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EVALUATION OF THE TIME REQUIRED FOR SURGICAL REMOVAL OF DEEPLY PALATALLY IMPACTED MAXILLARY CANINES USING A NOVEL SURGICAL TEMPLATE VERSUS FREE HAND TECHNIQUE (A RANDOMIZED CONTROLLED TRIAL)

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ABSTRACT

Introduction: Maxillary canines have the highest frequency of impaction behind that of the third molars. The majority of maxillary impacted canines are palatal compared to labial. Cone-beam computed tomography (CBCT) of impacted maxillary canines can determine the exact location of the tooth. Free hand technique for the removal of palatally impacted maxillary canine tooth is associated with complications such as postoperative pain, swelling, necrosis, or a deformity of the maxilla due to massive bone removal. To minimize adverse effects caused by conventional technique, a surgical template for intraoperative navigation can be used to overcome the drawbacks of the traditional technique.

Objectives: To evaluate the efficiency of a novel surgical template for surgical removal of deeply palatally impacted maxillary canines (DPIMC).

Materials and Methods: Twenty patients aged from 16 to 35 years old with DPIMC referred from the Outpatient Clinic of Oral and Maxillofacial Surgery Department and Orthodontic Department, Faculty of Dentistry, Alexandria University indicated for extraction were equally and randomly allocated into 2 groups; a novel surgical template was used in extraction of the DPIMC (Study group) versus free hand technique (Control group). Operation time, postoperative pain and bone density were evaluated to assess the efficiency of this surgical template.

Results: The Study group had a statistically significant shorter operation time compared with the Control group ($p<.001$). No statistically significant differences in postoperative pain or bone density were detected between the two groups.

Conclusion: The novel surgical template can significantly reduce the time needed for extraction of DPIMC, increases accuracy, minimize surgical complications and decrease patient's morbidity.

KEYWORDS: Cone-beam computed tomography; Surgical template; Impacted maxillary canine.

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INTRODUCTION

Maxillary canines have the highest frequency of impaction behind that of the third molars, with a prevalence reported to be between 1% and 3% and a 2:1 female to male ratio. They can be impacted palatally, buccally, or centrally; however, palatal impaction is the most frequent. Alteration in the aesthetic of the smile, resorption of lateral incisors and cystic degeneration are some of the aesthetic and functional drawbacks due to maxillary canine impaction [(1)].

The etiology of the palatal canine abnormal position is still unknown, but a potential genetic effect has been proposed. It has been proven that family members are more likely to have palatally impacted canines. Additionally, there might be a correlation with absent, malformed or diminutive lateral incisors, an absence of crowding and late developing dentitions [(2)].

Concerning the diagnostic methods of impacted maxillary canines, the following different ways were evaluated: CBCT, extraoral radiography (dental panoramic imaging and cephalometric imaging) and intraoral radiography (horizontal parallax and vertical parallax methods) [(3)].

Cone-beam computed tomography of impacted maxillary canines can determine exactly the buccal and palatal positions, bone quantity covering the teeth, the 3D proximity and resorption of roots of adjacent teeth, the condition of neighboring teeth and finally the local anatomic considerations. Therefore, CBCT is the most precise diagnostic method for locating impacted maxillary canines [(1)].

The goal of treating impacted canines is to realign the teeth in the dental arch properly while avoiding any negative effects on the impacted canine, adjacent teeth, and periodontal tissues. Severely impacted canines are typically diagnosed and treated using a multidisciplinary approach that includes both surgery and orthodontics. Treatment options for abnormally positioned canines include observation, orthodontic extrusion, interceptive treatment, transalveolar transplantation (surgical up-righting of the impacted tooth) and canine extraction. In order to decide the most appropriate treatment, the patient and the practitioner must consider the available treatment options and their predictability [(4)].

Surgical removal of the impacted canine is considered when the canine is severely malpositioned, the impacted canine is ankylosed, the impacted canine suffered internal or external resorption of the root, there is evidence for resorption on the roots from the surrounding teeth produced by the pressure from the eruption of the canine, alignment is not being considered, in situations where there are pathological changes and/ or its retention would block orthodontic tooth movement and if the patient refuses active treatment and/or is satisfied with their dental appearance. If necessary, fixed orthodontic appliances can be used to bring the first premolar forward to imitate a canine tooth. The best results will be obtained if there is good contact between the lateral incisor and first premolar or the patient is willing to undergo orthodontic treatment to replace the canine with the first premolar. It is important to evaluate and discuss with the patient the potential risk of damaging the roots of neighboring teeth during extraction of the impacted canine [(2)].

The traditional method of extracting palatally impacted maxillary canine tooth is associated with complications such as postoperative pain, swelling, necrosis, tooth penetrating nasal cavity, or a deformity of the maxilla due to massive bone removal.

It has been demonstrated that surgical guides made using computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies are effective in maxillofacial surgeries (5, 6). Nevertheless, it is noted that there are no reports regarding the viability of surgical guide surgery with respect to palatally impacted maxillary canine.

Piezosurgery, has shown to be a useful technique for cutting bone without encountering necrosis from overheating and harming soft tissues. Oral and maxillofacial surgeons generally appreciate its accuracy in surgery and its atraumatic tissue manipulation [7].

This study was conducted to evaluate the efficiency of a novel surgical template for surgical removal of DPIMC.

MATERIALS AND METHODS

Informed Consent

The clinical part of the study was performed after acquiring the ethical clearance from the Research Ethics Committee, Faculty of Dentistry, Alexandria University (ethical approval number: 0478 – 8/2022) . Informed written consent was obtained from all patients before the operation.

Patient Selection

Twenty patients with DPIMC referred from the Outpatient Clinic of Oral and Maxillofacial Surgery Department and Orthodontic Department, Faculty of Dentistry, Alexandria University indicated for extraction were equally and randomly allocated into 2 groups; a novel surgical template was used in extraction of the DPIMC (Study group) versus free hand technique (Control group).

