Efficacy and safety of locally injectable vitamin C on accelerating the orthodontic movement of maxillary canine impaction (oral mesotherapy technique): prospective study

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Summary

***Purpose*. The purpose of this study is to investigate the role and efficiency of the locally injected vitamin C in the enhancement of the palatally impacted canine movement.**
***Materials and methods*. Twelve adult patients with unilateral palatally impacted canines were included in this study. The enrolled patients were randomly allocated into the study groups; control group; conventional orthodontic traction and the intervention group: orthodontic traction enhanced by intraepidermic vitamin C injection. The study duration was 12 months.**
***Results*. The clinical evaluation revealed higher traction rate of the vitamin C enhanced group with preserved alveolar bone level, gingival biotype and width of the keratinized gingival tissues.**
***Conclusion*. Locally injected vitamin C is one of the potent eruption accelerator that has the advantage of keeping the integrity of the surrounding periodontium.**

KEY WORDS: palatally impacted canines; oral mesotherapy; locally injected vitamin c; gingival biotype; alveolar bone loss; non-surgical canine traction.

Introduction

Impaction simply refers to a tooth that failed to erupt reaching its position to be properly aligned within the dental arch. Till now, the exact cause of impaction is unknown (1). Wisdoms or third molars are the most frequently impacted teeth followed by maxillary canines. The incidence of impaction is higher in maxilla than in mandible. The majority of impacted canines are palatally located (85%) (1, 2).
Maxillary canines have the longest eruption period because of its eruption through the canine fossae. The canine is considered impacted if the eruption is delayed 6 months after its root completion (3).
The maxillary lateral incisor exhibits an important role in directing the eruption pathway of canines. Upon its absence, failure of canine eruption could occur. The congenitally missing lateral incisors are commonly found in young females (4, 5).
The eruption process of canines usually begins at the age of 8 years old. It usually erupts in the oral cavity at the age between 10-12 years old. Bilateral palatal maxillary canine impaction is more common than the unilateral pattern. Orthodontic management of palatal impaction becomes more complicated during late adulthood period. The success rate decreases after thirties to be ranged between 40-50% while under thirty it is about 100% (3, 6).
Many theories have explained the cause of such problem: guidance theory and genetic theory. The guidance theory proposed the presence of any abnormalities or local factors interfering the eruption pathway including congenitally missed teeth, odontomes or transposition of teeth. If the lateral incisor failed to erupt, it exhibits a problem causing impaction of canines. Furthermore, it is also related to the long and torturous pathway. On the other hand, the genetic theory is based mainly on the genetic makeup which may be associated with the presence of local factor. The genetic background controls the tooth shape and size, the dental arch shape and size. It is also related to the presence or absence of the lateral incisor (1, 5).
Furthermore, several etiological factors have been suggested. These factors can be categorized into patient related and site related factors. The patient related factors include the patient's age, vitamin D deficiency, patient cooperation and impaired medical status (endocrinal disturbance, irradiation, fever). While the site related factors include true or relative deficiency of the interdental space, trauma, ankylosis, malpositioning of the impacted tooth (rotation), lack of keratinized tissue, the length of impacted tooth journey to reach its position (depth of impaction), bone density, amount of root formation, dilacerations, cystic or neoplastic lesions, premature closure of root and presence of alveolar fissure (1-3, 6, 7).
Childhood and adolescence are the currently suitable periods for orthodontic correction for impacted canines because of maximum bone flexibility which could be decreased or lost

during adulthood period. However, the surgical removal of impacted canines is still an important treatment option when dealing with untreatable conditions (2).

The success rate of orthodontic correction of impacted canine depends also on the condition of adjacent teeth and the alveolar bone height. The mesio-distal position of the canine's tip according to the long axis of the lateral incisor's root is the main determinant of the prognosis of its eruption. The pure mesial position of canine's tip has the worst prognosis, while the purely distal location has the best outcome (3).

