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DIODE LASER CLINICAL EFFICACY AND MINI-INVASIVITY IN SURGICAL EXPOSURE OF IMPACTED TEETH.

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Abstract:	The gold standard to arrange impacted teeth in the dental arch is represented by a surgical approach followed by orthodontic traction force application. In literature, many surgical approaches are proposed to reach such scope. The aim of the present study is to demonstrate how laser technique could positively assist surgical approaches. Study population was composed by 16 patients undergoing orthodontic treatment of twenty impacted teeth. In ten cases (population A) surgical exposure of the impacted teeth was performed using a 980 nm diode laser, while in the other ten cases (population B), surgical incision was performed using a traditional lancet. Only three patients of the population A needed local anesthesia for surgical procedure while the remaining seven patients reported only faint pain during surgery. Two patients referred post-surgical pain (NRS scale average value = 2) and needed to take analgesics. None of the patients showed other post-surgical side effects (bleeding, edema). All population B patients needed infiltrative anesthesia and referred post surgical pain (NRS scale average value > 4) treated with analgesics. Moreover, in such population, four patients referred lips edema while four showed bleeding and six needed surgical

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Cover Letter

UNIVERSITÀ DEL PIEMONTE ORIENTALE

Novara, 7th July 2016

Sir Mutaz B. Habal
Editor in Chief
Journal of Craniofacial Surgery

Dear Sir,
I'm sending you a revised version of our paper "**DIODE LASER CLINICAL EFFICACY AND MINI-INVASIVITY IN SURGICAL EXPOSURE OF IMPACTED TEETH" SCS 16-0639**
The Authors modified the paper according to the reviewers' comments and we hope that the modifications made could allow the acceptance of our paper for publication in the JCFS.
Looking forward for your response I remain
Best regards

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Sincerely

Mario Migliario

Response to the Reviewer

The authors thanks the reviewer for the comments that helped us to improve the quality of our work.

The authors tried to improve the language and modified the pics as requested.

Moreover the text has been rearranged to submit the work as a clinical note and all the modified text has been outlined in yellow.

Hoping all the changes made could make our work acceptable for the publication in The journal of Craniofacial Surgery we remain.

Best regards

Manuscript (All Manuscript Text Pages in MS Word format,
including Title Page, References and Figure Legends)

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ABSTRACT

The gold standard to arrange impacted teeth in the dental arch is represented by a surgical approach followed by orthodontic traction force application. In literature, many surgical approaches are proposed to reach such scope. The aim of the present study is to demonstrate how laser technique could positively assist surgical approaches.

Study population was composed by sixteen patients undergoing orthodontic treatment of twenty impacted teeth. In ten cases (population A) surgical exposure of the impacted teeth was performed using a 980 nm diode laser, while in the other ten cases (population B), surgical incision was performed using a traditional lancet.

Only three patients of the population A needed local anesthesia for surgical procedure while the remaining seven patients reported only faint pain during surgery. Two patients referred post-surgical pain (NRS scale average value = 2) and needed to take analgesics. None of the patients showed other post-surgical side effects (bleeding, edema).

All population B patients needed infiltrative anesthesia and referred post surgical pain (NRS scale average value > 4) treated with analgesics. Moreover, in such population, four patients referred lips edema while four showed bleeding and six needed surgical sutures of soft tissues.

The lack of side effects of laser surgical approach to expose impacted teeth must persuade dental practitioners to choose such clinical approach to closed surgical approach every time it is possible.

Keywords: diode laser; impacted teeth; orthodontic-surgical treatment.

Short title: DIODE LASER IN SURGERY OF IMPACTED TEETH.

INTRODUCTION

In human dentition the prevalence of the lack of eruption of frontal teeth vary from 1 to 2.5% depending on the study population characteristics (sex, age, ethnic origin). Such condition is much more frequent when considering patients of European ethnicity or women. Moreover, such condition affects more frequently the maxillary arch, with maxillary canines representing the most affected teeth after the third molars [1, 2, 3].

The lack of permanent teeth eruption, especially in the frontal part of the dental arch, triggers both aesthetic and functional outcomes, finally resulting in the need of their re-arrangement in the dental arch by combined orthodontic and surgical approaches [4, 5].