Inclusion criteria

Patients with DPIMC referred from Orthodontic Department, Faculty of Dentistry, Alexandria University indicated for extraction; after being subjected to CBCT interpretation, patients who reject orthodontic treatment, patients from 16-35 years old with no gender predilection that agrees to present for follow-up visits for a minimum postoperative period of 6 months and patients who are willing and able to comply with the study protocol. The exclusion criteria were; medically compromised patients contradicting the operation (bone diseases and bleeding disorders), heavy smoker patients and patients in which the impacted canine can be orthodontically extruded.

Materials

The materials used in this procedure were; surgical template (NextDent SG, NextDent, Soesterberg, Netherlands), piezotome device using the bone saw slim tip (BS1S) and SL2 tip (Acteon, Satelec, France), xenogenic bone graft (OneXeno Graft, OneGraft, Germany) and collagen membrane (Hypro Sorb Collagen Membrane, Bioimplon GmbH, Friedrich-List-Str. 27, 35398 Giessen, Germany).

Patient Evaluation

Pre-surgical clinical examination was conducted for all patients: Patients data were collected; name, gender and age as well as medical and dental history. The palatal mucosa was also examined for assessment of the site of surgical template adaptation. Also, preoperative evaluation for all patients included CBCT (Vatech, Seoul, Korea, at 12 mA, 94 KV) to determine the exact position of the impacted canine and for virtual treatment planning (Figure 1).

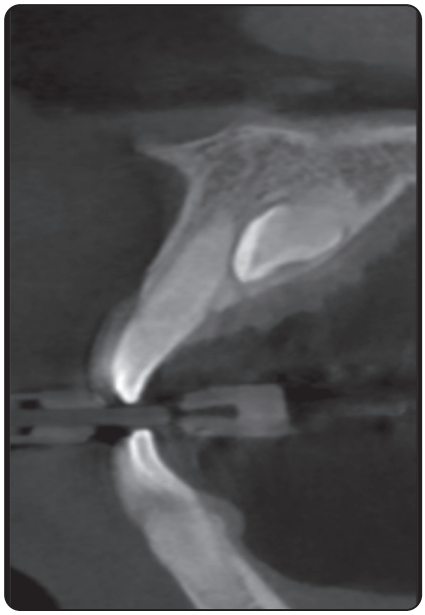

Fig. (1) Preoperative CBCT (Sagittal view)

Fabrication of the surgical template

Cone-beam computed tomography scans (Vatech, Seoul, Korea, at 12 mA, 94 KV) were performed and obtained in Digital Imaging and Communications in Medicine (DICOM) format, then imported to OnDemand3D™ software (Cybermed Inc., Seoul, Korea) to obtain an axial, coronal and sagittal views. Scanning of the stone models was carried out using Ceramill map 400 (Amman Girrbach, Austria) after taking impression of both arches, then imported into the software [8].

The surgical template was designed in 2 parts: the osteotomy guide plate and installation groove. For stability, the installation groove's fixing portion matches with the teeth [8]. The projection image of the bone surface of DPIMC was used to determine the position and shape of the osteotomy guide plate (Figure 2). The resultant 3D virtual template was exported as STL (stereolithographic) file to a 3D printer (Elegoo Mars 3, Shenzhen, China) and the template was fabricated using a biocompatible resin (Figure 3). The surgical templates were checked on the models. This was done to ensure that the template fit properly and to check its stability before the surgeries were scheduled. After confirming the fit of the surgical templates, patients were scheduled for surgery.

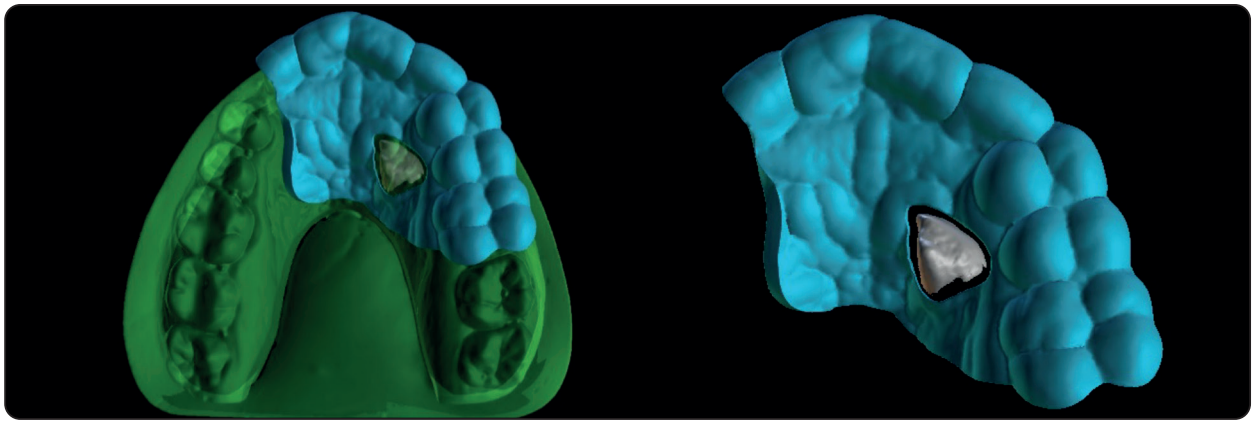

Fig. (2) Design of the Surgical Template

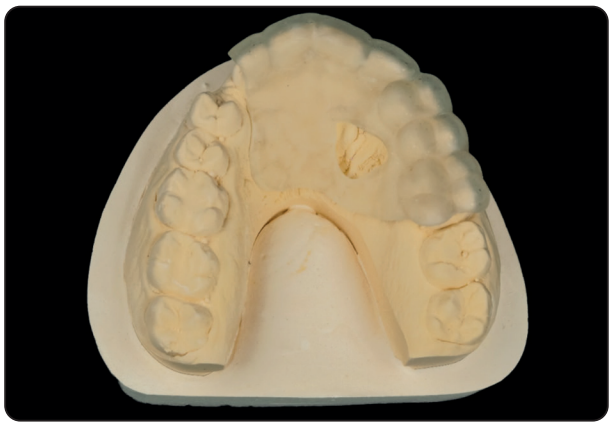

Fig. (3) Surgical Template.