The treatment plan must be designated and supervised by a team composed of: orthodontist, oral surgeon and periodontist. First, diagnosis should be done depending on the clinical and radiographic examination. The preliminary clinical examination is divided into 2 stages; inspection and palpation (canine bulge). The absence of canine bulge at younger age is not an indicator for its impaction. The palatally impacted canines usually exert pressure on the root of the lateral incisor causing palatal displacement of its crown causing resorption and mobility of the lateral incisor's root (4, 6, 7). The radiographic examination helps to detect the definite position of impacted tooth either by using occlusal, panoramic views or computed tomograhy or both.

Following diagnosis and during the surgical exposure phase, retained teeth or other lesions as odontomes, tooth sac or fibrotic mass have to be removed. It usually begins by the early extraction of the retained deciduous canine at the age of 10-13 years. Such removal permits a path for natural eruption of impacted canine (5, 8). According to the vertical dimension, the length of the canine crown is more important than the horizontal one. In the sagittal dimension, the canine overlapping and the bucco-lingual positioning of the apex are important to decide either to expose or remove the impacted canine (9). During surgical exposure, it is recommended to avoid exposure of the cemento enamel junction (CEJ) in order to avoid the disturbance of the related periodontal ligaments. Sufficient space should be created in relation to the impacted canine prior to its traction. The attachments are preferred to be in a lower labiopalatal position in order to avoid tearing of the flap (5, 7, 9).

As an average, the journey that the palatally impacted canine travels usually takes 1-3 years (1). The suitable age for traction ranges 12 y in females and 13 y in males (9). The first stage of canine positioning is the longest phase while its adaptation to the right position takes less time. Light force (about 60 g) is recommended (5, 7, 9).

The traction duration depends on its position. Initial provision of adequate space should be initially achieved. The average visits are nearly 10 with younger patients with mesial impaction while more than 25 visits are needed in older patients. If the canine is about 14 mm away from the occlusal plane, the treatment may spend an average of 31.1 months to be fully erupted. The orthodontic traction should be performed without negatively affecting the periodontal condition of the tooth. During traction process, several complications could result in ankylosis, discoloration, loss or vitality, recession, alveolar bone loss, and loss of keratinized gingiva. If ankylosis, internal or external resorption, dilacerations, extremely mesial impaction (between the central and lateral incisors) occurred, the impacted tooth has to be extracted (3, 10, 11).

Most of the systemic diseases as endocrine disorders, protein and vitamin malnutrition cause delayed tooth eruption except diabetes mellitus (12).

Therefore, the correction of such disturbances was suggested and several topical or systemic chemical agents have been used to potentiate the movement of orthodontically tracted teeth. Formerly, exogenous single or multiple prostaglandin injections were used (13). Local vitamin D was also injected for several weeks and an increase in the osteoclastic activity in the pressure site and in the number of osteoblasts on the compression site was found. A daily local injection of parathyroid hormone (PTH) was also used to induce local bone resorption. A weekly injection of relaxin hormone was also found to accelerate tooth movement via soft tissue remodeling, rather than bone, through increasing the collagen at the tension side over its amount in the compression side. It also decreases the organization of the periodontal ligaments surrounding the tooth causing extra mobility (14, 15). Topical bisphosphonates were used in order to reduce prostaglandin E2 production (16).

Furthermore, low level laser therapy is another non-surgical approach that depends on the bone bending action caused by the orthodontic movement which creates negatively charged concave surface and positively charged convex surface. The concave surface easily attracts osteoblasts while the convex surface attracts osteoclasts (14).

Growing evidence has suggested the role of vitamin C (vit-C) in enhancing the quality and outcome of the orthodontic treatment. This is proved when tooth movement period was following systemic administration of vitamin C reduced (up to 17 days) (17, 18). It was also noticed that its deficiency reduced the tooth movement and arrested osteogenesis in Miresmaeili et al. (2015) (19).

Vit C induces its action through modifying the osteoclastic activity, osteogenesis, tissue healing and periodontal ligament organization. It increases the collagen I synthesis that represents the main component of bone matrix and periodontal ligament (20). It also accelerates the bone mineralization, formation of collagen type X, expression of alkaline phosphatase, osteoblast growth and differentiation (21).