A careful study of the impacted teeth clinical localization must always be carried out before the surgical treatment [4].

Optical inspection and physical palpation could be useful to obtain information about impacted tooth position but are insufficient to identify the better treatment [2, 6, 7].

Panoramic radiography represent the first tool used to discern by differential diagnosis between agenesis and impacted teeth. To date oral radiography with Clark method has been replaced by computerized tomography, representing a more accurate analytical approach [1, 6, 8, 9, 10, 11].

When impacted teeth are diagnosed, the first clinical intervention is represented by the orthodontic creation of a physical area for the tooth re-arrangement [4, 5, 7]; the second is the surgical exposure of the impacted tooth and finally traction force must be applied orthodontically [4, 12].

When the impacted tooth is correctly re-arranged in the dental arch it could be necessary a further treatment to assure the conservation of the obtained results [4, 7].

Impacted tooth alignment in the dental arch needs a physical eruption space and its creation must be carried out before surgical intervention, as such orthodontic approach can induce by itself the spontaneous impacted tooth eruption. On the other hand, the lack of an adequate physical eruption space, nullify any re-arrangement attempt [4, 7].

Impacted tooth position plays a pivotal role in defining the surgical approach to that clinical problem [4, 12, 13, 14].

From a literature review, it is clear that not all the Authors agree on a single surgical approach to impacted teeth treatment [12, 13, 14, 15, 16].

Chapokas et al [5] propose a classification in three categories of maxillary canine that will guide the surgeon selecting the surgical technique exposure.

Clinically there is a traditional distinction between open or closed approaches for the application of traction force, mainly differing in the exposition or not in the oral cavity of the impacted tooth at the end of surgery.

Moreover, in all approaches it is recommended to arrange the eruption path by eliminating bone tissue, without connective tissue damage around closer teeth [5, 7, 12, 13, 14, 16].

Chapokas class I and III impacted teeth exposure are open surgical techniques: class I treatment requires gingivectomy around the crown with immediate exposure of the crown while class III exposure requires an apically positioned flap. The treatment of both class I and III impacted teeth allow the conservation of an adequate zone of keratinized gingiva, nevertheless in both cases the application of orthodontic devices needs, sometimes, to be delayed because of tissue bleeding.

Chapokas class II impacted teeth are located deeply in the center of the alveolar ridge; in this case it is necessary to prepare a full thickness mucoperiosteal flap to get access to the bone covering the

crown of the impacted tooth. After bone removal, attachment and the traction force wire positioning, the flap is reflected on the crown and it is sutured [4, 5, 7, 12, 13, 14, 15, 16, 17, 18].
As a rule, open approach would be the best choice when it is possible to preserve an adequate zone of keratinized gingiva around the exposed teeth; moreover sometimes it is possible to position immediately orthodontic attachment as traction force application after crown exposure.
The Class I technique is not habitual because of its main side effects represented by post-operative pain, bleeding and longer recovery period. The technique for the Class III impacted teeth include more difficulty and risk of tissues recession. On the other hand, closed approach is always the best choice when the tooth is deeply impacted [5, 7, 12, 13, 14, 16, 18, 19].
With an always increasing use of bonding materials, the use of threaded pins or wires crossing the crown are always less used. Today, in the clinical practice, there is a wide use of small surgical nets, orthodontic buttons or brackets but orthodontic attachment and traction force application represent a key difficult step; everybody knows that bleeding during surgery is a common undesired side effect, getting more difficult the brackets and buttons bonding and their adherence must be verified before patient release [4, 5, 13, 14].
The traction wire is attached to orthodontic devices and produces a steady and continue 50-80 g force parallel to tooth axis and directed to alveolar center until tooth eruption. Once reached tooth eruption, the bracket is rearranged to correctly place the tooth in the dental arch. [4, 5, 13].
Before surgical laser wide clinical use, the open surgical techniques for the treatment of Class I impacted teeth was not habitual because of its main side effects represented by post-operative pain and bleeding [5, 7, 12, 13, 14, 16, 18, 19]
Today diode laser use is getting an even increasing importance in dentistry [20, 21, 22] especially for small oral surgery interventions: the lack of bleeding during surgery thus represents a clear advantage of surgical laser approach and often represent an indispensable completion of many orthodontic procedures [20, 23, 24, 25, 26, 27].
The aim of this study is to describe a protocol for diode laser use to expose impacted teeth, allowing dental practitioners and orthodontists to use such innovative clinical approach even if they do not have a strong experience in oral surgery.