Surgical Procedure

All patients were treated under local anesthesia using articaine hydrochloride 4% and adrenaline 1:100,000 (Septanest; Septodont, France). Incision was done in the gingival margin on the palatal side from the distal of the ipsilateral second premolar and is extended up to the contralateral lateral incisor or premolar. Elevation of a full thickness mucoperiosteal flap was achieved using a periosteal elevator.

In the "Study group", the fixing portion of the installation groove was embedded into teeth's occlusal surfaces for stability (Figure 4A, 4B). The osteotomy guide plate's internal edge served as a guide for the bone removal route. Bone was removed with piezotome device using BS1S tip within the boundaries of the osteotomy plate and the bone shell was removed at once to expose the crown

of the DPIMC. An elevator was used to luxate and elevate the tooth (Figure 4C, 4D, 4E). Sectioning of the tooth was carried out whenever necessary using a straight fissure bur (Figure 4F). In the "Control group", bone was removed with piezotome device using SL2 tip above the expected canine site (Figure 5A, 5B). Elevation of the tooth was carried out and tooth sectioning was done if required (Figure 5C).

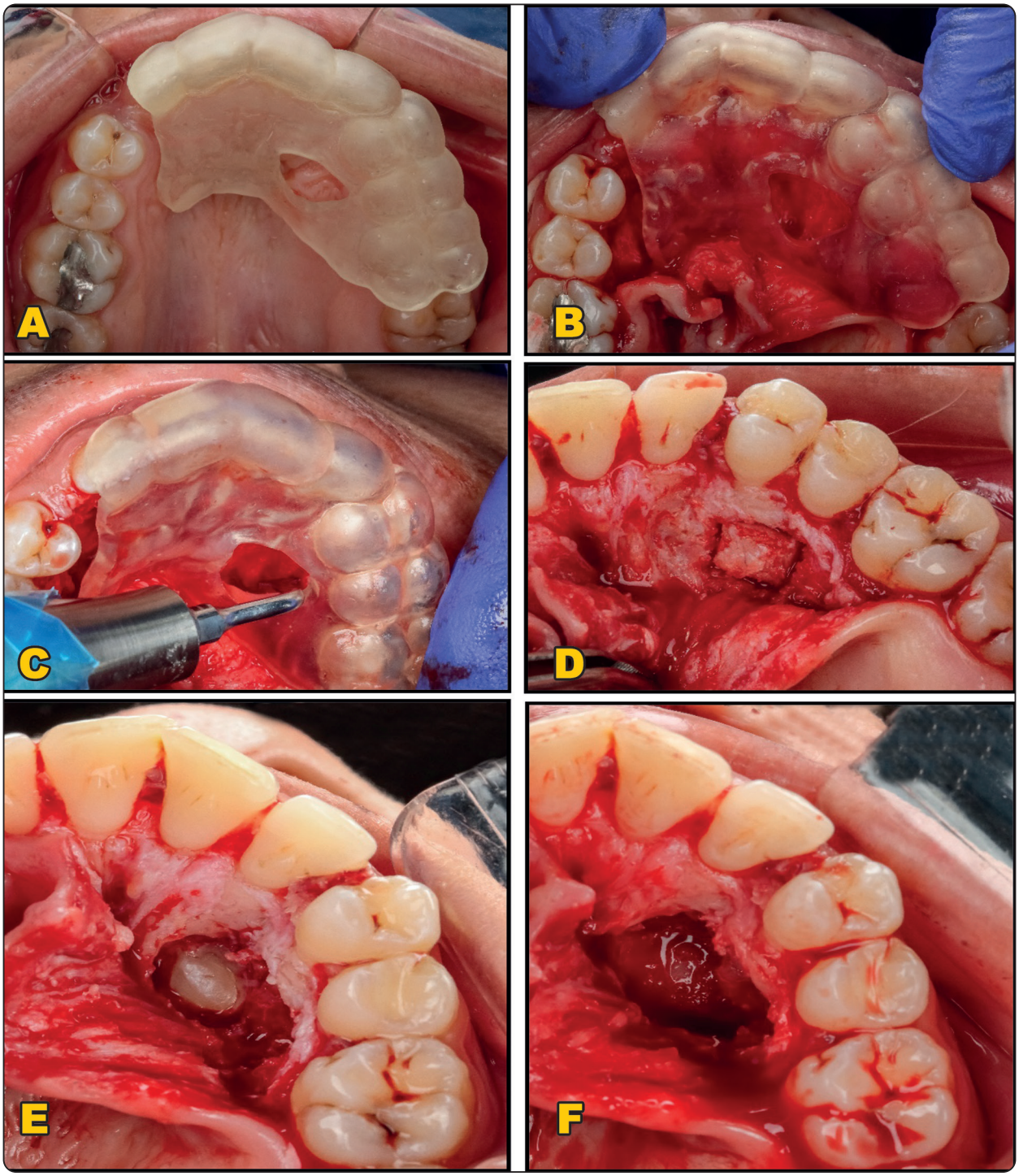

Fig. (4) Intraoperative – Study group (A. Surgical template trial before flap elevation. B. surgical template adaptation after flap elevation. C. bone cutting using BS1S tip. D. well defined boundaries of the bone shell. E. exposing the deeply palatally impacted maxillary canine (DPIMC). F. tooth extracted).