In tissue engineering experiments, previous studies showed that the sustained release of vitamin C, when used with scaffolds, stimulates the formation of type I collagen and alkaline phosphatase resulting in bone regeneration (22, 23).

Moreover, previous researches reported the positive effects of vitamin C on enhancing the growth of skeletal bones including femur and vertebrae. It markedly improves the bone densities (24).

The aim of the present study is to evaluate the efficacy and safety of the locally injected vitamin C in acceleration of the rate of maxillary palatally impacted canine traction and preservation of the integrity of the surrounding periodontium along one year.

Methodology

Ethical aspects

The treatment protocol was approved by the ethics committee of scientific research. Each patient (or legal guardian) signed an informed detailed consent form before participation explaining the benefits, steps and side effects of the treatment protocol. The injection protocol of vitamin C was approved from the ethical committee of Faculty of Dentistry-Cairo University.

Study design

The study was designed as prospective longitudinal clinical study. The current study describes a phase of the orthodon-

tic treatment plan during one year of the beginning of the traction of a palatally impacted canine. All patients were randomly allocated in the study groups. Randomization was carried out by using computer-generated random numbers. The study was registered in clinical trials.gov (NCT03260829).

Patient selection

The study was conducted on the referred patients to the post-graduate clinic of orthodontics department at faculty of oral and dental medicine Cairo University between the years 2014 and 2015. The diagnosis procedure was done by one examiner (M.Y). An initial evaluation, including medical and dental history, clinical and radiographic examination, was conducted to determine patient eligibility for the study. The design of the study started with 30 patients whom ended the mixed dentition stage with palatally positioned canines. Criteria of enrollment were as follows: 1) aged between 15-40 y; 2) medically free; 3) patient with good to fair oral hygiene (gingivitis may be included); 4) both sexes were included; 5) unilateral palatally positioned permanent canines; 5) absence of previous orthodontic treatment; 6) absence of supernumerary teeth, odontoms, cysts, traumatic injuries; 7) the α angle within grade II to III. All the reasons that could provoke gingival inflammation or bone resorption were excluded; 1) systemic diseases especially diabetes and bone diseases; 2) pregnant and lactating mothers; 3) local causes (smoking, mouth breathing, local trauma and periodontitis).

Patients' grouping

A total of 12 patients was enrolled at the beginning of the trial (T1). The subjects were allocated to the 2 treatment groups. The enrolled 12 patients were randomly allocated into 2 groups: control group contains 6 patients underwent canine traction using orthodontic treatment only and group 2 (intervention group) contains 6 patients underwent canine traction using orthodontic treatment and intraepidermic vitamin C injection. The study reported the rate of movement of palatally impacted canine during one year period starting after the surgical exposure of the impaction using closed technique and from the beginning of the canine traction phase. The available space should suits for the mesio-distal dimension of the crown of impacted canine.

Patient preparation

Each patient underwent full-mouth sessions of supragingival debridement using ultrasonic and hand instrumentation and received personalized oral hygiene instructions. In addition, chlorehexidine 0.12% mouth rinsing was recommended twice daily for one week. All patients placed on a 2 weeks maintenance recall appointments. The enrolled patients have to achieve residual inflammation (<15% of plaque and bleeding scores according to O'Leary et al. scoring system) and optimal soft tissue conditions prior the beginning of the canine traction period.

Radiographic examination

The radiographic parameters were measured by the same examiner (H.M.D). These parameters had to be detected at the beginning and at the end of the procedure. The three dimensional location (vertical, mesio-distal, bucco-palatal location) of canine was detected by clinical and radiographic examination. While the radiographic examination depends on panoramic, occlusal and cone beam computed tomography (CBCT) (to detect the presence of root resorption). Radiographic measurements were reported prior the beginning, during and at the end of traction procedure (1). The type of impaction was determined through the panoramic and occlusal radiograph based on *Ericson & Kurol's* classification (1988) (25) at T1 and T2 (12 months) (Table 1).

Clinical evaluation

The periodontal parameters were measured by the same operator (N.M.Y). Probing depths, soft tissue biotype, alveolar bone level (bone sounding) and width of the keratinized gingival tissues were measures using William's periodontal probe. Clinical evaluation of the position of the impacted canine depends mainly on palpating the canine bulge. Both groups underwent the same orthodontic treatment protocol.