PATIENTS, MATERIALS AND METHODS

For this study, 16 patients undergoing orthodontic therapy for impacted teeth were enrolled between January and September 2015. For patient enrollment, the following inclusion criteria were adopted: 1) orthodontic case study documentation (orthodontic models, photo, panoramic and cephalometric); 2) presence of at least one impacted tooth needing surgical exposure, 3) impacted tooth position allowing open surgical exposure, 4) informed consent signature (according to Italian law 675).
To identify each study participant an unambiguous code composed by 2 letters (first and family names initials) and 4 numbers (month and year of birth) has been established.
Study population was composed of 9 males and 7 females (age range spanning between 10 years and 7 months and 24 years and 4 months); a total of 20 Chapokas Class I and Class III impacted teeth were treated as showed in table 1 and table 2.
For each selected patient, clinical history (personal data, past or present illnesses, drug treatment, past dental treatments) has been recorded.
Four patients (B.A.01/05, G.L.06/99, L.M.06/95, M.F.08/02) had two impacted teeth therefore by draw one tooth has been assigned to the population A and the other to the population B; similarly

also the other 12 patients were assigned to the two populations. Finally, always for draw it was determined that the population A would be treated with laser and the population B with traditional surgical techniques.

Clinical study on population A was performed using a diode laser (GIOTTO 7 WATT, Dental Medical Technologies srl, Lissone, Italy), with the following clinical protocol:

1) Laser biostimulation of tissues covering impacted tooth crown to reduce pain; laser working settings: λ =980 nm, power=1 W, continuous emission, optical fiber = 600 µm positioned vertically at a distance of 10 mm from the target tissue, twice for 30 sec/cm^2 (figure 1A)
2) Contact for about 30 sec. of the alveolar mucous covering impacted tooth with cotton pellets soaked with 15% Lidocaine Spray (G. Ogna & Soons, Muggiò Milano, Italy)
3) Impacted tooth crown exposure through a surgical incision performed with laser light (working settings: λ =980 nm, optical fiber = 320 µm, power 1.5 W, pulsed emission (20 sec on/10 sec off)) (figure 1B)
4) During the whole surgical procedure the intervention area was keep moist by touching with cotton pellets soaked with lidocaine and eight volumes hydrogen peroxide.
5) After impacted tooth crown localization, the surgical incision has been enlarged in centrifugal direction in order to prevent tissue healing and recoating (figure 1C).
6) Finally using bonding materials, orthodontic buttons or brackets have been positioned, traction force was applied and their adherence verified before patient release (figure 1D).
7) Infiltrative anesthesia, when necessary, has been performed with 1:100.000 articaine chloridrate (Septodont , Saint-Maur-des-Fosse Cedex, France).

The whole surgical procedure duration was comprised between 8 and 23 minutes.

At the end of the surgical procedure, each patient was asked to point out pain associated to the intervention according to a Numerical Rating Scale (NRS) divided into 11 boxes, from 0, no discomfort, to 10, unbearable pain [29].

Clinical study on population B was performed using the following clinical protocol:

1) Infiltrative anesthesia has been performed with 1:100.000 articaine chloridrate (Septodont , Saint-Maur-des-Fosse Cedex, France).
2) Impacted tooth crown exposure was performed through a surgical incision with a lancet n°15 (0351-15 ASA Dental, Bozzano Lucca, Italy) and periosteotomy with a Prichard periosteal detacher (0351-15 ASA Dental, Bozzano Lucca, Italy).
3) The mucoperiosteal flap, in the Class III impacted teeth, have been sutured with Soie Perma-Hand 5-0 (Ethicon LLC, San Lorenzo Puerto Rico, USA).
4) When it was possible to keep dry the intervention area, using bonding materials, orthodontic buttons or brackets were positioned, traction force was applied and their adherence verified before patient release.

The whole surgical procedure duration was comprised between 21 and 43 minutes.