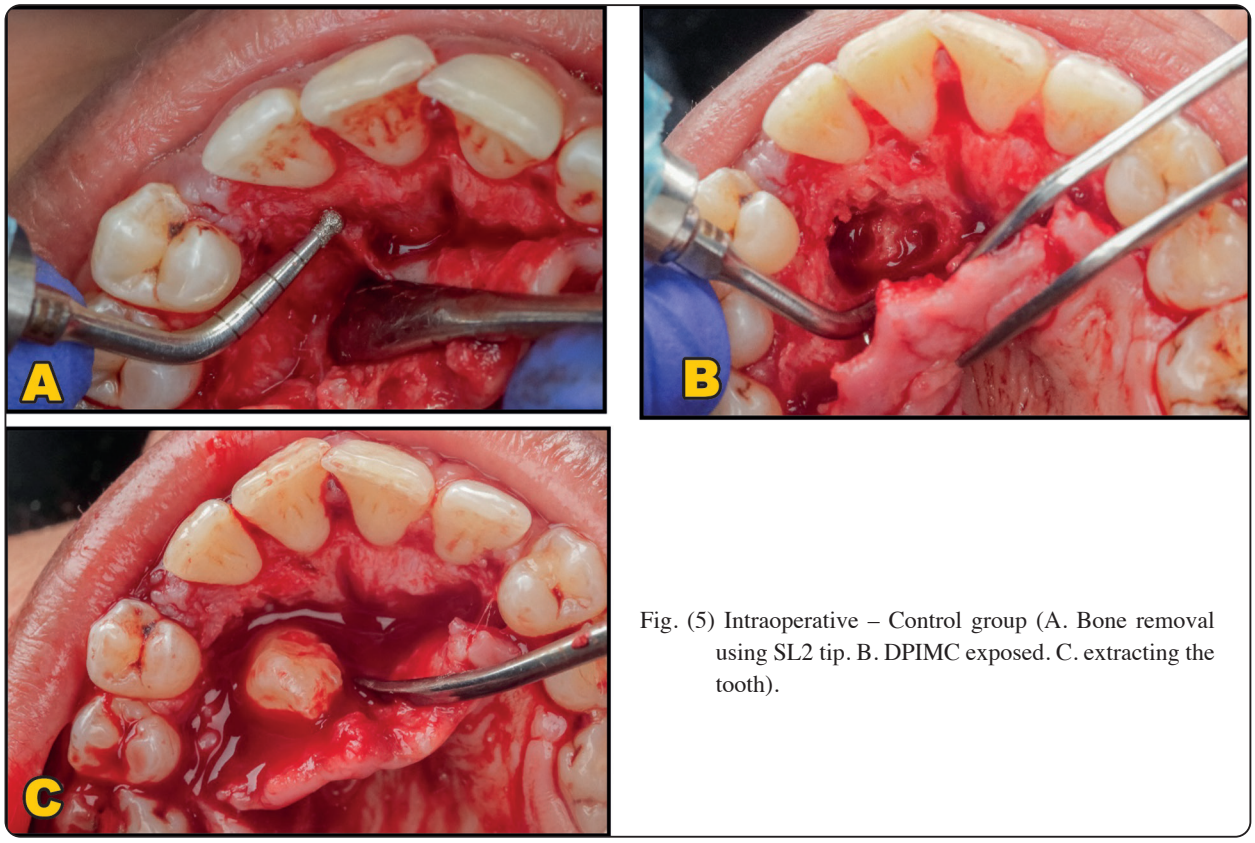

Fig. (5) Intraoperative – Control group (A. Bone removal using SL2 tip. B. DPIMC exposed. C. extracting the tooth).

In both groups, the surgical site was curetted and irrigated with warm sterile saline. The defect was lightly packed with xenograft (Figure 6). A collagen membrane was placed to completely cover the surgical site filled with xenograft (Figure 7). Flap was repositioned and closed using 3/0 silk sutures (Figure 8).

Postoperatively, patients were prescribed antibiotics, anti-inflammatory drugs and analgesics and was advised to gargle with mouthwash the next day.

Parameters assessed

- Operation time in minutes from start of the incision to the last suture (9).

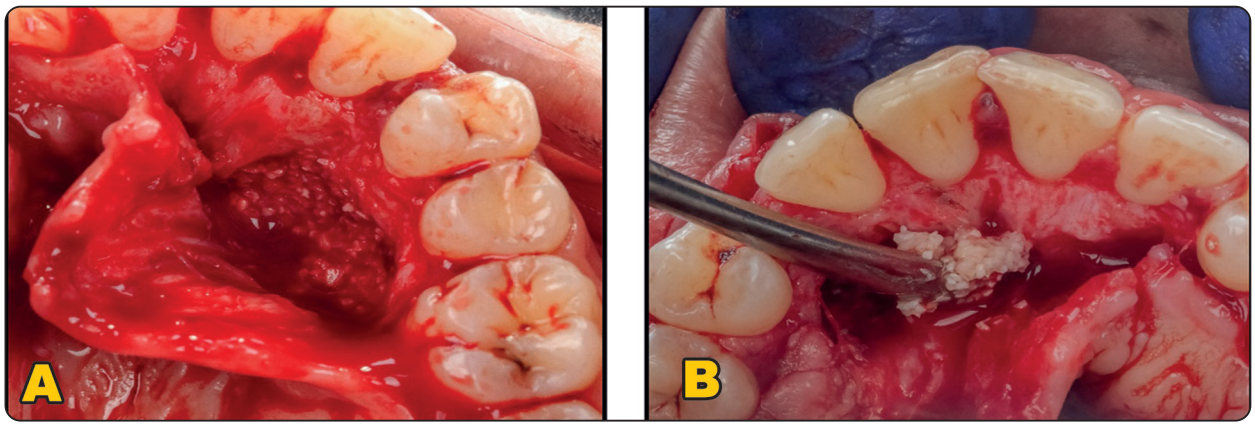

Fig. (6) Application of the grafting material (A. Study Group. B. Control group).