Table 1 - The Ericson & Kurol's classification (1988) of impacted canine.

	Grade I	Grade II	Grade III	Grade IV
1. Canine angulation to midline	0 to 15° (good prognosis)	16 to 30° (average prognosis)	≥ 31° (poor prognosis)	
2. Position of canine root apex in the horizontal plane	Apex above the normal canine position (good prognosis)	Apex above the 1st premolar region (average prognosis)	Apex above the 2nd premolar region (poor prognosis)	
3. Lateral incisor root overlap	No horizontal overlap (good prognosis)	Overlap less than half the root width (average prognosis)	Overlap more than half, the root width, but less than the whole root width (average prognosis)	Complete overlap of the root width or more (poor prognosis)
4. Degree of vertical impaction	Crown is at coronal 1/3 of the lateral incisor root (good prognosis)	Crown is at the middle 1/3 of the lateral incisor root (average prognosis)	Crown is at the apical 1/3 of the lateral incisor root (average prognosis)	Crown is below apex of the lateral incisor root (poor prognosis)
5. Ratio of root formation	1/3 of root formed (good prognosis)	2/3 of root formed (average prognosis)	Root is completely formed (poor prognosis)	

Primary and secondary outcomes

In order to critically evaluate the study outcomes, several parameters were chosen in order to report any changes. The rate of the orthodontic tooth movement is the primary outcome while the secondary outcomes were facial tissue biotype, width of keratinized tissues, facial alveolar bone thickness and the lateral incisor root resorption.

Orthodontic procedure

The orthodontic treatment was done by H.M.D. Subjects were treated by using fixed pre-adjusted edgewise orthodontic appliance (0.022″ x 0.028″ slot) ROTH prescription. Both arches were initially leveled and aligned using arch wire sequence starting by 0.016" NiTi & ending by 0.019"X0.025" st.starch wires. Space opening for accommodating the impacted canine was done by using sequentially activated NiTi open coil spring (0.010″ x 0.030″) until sufficient space was achieved.

Surgical exposure of impacted canine was done using closed flap technique where button was bonded at the time of surgical exposure after sufficient dryness and enamel preparation. A ligature wire (0.012″) was tied to it which was projected from the flap borders and then an active power chain was tied on one end to the ligature wire and on the other end to the main arch wire (0.019"X0.025" st.st). Activation was done every 2 weeks until the canine appeared.

When the canine's labial surface was accessible, a bracket was bonded and it was tracked to the occlusal plane by engaging 0.012″ overlay wire into the bracket slot. Afterwards, bracket re-positioning was done and the canine was engaged to the main arch wire (0.018″NiTi). After the canine was leveled & aligned interim records were taken, followed by final finishing and detailing finally permanent retention was done after de-bonding. No additional surgical or orthodontic therapy beyond the needed plan.

Injection procedure

The same operator (N.M.Y.) was responsible for injection procedures. The site of interest was topically anesthetized. The dosage of the intraepidermic injection was adjusted according to Yussif et al. (2016) (20). The recommended dosage was divided by 6 (maxillary six anterior) to calculate the required dose for a single tooth. Vitamin C was equally distributed palatally with prevalent extension to the whole target region respectively using special syringes with finest gauge 30 (26). The used dosage is suitable to an area equivalent to the impacted tooth (20). Needle is inserted till reaching the bone and then slight retraction for ideal needle positioning to be parallel to the mucosal surface (within papillary connective tissue). The injected area was massaged for equal distribution of the injected vitamin. The traction wire was the reference for the canine location during injection. Injection visits was repeated every 2 weeks (two visits per month).

At the end of each session, patients were prescribed a rescue analgesic (ibuprofen 200 mg) to be used as needed. The patients were asked to abstain from mechanical oral hygiene procedures in relation to the target region for the day of procedure only.