At the end of the surgical procedure, each patient was asked to point out pain associated to the intervention according to a Numerical Rating Scale (NRS) divided into 11 boxes, from 0, no discomfort, to 10, unbearable pain [28].

RESULTS

During the study, 20 impacted teeth were exposed in 16 patients, ten using laser (table 1) and ten using traditional procedures (table 2).

In 7 patients of the population A (5 Class I and 5 Class III impacted teeth) topical anesthesia combined with antalgic laser biostimulation was sufficient to manage pain (maximum pain evaluation on NRS scale = 2); in 3 patients approximately 0.20 ml of anesthetic (1:100.000 articaine chloridrate) was infiltrated in the mucosa overlying the crown of the impacted teeth. None of the interventions was characterized by bleeding or other side effects and none of the patients needed sutures. In all patients it was possible, using bonding materials, to position orthodontic buttons or brackets for traction force application and their adherence was verified before patient release. Patients were examined after 1, 7 and 14 days; only two patients reported a slight pain (NRS scale = 2) immediately after surgery and they were treated with only one dose of OTC analgesic (table 3)
The longest intervention was represented by the exposure of MF 08/02 upper right palatal canine (figures 1A-D).
All patients of the population B (4 Class I and 6 Class III impacted teeth) needed infiltrating anesthesia (anesthetic dosage ranging from 1.7 ml to 3.4 ml of 1:100.000 articaine chloridrate) to manage surgical pain. All interventions were characterized by intraoperative bleeding; the six patients with Class III impacted teeth needed sutures of the repositioned flap and it was possible, using bonding materials, to position orthodontic brackets for traction force and their adherence was verified before patient release. The four patients with Class I impacted teeth did not need sutures but it was not possible to position orthodontic devices for traction force application because of postoperative bleeding. Patients were examined after 1, 7 and 14 days; all patients reported pain (average value on NRS scale = 4) immediately after surgery and up to 5 days; all were treated with OTC analgesic (table 3).
The longest intervention was represented by the exposure of a upper left canine.

DISCUSSION

Impaction is a condition characterized by the lack of a tooth in the dental arch after the usual period of teeth eruption; its etiology may be related to general or local factors.
Early diagnosis of impaction is essential in order to assure better prognosis.
The exact position of the impacted tooth is crucial for the selection of the most appropriate therapy, including, in most cases, a combined surgical-orthodontic approach.
Different lasers are commonly used in medicine and they differ among each others in terms of their radiation wavelength, as different wavelengths produce different biological effects on vital tissues [29, 30].
In dentistry laser is used since ‘80s and nowadays laser technology helps dentists in performing many procedures [20, 21, 22].
In general dental practice diode laser are very common. Diode lasers are characterized by radiation wavelengths ranging from 635 nm (red region of the visible spectrum) to 980 nm (infrared portion of the light spectrum) and display power settings ranging from 0.1 to 15 W, thus allowing a wide array of clinical applications. Among laser clinical applications there are soft tissue surgery [23, 24, 25, 26, 27], non surgical periodontal treatments, even if there are conflicting opinions among the various authors [31, 32, 33, 34, 35], antimicrobic treatment of dental hard tissues [36] and endodontic therapy [37].
Moreover, laser treatment could be used to manage operative pain [24, 38] along with to induce biostimulation and tissue regeneration [39, 40, 41, 42, 43].