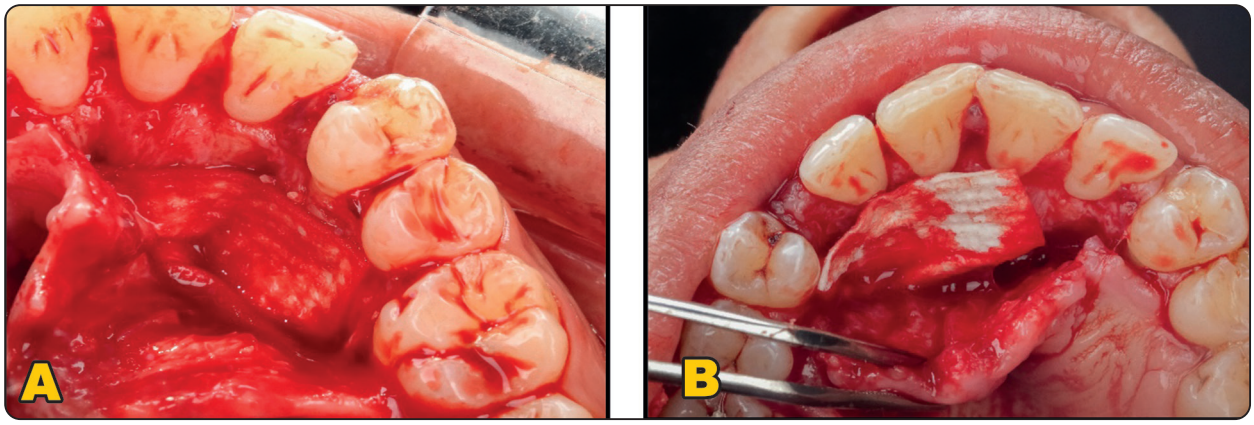

Fig. (7) Application of the collagen membrane (A. Study Group. B. Control group).

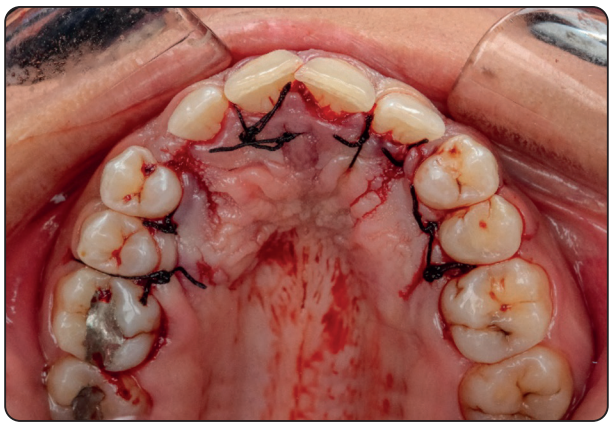

Fig. (8) Suturing (Study Group).

- Postoperative pain level using a 10-point Visual Analogue Scale (VAS) after 24 hours, 48 hours and 1 week, where zero indicates no pain and 10 indicates the maximum pain level (10).
- Bone density: A CBCT was obtained immediately and after six months postoperatively. Measurement of bone density was done using OnDemand3D™ software. The software displayed the mean, minimum and maximum bone density readings. Bone density was measured in Hounsfield unit (HU) which represents a scale of radiodensity [11].

Statistical Analysis

Data were collected and entered into the computer using the SPSS (Statistical Package for Social Science) program for statistical analysis (ver 25). Continuous variables proved to be normally distributed by Shapiro–Wilk test. So, parametric statistics was adopted. Data were described using minimum, maximum, mean, standard deviation, standard error of the mean, 95% CI of the mean and 25th to 75th percentile. Categorical variables were described using frequency and percentage. Comparisons were carried out between two studied independent normally distributed subgroups using independent sample t test. Comparisons were carried out between two studied dependent normally distributed subgroups using paired-samples t test.

Pearsons Chi-square test was used to test association between qualitative variables. Fisher's Exact test and Monte Carlo corrections were carried out when indicated (n x m table or any expected cells less than 5). Kendall's W (also known as Kendall's coefficient of concordance) was used. Pairwise comparison was carried out using Dunn-Sidak method. p value was adjusted using Bonferroni correction method.

During sample size calculation, beta error accepted up to 20% with a power of study of 80%. An alpha level was set to 5% with a significance level of 95%. Statistical significance was tested at p value <.05.

RESULTS

This study included 20 patients with deeply palatally impacted maxillary canines (DPIMC). Patients were referred from the Outpatient Clinic of Oral and Maxillofacial Surgery Department and Orthodontic Department, Faculty of Dentistry, Alexandria University. Patients were randomly divided between study group (10 cases) and control group (10 cases). In the Study Group (n=10): males were 3/10 (30.00%) while females were 7/10 (70.00%), the age ranged from 18.00 to 28.00 years, with a mean±SD. of 22.80±3.08 years, 95% Confidence interval (CI) of the mean 20.59-25.01, and 25th Percentile –75th Percentile of 21.00-25.00 years. In the Control group (n=10): males were 40/10 (40.00%) while females were 6/10 (60.00%), the age ranged from 18.00 to 29.00 years, with a mean±SD. of 22.40±3.98 years, 95% CI of the mean 19.55-25.25, and 25th Percentile –75th Percentile of 20.00-24.00 years.

Operation time

Study Group (n=10)**:** the operation time ranged from 41.00 to 52.00 min, with a mean±SD. of 46.00±3.33 min, 95% CI of the mean 43.62-48.38, and 25th Percentile –75th Percentile of 44.00-48.00 min.

Control group (n=10): the operation time ranged from 53.00 to 64.00 min, with a mean±SD. of 57.70±3.50 min, 95% CI of the mean 55.20-60.20, and 25th Percentile –75th Percentile of 55.00-60.00 min.