Clinical parameters

The rate of tooth movement is the primary outcome while the clinical and radiographic periodontal and orthodontic parameters were the secondary outcomes. The periodontal parameters included: width of keratinized gingiva, tissue biotype, labial bone thickness (radiographic parameter), bone resorption in relation to lateral incisor and incidence of gingival recession. While the orthodontic parameters included: rate of tooth movement, distance between tip and occlusal plan, alpha angle, position of canine apex in horizontal plan, lateral incisor root overlap, degree of vertical impaction and root resorption. Clinical photographs were taken during injection visits to ensure canine movement and changes of the periodontal tissues.

Re-evaluation and follow-up

All subjects were evaluated at the second observation time point after a year of the surgical exposure (T2).

Statistical analysis

The obtained data were statistically described in terms of mean ± standard deviation (± SD), median, frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between pre and post treatment values was done using paired *t* test. *P* values less than 0.05 was considered statistically significant. All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) release 15 for Microsoft Windows (2006).

Results

Demographic data

Twelve patients were enrolled in the study. There were no dropouts from the T1 to T2. The enrolled patients ranged between 16 to 34 years old. The age range indicates the completion of the root of the impacted tooth and the different cellular activity in the wide age range. All patients were beyond the average age of normal eruption (8-13 y). At the age of 14, the unerupted canines are usually considered to be impacted (3). It can be seen that 9 (75%) out of 12 enrolled patients were females and only 3 (25%) were males. The difference of the enrolled frequency and percent may reflects the overcare of the female patients to esthetics or the increased incidence of canine impaction in females.

The treated patients suffered from a unilateral palatal impaction of the maxillary canine with no retained deciduous canine or any objects interfering with eruption. The canines' roots were completely formed (grade III) in all cases.

The canine distribution was clinically detected by the canine bulge while radiographically, the distance between the canine tip and occlusal plane was numerically reported. Six (50%) out of 12 patients had right impaction and the remaining 6 (50%) patients had left impaction. Radiographically, the distance between the canine tip to the occlusal plane (future ideal position) was measured. It ranged between 8-14 mm. It was difficult to standardize the exact canine to occlusal plane distance between the enrolled patients as it will prolong the recruitment period. About 91.7% of the enrolled pa-

tients recorded grade II alpha angle while only one (8.4 %) patient had grade III angle. The horizontal position of the canine root apex was reported ranging between grade II and III. In grade II, the root tip was located at first premolar in 6 patients (50%) while the root tip was at the second premolar (grade III) in the other 6 patients (50%). While the degree of vertical dimension ranged between the 4 grades as; grade I (1 patient or 8.3%), grade II (2 patients or 16.7%), grade III (8 patients or 66.7%) and grade IV (1 patient or 8.3%).

The relation between canine and the neighboring lateral incisor was detected using 2 parameters; lateral incisor root overlap and lateral incisor root resorption. In lateral incisor root overlap; 6 (50%) patients were grade I, 4 patients were grade II (33.3%) and finally 2 patients were grade III (16.7%). The lateral incisor root resorption was reported in 5 (41.7%) out of 12 patients suffered from mild resorption prior the treatment due to the position of the canines' tips nears the apex of the lateral incisors.

All patients were periodontally and caries free. Normal sulcus depth (1-3 mm) in relation to the surrounding teeth was detected pre-operatively using William's periodontal probe. In relation to the future location of canine facially, tissues were needed to be examined if suits or not by detecting; tissue biotype, width of keratinized zone and alveolar bone thickness. Regarding facial tissue biotype, the pre-operative measurements ranged between moderate (8 patients or 66.6%) to thick (4 patients or 33.3%). While the pre-operative width of the keratinized zone ranged between 4-7 mm which is adequate to keep the health of the tracted teeth. Finally, the thickness of the facial alveolar bone was radiographically measured. Although the presence of a facial concavity in most of patients, the palatal bone thickness was adequate enough to begin the traction procedure. The bone thickness ranged between 4-5 mm.

Primary outcome measurement

The primary outcome was the rate of the orthodontic tooth movement along the impacted canine pathway. Statistically, greater mean area percent of the rate of tooth movement was recorded in intervention group (2.25±0.274), compared to the control group (1.08±0.376). Unpaired t test revealed that the difference was statistically significant (p<0.003) (Table 2). While clinically, significant improvement was reported the movement rate in the intervention group (2- 2.5 mm) while in control group, lower rate (0.5-1.5 mm) was detected.

