleber (2003) associates this fact with the reluctance of dentists to drill a healthy soft and hard tissue and in some cases the difficulty of inserting a needle precisely into the drilled hole.

Considering, the maximum reading of the pulp tester (here 10) for a successful anesthesia was due to studies of Dreven *et al*. (1987) and Certosimo and Archer (1996), who demonstrated that the criterion was necessary for performing a painless restorative treatment. More unsuccessful injections in the premolar region might be due to dense cortical bone of mental foramen that acts like a dam and reduces the diffusion rate of anesthetic solution. Also reduced diameter and fewer nutrient canals compared to posterior region might play a role. Reported primary intraligamentary anesthesia success rates of 74-92% were <99% observed in CA (Kaufman *et al*., 1984; Khedari, 1982; Malamed, 1982) that might be due to subperiosteal nature of CA. Giffin (1994) believes that in this method the injectate is captured over the a broader bone area, allowing access to more alveolar crest nutrient canal foramina, despite the apparently greater relative number of nutrient canal foramina in tooth socket cribriform plate. It seems that the high success rate of CA is due to fast (or even immediate) diffusion of anesthetic agent through the very porous region of dental socket. This fact is also confirmed by other series of CT scans (same exposure angle, near successive times).

Longer duration of anesthesia in IANB compared to CA was an expected finding. CA produced duration of anesthesia similar to those of reported intraligamentary injection (Dower and Barniv, 2004). This was expected because both methods rely on perfusion of medullary bone. The most successful IANB injections were in the third molar region. This could be because of supplemental long buccal injection and shorter distance of the tooth to the injection site.

We observed a case of buccal tissue anesthesia in the block group due to long buccal nerve anesthesia. Less bleeding in the CA group can be a result of more concentrated volume of the vasoconstrictor agent in the extraction site comparing to the IANB. CA required considerably less than one full anesthetic cartridge of anesthetic. This reduces amount of anesthetic significantly reduces the bolus of epinephrine when compared to conventional block techniques such as IANB. Another advantage of CA is its 0% of positive aspiration. The above facts might explain the reason for the statistically lesser readings of blood pressure and the heart (pulse) rate. Indeed many patients are less acquainted with the CA at least as a primary technique but have experienced the IANB many times before. A single bad experience with the IANB might be enough for increased anxiety and cause systemic effects. Longer penetration time (before the deposition of the anesthetic agent) and possible changes in the needle direction by the clinician to meet the required clinical landmarks is another reason for the increased anxiety.

As with intraosseous types of injections, the CA allows bilateral treatment of mandibular areas without complete mandibular numbness and lack of tongue control.

CA injections penetrate the uncomplicated tissue structures aseptically that probably accounts for mild post injection discomfort (gingival soreness) (Giffin, 1994). The presence of anatomical anomalies such as tori at the proposed site of injection would preclude the dentist from using the CA effectively. This contraindication might include the situations in that a medullary bone density variation (for example condensing osteitis) is present. The mentioned factors necessitate for accurate clinical and radiographic survey prior to selection of injection technique.

All patients were pleased that CA did not interfere with tongue and lip sensation compared with IANB. Patient's ability to return to their regular daily routines immediately postoperatively with oral tissues that feel normal can increase the perceived volume of this technique for dentists and patients.

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