The Study Group had a statistically significant shorter operation time compared with the Control Group (p<.001) (Figure 9).

Pain

After 24 hours:

In the Study Group (n=10): the VAS was mild in 2/10 (20.00%), moderate VAS grade in 8/10 (80.00%) and none of the patients had severe VAS grade. In the Control group (n=10): none of the patients had mild VAS grade, while 8/10 (80.00%) had moderate VAS grade and 2/10 (20.00%) had severe VAS grade. There was no statistically significant difference in VAS grade between the two studied age groups after 24 hours (p=.234).

After 48 hours:

In the Study Group (n=10): the VAS was mild in 9/10 (90.00%) and moderate VAS grade in 1/10 (10.00%). In the Control group (n=10): the VAS grade was mild in 5/10 (50.00%) while was moderate in 5/10 (50.00%). There was no statistically significant difference in VAS grade between the two studied age groups after 48 hours (p=.070).

After one week:

In the Study Group (n=10): 6/10 (60.00%) had no pain while 4/10 (40.00%) had mild VAS Grade. In the Control group (n=10): 2/10 (20.00%) had no pain while 8/10 had mild VAS grade. There was no statistically significant difference in VAS grade between the two studied age groups after one week (p=.170).

Pairwise comparison revealed that there was a statistically significant decrease in VAS grade after one week compared with 24 hours after operation in the Study and Control groups. (p<.001 and p<.001 respectively) (Table 1).

Bone Density

Immediately after the operation:

In the Study Group (n=10) : The bone density ranged from 408.00 to 543.00 HU, with a mean±SD. of 485.60±48.35 HU, 95% CI of the mean 451.01-520.19, and 25th Percentile –75th Percentile of 448.00-530.00 HU.

In the Control group (n=10): The bone density ranged from 364.00 to 477.00 HU, with a mean±SD. of 420.80±33.78 HU, 95% CI of the mean 396.63-444.97, and 25th Percentile –75th Percentile of 402.00-443.00 HU.

The bone density was statistically significantly higher in the Study Group compared with the Control Group immediately after operation (p=.003).

After six months:

In the Study Group (n=10) : The bone density ranged from 576.00 to 767.00HU, with a mean±SD. of 699.50±68.24 HU, 95% CI of the mean 650.69-748.31, and 25th Percentile –75th Percentile of 640.00-760.00 HU.

In the Control group (n=10): The bone density ranged from 520.00 to 681.00 HU, with a mean±SD. of 611.00±57.30 HU, 95% CI of the mean 570.01-651.99, and 25th Percentile –75th Percentile of 574.00-669.00 HU.

The bone density was statistically significantly higher in the Study Group compared with the Control Group after six months (p=.006).

Intergroup analysis revealed that bone density was statistically significantly higher after six months compared with immediately after operation in the Study Group and the Control Group (p<.001 and p<.001, respectively).

Percentage change:

In the Study Group (n=10) : The bone density percentage change ranged from 41.13 to 53.71%, with a mean±SD. of 44.11±4.03%, 95% CI of the mean 41.23-47.00, and 25th Percentile –75th Percentile of 41.25-46.96%.

In the Control group (n=10): The bone density percentage change ranged from 40.90 to 54.52%, with a mean±SD. of 45.11±5.03%, 95% CI of the mean 41.52-48.71, and 25th Percentile –75th Percentile of 42.65-47.03%.

There was no statistically significant difference in bone density percentage change between the two studied groups (p=.630) (Figure 10).

TABLE (1) Comparison of the VAS grade in the two studied groups.

VAS grade after 24 hours	Group		Test of significance *p* value
	Study Group (n=10)	Control Group (n=20)	
After 24 hours			
Mild (1-3) discomfort (n=2) (10.00%)			
- n	2	0	
- % within VAS grade after 24 hours	100.00%	0.00%	
- % within Group	20.00%	0.00%	
Moderate (4-6) pain (n=16) (80.00%)			$X^2_{(MC)(df=2)}$=4.00
- n	8	8	p=.234 NS
- % within VAS grade after 24 hours	50.00%	50.00%	
- % within Group	80.00%	80.00%	
Severe (6-10) pain (n=2) (10.00%)			
- n	0	2	
- % within VAS grade after 24 hours	0.00%	100.00%	
- % within Group	0.00%	20.00%	
After 48 hours			
Mild (1-3) mild discomfort (n=14) (70.00%)			
- n	9	5	
- % within VAS grade after 48 hours	64.29%	35.71%	$X^2_{(FE)(df=1)}$=3.810
- % within Group	90.00%	50.00%	p=.070 NS
Moderate (4-6) pain (n=16) (80.00%)			
- n	1	5	
- % within VAS grade after 48 hours	16.67%	83.33%	
- % within Group	10.00%	50.00%	

VAS grade after 24 hours	Group		Test of significance *p* value
	Study Group (n=10)	Control Group (n=20)	
After one week			
No pain (0) (n=8) (40.00%)			
- n	6	2	
- % within VAS grade one week	75.00%	25.00%	$X^2_{(FE)(df=1)}$=3.333
- % within Group	60.00%	20.00%	*p*=.170 NS
Mild (1-3) discomfort (n=12) (60.00%)			
- n	4	8	
- % within VAS grade after one week	33.33%	66.67%	
- % within Group	40.00%	80.00%	

n: ***number of patients*** **MC:** ***Monte Carlo*** **X^2:** ***Pearson Chi-Square***
df: ***degree of freedom*** **t:** ***Independent Samples Test*** **NS:** ***Statistically not significant (p≥.05)***

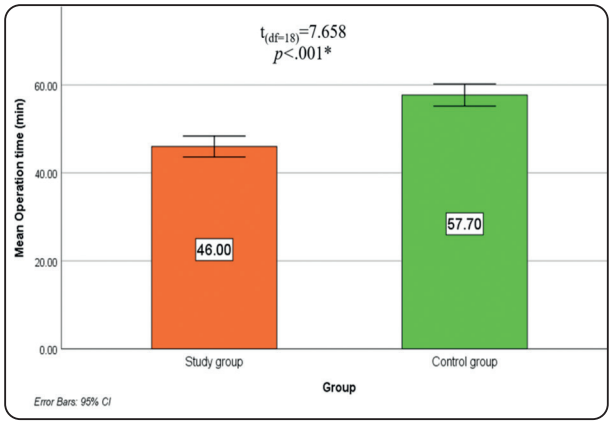

Fig. (9) Simple Bar of Mean of operation time (min) (± 95% CI) by Groups.