Secondary outcomes measurement

The improvement of treatment was detected during 12 months which began after healing of the exposure wound.

Regarding facial tissue biotype, the post-operative clinical results showed improvement of the facial gingival biotype in 6 patients in all patient of intervention group (100%) with different degrees. Although the used biotype index is quite accurate but the progression within the grade range could not be reported. Therefore, all the cases recorded thick biotype. Limited improvement was reported in cases with pre-operative thick biotype (≤0.5 mm) while the moderate biotype cases showed great improvement ranged between 1-1.5 mm. On the other hand, in the control group, no statistical significant improvement of the facial biotype was reported. Clinically reported reduction of the gingival biotype was detected in all cases with 2 cases converted into thin biotype. Although the clinical significance difference, there was no intragroup statistical significant difference in both groups. The intergroup correlation showed statistical significant difference (p-value=0.002) between both groups.

Secondly, the keratinized zone width was checked in order to report its changes during tooth traction. No intra (p-value= 1.0) or intergroup statistical significant difference (p-value=0.416) was reported during canine traction or alignment in the width of keratinized tissues between the pre and post-operative values.

Post-operative gingival margin level was measured by plotting a horizontal line extending between midfacial cement-enamel junction (CEJ) between neighboring teeth (lateral incisor and first premolar). It was detected only post-operatively. There were no statistical significant differences between both groups post-operatively. On the clinical level, no incidence of recession defects was reported.

The alveolar bone thickness is a radiographic parameter that was measured pre and postoperatively. The intragroup analysis of control and intervention group separately showed statistical significant differences (p-value= 0.000). While the intergroup analysis between the post-operative results in both groups showed statistical and radiographic significant difference (p-value=0.002).

Finally, the lateral incisor root resorption was measured pre-operatively in order to detect if the procedure itself causes resportion or not. On the radiographic level, there were no detectable differences that could be even measured. So the differences could not be evaluated.

Discussion

Canines play an important role in preserving the facial esthetics and function. However, it is the most commonly impacted teeth that require orthodontic treatment. Although the marvelous esthetic outcome obtained at the end of high maxillary canine treatment, its traction is considered the great challenges to both the orthodontist and peridoontist. The needed time may equal the period of the whole orthodontic procedure (2).

The canine impaction depends on several factors but, the tooth location and patient's age are the main factors that control the pathway of the impacted tooth. The traction procedure consists of three stages; verticalization, palatal positioning and finally tooth extrusion (3).

The current clinical study examined the efficacy of the intraepidermal injection of vitamin C in accelerating the impacted canine traction during the clinical observation period (one year). A canine was considered to be successfully erupted when the traction procedure permits the canine to properly align without further surgical intervention (27).

In all treated patients in this study, the root was completely formed (grade III) which could be one of the main causes of impaction and difficult tooth allocation. Retained deciduous canines act as a mechanical obstacle that prevents the normal eruption of the permanent canines. According to literature, removal of deciduous canine favors a benefit as it gives more space for physiologic eruption. In the current study, the absence of deciduous canines didn't favor an extra benefit. It could be attributed to the completion of the root of permanent canine, patient's age and the high positions of the included canines (8).

Prior to the traction process, careful examination was done and the location of impacted canine was accurately deter-