Laser treatment could also be used to treat dentin hypersensitivity [44, 45], to obtain gingival retraction without bleeding for the exposure of subgingival finish line of indirect restorations [46] and for many pedodontic [47] and orthodontic procedures [24, 25, 48].
In dental clinical practice it is often necessary to deal with and resolve cases of impacted teeth in order to improve aesthetics and mastication.
The proper orthodontic-surgical treatment allows, in most cases, a correct repositioning in the arch of the impacted element; this repositioning, however, must not damage neither closer teeth or periodontal tissues [5, 13, 49].
When the impacted tooth is not deeply retained, and the surgical exposure of the crown allow the conservation of the attached gingiva, diode laser approach represent an advantageous solution. In fact, it allows not only the lack of bleeding during surgery, but also avoids or reduces the use of anesthetics, analgesic and anti-inflammatory drugs. Moreover, laser approach does not need suture and assure minimal postoperative complications, along with a rapid and predictable healing of the tissues. Lastly, the major advantage of laser surgery is represented by the possibility to immediately position the retaining and traction means in the absence of bleeding [24, 26].
Cases reported herein, highlight laser approach easiness, allowing small surgery interventions to be carried out also by dental practitioners not routinely performing oral surgery interventions. Laser approach shows many advantages: 1) psychologic trauma reduction as the surgical intervention can be performed by the attending physician, 2) uselessness of pharmacological local anesthesia, with a significant reduction of side effects; 3) reduced invasiveness of surgery; 4) lack of bleeding during surgery; 5) immediate positioning of orthodontic buttons or brackets ; 6) traction force and their adherence verified before patient release; 7) lack of post-surgery side effects; 8) good tissue healing; 9) quick amortization of laser costs.
Diode laser thus represents an important asset in clinical practice allowing an even increasing reduction of surgery invasiveness.

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FIGURE LEGENDS

Figure 1

A) Laser biostimulation of tissues covering impacted tooth crown to relieve pain

B) Localization of impacted tooth crown

C) Exposure of the impacted tooth crown

D) Orthodontic button positioned for traction device.

Figure 1

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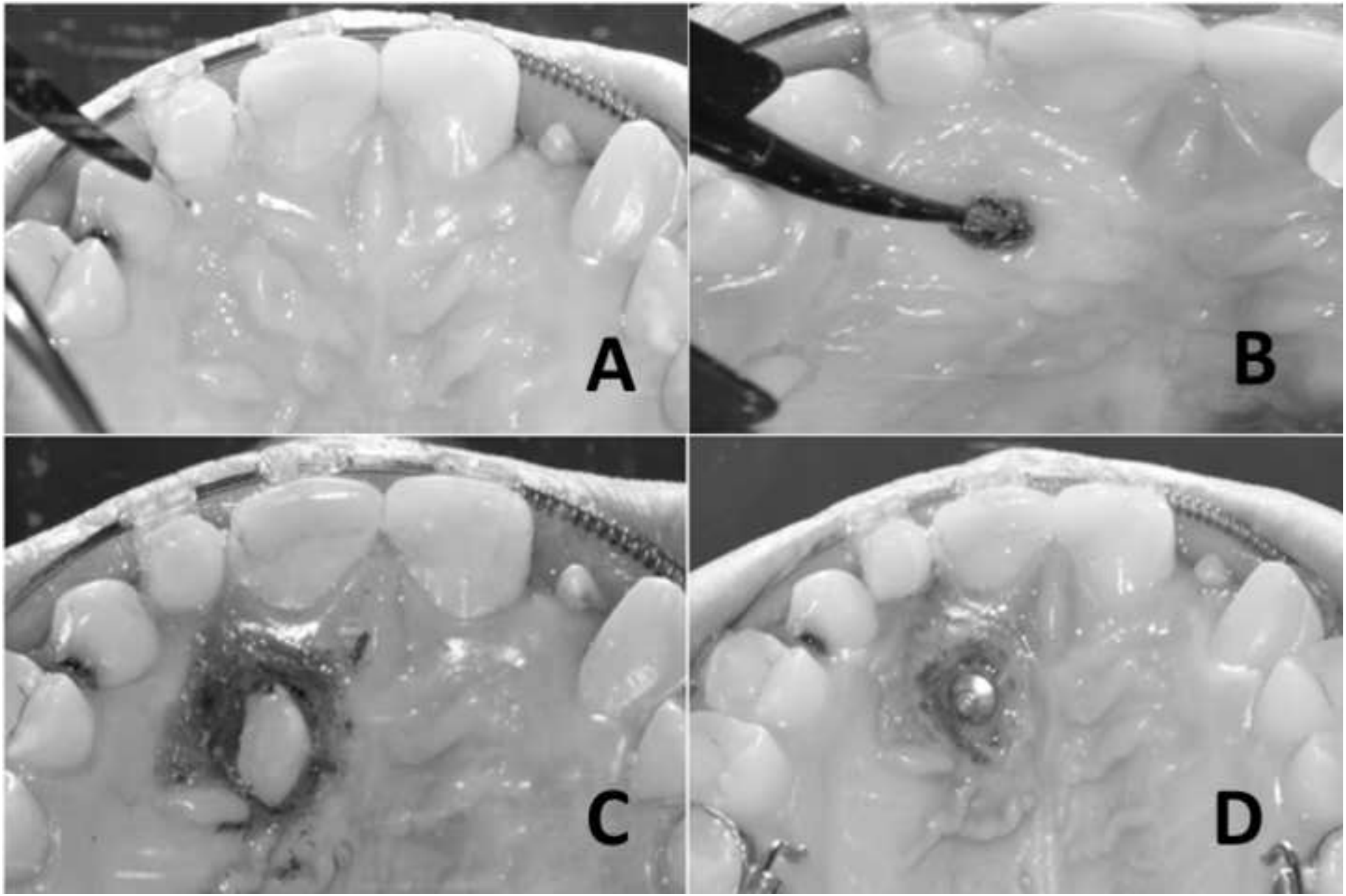