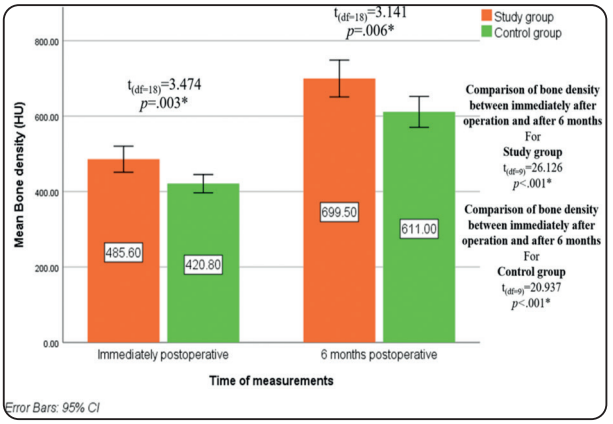

Fig. (10) Clustered Bar Chart of Bone density (HU) (± 95% CI) in the Studied Groups.

DISCUSSION

A unique surgical template for extraction OF DPIMC was used in the current study. This study shows that the new surgical template successfully exposes the DPIMC, facilitating quick extraction following template removal. Prior research has emphasized the importance of accurately locating deeply impacted supernumerary teeth (DIMSNT) during surgery. Studies have highlighted the benefits of using an osteotomy guide plate for DIMSNT extraction; however, these guides typically only indicate the region of DIMSNT without providing navigation[12]. To overcome these limitations, Retana et al. designed a dynamic navigation system to improve the exposure of the DIMSNT[13].

Navigation systems have limited clinical application prospects, despite enabling precise bone removal. According to the current study, we enhanced the osteotomy guide plate to better shape the tooth. During the operation, bone removal is done within the edges of the osteotomy plate. This precise positioning enables the immediate exposure and extraction of the DPIMC.

Lui et al. (2022) [8], assessed the effectiveness and safety of a new surgical template for extracting DIMSNT in the anterior maxilla. The study included 40 patients with DIMSNT divided into two groups of 20 patients each for extraction. In group I, a surgical template was used, selected based on CBCT and model scans. In comparison, group II underwent surgeries by freehand technique using only CBCT data.

Hu et al. (2017) [14], aimed to present a new technique for mesiodens extraction by piezosurgery and to compare the differences between a computer-aided design surgical guide template and free-hand operation. The study included eight patients with mesiodens, divided into two equal groups: a template group and a freehand group. The mean age of the total group was 19.13 years (range 14-28) and males were 75% of the all studied population.

In the current study, the mean age of the Study Group was 22.80±3.08 years and males represented 42.9%, while in in the Control group, the mean age was 22.40±3.98 years and males were 57.1%, There was no statistically significant difference in age and sex distribution between the two studied age groups (p=.804 and p=1.000, respectively).

Similarly, in Lui et al. (2022) [8], study, the mean age of the Template Group was 9.40±3.85 years and males represented 55%, while in in the Freehand Group, the mean age was 9.52±4.35 years and males were 60%, There was no statistically significant difference in age and sex distribution between the two studied age groups (p=.970 and p=0.756, respectively).

Additionally, the effects of the new surgical template with the conventional method was compared. According to this study, surgical guides can remarkably reduce operative time and postoperative complications. The precise exposure of the DPIMC could be the possible explanation for this.

In the Study Group, the operation time ranged from 41.00 to 52.00 min, with a mean±SD. of 46.00±3.33 min, while in the Control group it ranged from 53.00 to 64.00 min, with a mean±SD. of 57.70±3.50 min. The Study Group had a statistically significant shorter operation time compared with the Control Group (p<.001).

Aligning with our findings, Lui et al. (2022) (8), demonstrated that the operation mean time was 23.35±5.39 min and in the Freehand Group was 29.60±9.76 min. The Template Group had significantly shorter operation time than the Freehand Group (p=.0194).

In this study, the efficacy of canine extraction with presurgical CAD planning, comparing cases with and without the use of a surgical guide template was assessed. The findings demonstrated satisfactory clinical outcomes in both groups. Employing a surgical template led to a significant reduction in operative time. This improvement can be attributed to the template's ability to ensure accurate osteotomy and adequate exposure of the canine. In contrast, free-hand technique may require many osteotomies or tooth sectioning due to imprecise positioning. Thus, using a surgical template offers a more streamlined and efficient approach to canine extraction.

There are numerous benefits to using a surgical guide template. Firstly, the use of a surgical template significantly improves efficiency. It streamlines surgical steps, aids in reducing complications, and minimizes unnecessary osteotomy, ultimately leading to shorter operative times. While the time saved may seem minimal for experienced surgeons, it can be considerably more significant for younger and less experienced surgeons, potentially enhancing their learning curve.

Secondly, it enhances safety by ensuring sufficient preoperative planning and reducing the risk of complications, particularly for less experienced surgeons. While no structural damage occurred in either group in our study, the application of a guide template can provide an added layer of safety.

Additional advantage is the minimal bone loss associated with using a surgical template. The use of a surgical template helps avoid the need for extra osteotomy and preserve bone as much as possible.