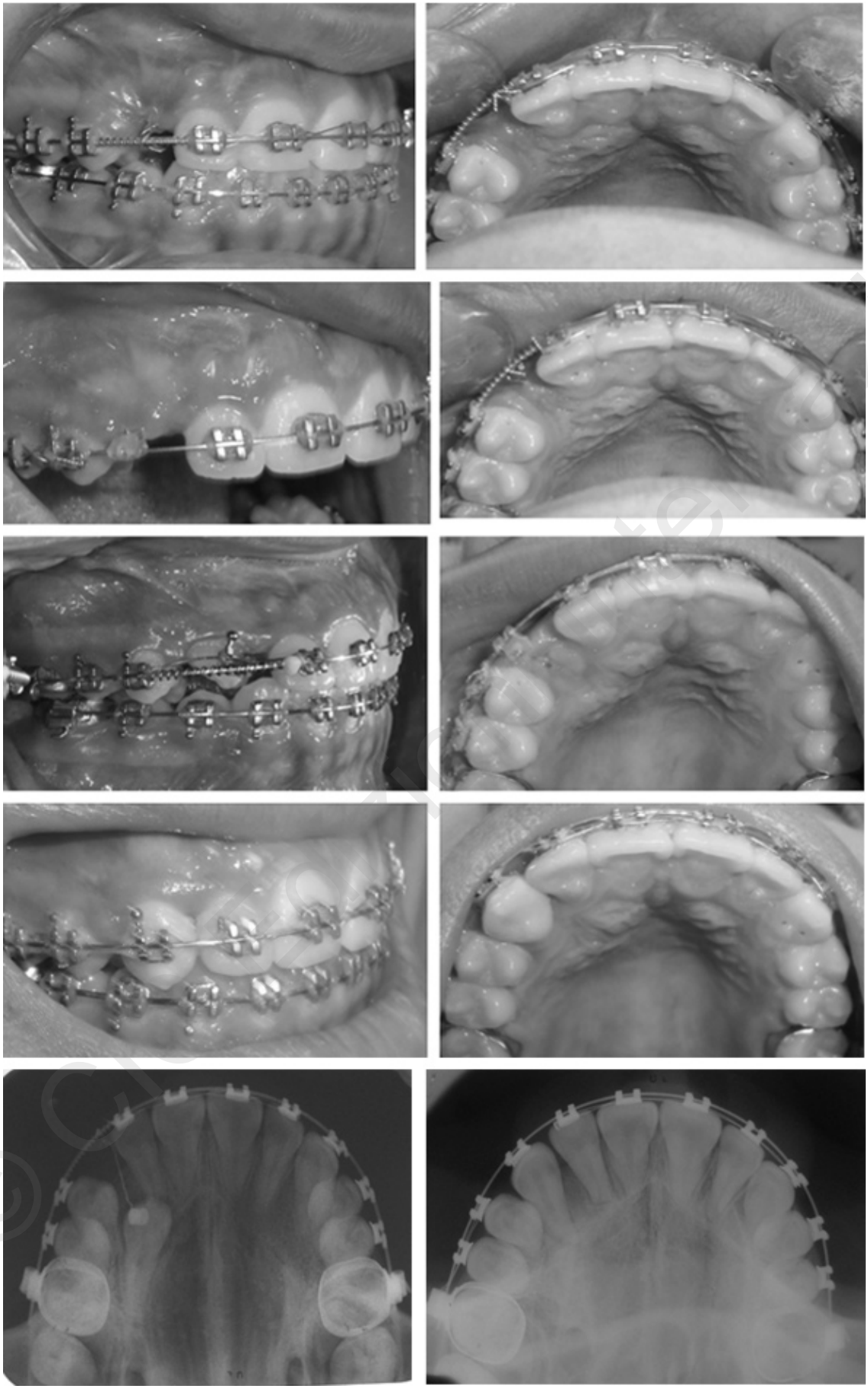

Figure 1 - A 19-year-old female suffered from unilateral palatally impacted canine with pre-operative resorption of the lateral incisor root.

Table 2 - Mean area percent the rate of tooth movement in control and vit C groups and significance of difference (primary outcome).

	Control group	Vit C group
Mean	1.08	2.25
Std Dev	0.376	0.274
Max	1.5	2.5
Min	0.5	2
t-value	-5.53	
P-value	<0.003	

mined. The mesio-distal space between the lateral incisor and the first premolar was evaluated either being adequate and suitable for the mesio-distal dimensions of the impacted canine or not.

The tips of the canines were located 8-14 mm from the occlusal plane which requires 15-31 months to be fully erupted in the oral cavity according to literature (3, 10, 11). Such position is considered far enough to be affected by the local problems like inadequate arch space.