Table 1. Population A: 10 patients / 10 teeth

N	identification code	gender	tooth, side	Chapokas classification	anesthesia	side effects
1	B.A. 01/05	male	1.2, vestibular	Class III	Topical	No pain No swelling No bleeding No analgesic
2	G.L. 06/99	male	4.7	Class I	Infiltrative	Pain No swelling No bleeding Analgesic
3	L.M. 06/95	female	2.3 vestibular	Class III	Topical	No pain No swelling No bleeding No analgesic
4	M.F. 08/02	female	1.3 palatal	Class I	Infiltrative	No pain No swelling No bleeding No analgesic
5	T.G. 06/00	female	1.3 vestibular	Class III	Topical	No pain No swelling No bleeding No analgesic
6	M.R. 10/96	Male	1.3 palatal	Class I	Topical	No pain No swelling No bleeding No analgesic
7	P.C. 05/91	female	1.3 palatal	Class I	Infiltrative	Pain No swelling No bleeding Analgesic
8	B.G. 02/00	female	2.3 palatal	Class I	Topical	No pain No swelling No bleeding No analgesic
9	G.A. 11/95	male	1.3 vestibular	Class III	Topical	No pain No swelling No bleeding No analgesic
10	V.C. 09/00	male	2.3 vestibular	Class III	Topical	No pain No swelling No bleeding No analgesic

Table 2 Population B: 10 patients /10 teeeth

N	identification code	gender	tooth, side	Chapokas Classification	anesthesia	side effects
1	B.A. 01/05	male	2.2, vestibular	Class III	Infiltrative	Pain Swelling No bleeding Analgesic
2	G.L. 06/99	male	3.7	Class I	Infiltrative	Pain No swelling Bleeding Analgesic
3	L.M. 06/95	female	1.3 vestibular	Class III	Infiltrative	Pain NoSwelling No bleeding Analgesic
4	M.F. 08/02	female	conoide 2.2, vestibular	Class III	Infiltrative	Pain No swelling No bleeding No nalgesic
5	Z.J 11/01	male	1.3 palatal	Class I	Infiltrative	Pain No swelling Bleeding Analgesic
6	F.A. 01/02	Male	1.3 palatal	Class I	Infiltrative	Pain No swelling Bleeding Analgesic
7	M.L. 05/97	female	1.3 vestibular	Class III	Infiltrative	Pain Swelling No bleeding Analgesic
8	P.S. 12/00	female	2.3 palatal	Class I	Infiltrative	Pain No swelling Bleeding Analgesic
9	B.R. 01/99	male	1.3 vestibular	Class III	Infiltrative	Pain Swelling No bleeding Analgesic
10	S.F. 02/02	male	2.3 vestibular	Class III	Infiltrative	Pain No swelling No bleeding Analgesic

Table 3. Results

	POPULATION A Laser	**POPULATION B Lancet**
Chapokas Class I	**5**	**4**
Chapokas Class III	**5**	**6**
Infiltrative anesthesia	**3**	**10**
Pain	**2**	**10**
Swelling	**0**	**4**
Bleeding	**0**	**4**
Analgesic	**2**	**10**
Immediate positioning of orthodontic devices	**10**	**6**