All patients were exposed using the closed technique which has several benefits in such situation. It was found that the post-operative healing is faster in closed technique than the open surgery (28). It also resulted in the best gingival esthetics and the easiest tooth movement due to lack of scar formation (29).

Low force magnitude was applied during the activation visits twice per month till the canine appeared and well aligned in its pathway (30). When alveolar bone was evaluated interproximally and labially, normal level (at the CEJ) were reported pre and post-operatively in both groups reflecting the balanced bone remodeling in the form of resorption and deposition in both sides and the resorption rate was within the normal permissible range.

Resorption of the roots of the lateral incisors was detected pre-operatively in 4 patients due to the position of the canine tips in relation to the lateral incisors' roots which may be attributed to the long term impaction. No bone or root resorption was detected in relation to the treated teeth after vitamin C injection.

Regarding the use of accelerators, vitamin C was selected rather than the other commonly used local agents. This is because of the triple magic like action of vitamin C; first, its effect on enhancing the cellular activity and differentiation within the physiologic limit (osteoblast, osteoclast, fibroblast) (24), second, its effect on controlling normal function of immune cells and in preserving inflammation levels which favors a high control of the amount of bone loss, finally, the superior effect of vitamin C on healing due to its anti-oxidant and anti-inflammatory properties (20, 21).

According to Jokar et al. (2015) (24), it was found that vitamin C administration increases the bone density, enhances calcium absorption and the formation of bone matrix.

The local administration of vitamin C is much preferred from the systemic administration to pass the problem of malabsorption of large doses that required for such conditions.

On the other hand, the intrepidermic injection (oral mesotherapy technique) was applied instead of the traditional intraligamentary injection. Several causes, that support and underlay this choice, can be divided into; site related, injectable vitamin C related and technique related. Palate is a highly traumatized site that needs the least traumatic techniques to be used. On the other hand, vitamin C is a mild acidic agent that requires cautious application to get the maximum benefits with minimal drawbacks. The intraepidermal injection is a method by which the injected agent is located in relation to the basement membrane and papillay connective tissue. In this technique topical anesthesia was enough to be used rather than the local anesthesia. It also favors the sustained release of the vitamin without direct contact of the introduced agent to the underlying bone. When compared with the intra-ligamentary technique, the intra-ligamentary technique is a highly traumatic technique to the periodontal ligament even with the usage of the thinnest needle gauge due to the back pressure resistance causing pain and inflammation which could result in extra bone resorption (26).

Generally, the orthodontic treatment in conjunction with mucosal injection of vitamin C was significantly more efficient and associated with faster eruption and higher rate of movement/month, compared to control group indicating the efficiency of vit C in accelerating and facilitating movement of impacted canines.

The number of injection visits ranged between 6-8 continuous undisturbed visits with 6-8 continuous and undisturbed orthodontic visits. The traction period ranged according to the patient's age, the impaction distance to the occlusal plan and the α angle. It was found that the addition of the mucosal vitamin C increased the prevalence rate of successful eruption and shortens the time needed for traction.

In the control group, minimum rate of canine movement (0.5 mm) was recorded in the oldest patient (30 yrs). In contrast, and within the intervention group, maximum movement rate of canines (2.5 mm) was observed in the oldest patient (34 yrs) with greatest vertical impaction (14 mm) and in the case with the greatest α angle (40 degrees) indicating the potentiality of vitamin C to overcome several factors implicated in complicating the treatment of canine impaction.

In consistence, a previous animal study showed that the induction of vitamin C deficiency was associated with disruption in teeth eruption and stability. The results were attributed to the importance of vitamin C as an essential component in the intercellular substance that is responsible for cellular cementation between adjacent cells. However, the intercellular substances reformed again after 18 hours of vitamin C administration (31). In addition, vitamin C influences the activity of fibroblast, osteoblast and odontoblast. It also permits normal protein and carbohydrate metabolism.

Based on our results and previous literature, vit-C can be used as an adjuvant treatment that facilitates orthodontic traction of impacted maxillary canines. However, further studies with larger population and wider age range are highly recommended.

Disclosure

This paper's contents are solely the responsibility of the Authors.

Competing interests

None of the Authors have any competing interests with respect to this paper.

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