However, it's important to note that using a surgical template may entail additional expenses and require specific equipment, which could limit its widespread adoption. Nonetheless, given its benefits, particularly for deeply embedded tooth extraction, the use of a surgical guide template remains highly valuable and justifiable.

Additionally, the use of surgical guide templates was associated with shorter operative times and minimized invasiveness compared to free-hand surgeries. This result aligns with Hu et al. (2017)[14], results which demonstrated that the operative time in the Template Group was significantly shorter than in Freehand Group (p=021).

Xu et al. (2024)[15], introduced a novel digital guide template utilizing an innovative flapless technique to investigate a minimally invasive approach for extracting deeply impacted palatal teeth. Forty patients diagnosed with completely impacted palatal teeth were randomly allocated equally into two groups: The experimental group utilized the new digital guide template for flapless extraction, whereas the control group employed the traditional freehand flap technique. The mean age of the template group (55% were males) was 11.20±2.46 years and that for the Freehand group (50% were males) was 11.70±2.18 years with no statistically significant difference in age and sex between the two studied groups (p=.501 and p=.752, respectively).

Xu et al. (2024)[15], demonstrated that the mean surgical time in the template group was slightly shorter at (18.15±4.88 minutes) compared to the Freehand group at (22.00±7.71 minutes). No statistically significant difference was observed, potentially attributable to the predominance of Class III impacted teeth in the guide group. (p=.067).

Xu et al. (2024)[15], demonstrated that the average duration of postoperative pain in the template group was significantly shorter than that in the conventional group (p<.01).

In the present study, there was no statistically significant difference in VAS grade between the two studied age groups after 24 hours, 48 hours and after one week (p=.234, p=.070 and p=.170 respectively). However, there was a statistically significant decrease in VAS grade after one week compared with 24 hours after operation in the Study and Controls groups (p<.001 and p<.001 respectively).

In contrast to our results, Lui et al. (2022)[8], demonstrated that the pain levels in the Template Group were significantly lower than in the Freehand Group on the 1st, 3rd, and 7th postoperative days. This difference in results may be attributed to performance of the surgical procedure under general anesthesia due to the complexities of the oral environment and varying levels of patient cooperation while in our study the procedure was performed under local anesthesia.

Nonetheless, there is potential for broader application under local anesthesia. Patients, upon diagnosis, can effectively communicate, undergo CBCT scanning, give oral impressions when needed, and await the manufacture of the surgical guide before revisiting the clinic for surgery. Utilizing the surgical template, it can effectively shorten operation times, decrease surgical trauma, alleviate patient anxieties regarding tooth extraction processes, and enhance doctor-patient relationships.

In oral surgery, there are still certain limitations on the use of surgical guide plates. It is imperative to trial the template on the patients before surgery because preoperative analysis data may differ from the actual surgical environment.

In Lui et al. (2022)[8] study, one case had the surgical guide plate fractured throughout the procedure. This unexpected finding suggests that the surgical guide's material may not have been strong enough to withstand the pressure exerted during the procedure.

In the present study, piezosurgery was employed to to peel the bone above the expected canine site. This approach was chosen for its minimally invasive nature and safety, and reducing bone loss. Accurate localization of canine teeth and understanding their relationship with surrounding structures is essential for successful surgical interventions. Traditional 2-dimensional radiographs offer only a general view of impacted teeth, often lacking precise details due to superposition and size alterations. In contrast, spiral CT and CBCT enable 3D reconstructions, providing clear visualization of the intraosseous location, inclination, and morphology of impacted canine teeth, as well as their proximity to adjacent roots, teeth, and cortical bone. This aids in surgical planning by avoiding superposition of structures. For deeply impacted canines, comprehensive assessment of adjacent structures through preoperative 3D imaging examination is recommended to determine the optimal surgical approach [16-19].

However, CT or CBCT may not accurately reflect specific tooth features, especially occlusal surfaces, compared to plaster models. The teeth outlines on imaging scans can be unclear and often distorted. Therefore, combining data from laser scans of the teeth could enhance the precision of surgical guide templates, leading to precise positioning and outstanding intraoperative stability.

In the present study, bone density was statistically significantly higher in the Study Group compared with the Control Group immediately and after six months of the operation (p=.003 and p=.006 respectively. Intergroup analysis revealed that bone density was statistically significantly higher after six months compared with immediately after operation in the Study Group compared and the Control Group (p<.001 and p<.001, respectively). However, there was no statistically significant difference in bone density percentage change between the two studied groups (p=.630).

Arakji et al. (2016)[20], evaluated the effect of using piezosurgery compared to traditional surgical methods in the extraction of impacted mandibular third molars, assessing postoperative complications and bone regeneration. On radiographic assessment, significant statistical differences were observed between the two areas, with the piezosurgery site demonstrating enhanced bone quality (p≤.0001) immediately, three months and 6 months postoperative.

Vercelotti et al. (2005)[21], compared piezosurgery with carbide burs in ostectomy, demonstrating superior bone healing in both quantity and quality with piezosurgery in surgeries.

Additionally, Rullo et al. (2013)[22], conducted an analysis of bone histology, noting distinct histological disparities between bone collected with bur and ultrasonic devices. They observed greater structural integrity, well-defined osteotomy lines, and no evidence of bone heat osteonecrosis in bone harvested with the piezoelectric device.

Apart from cost and the risk of surgical tip breakage, the primary drawback of piezosurgery observed thus far is the extended operating time due to its slow cutting rate [20]. However, in this study, using piezosurgery with the template led to shorter time of operation.

Keyhan (2019) [23], examine the postoperative complications following impacted third molar surgeries involving bone removal, utilizing laser, piezoelectric equipment, and conventional rotary instruments. They observed that on the day of piezosurgery, there was a decrease in postoperative pain, trismus, and swelling. This reduction in discomfort may potentially contribute to increased bone density within the extraction cavity and mitigate bone loss around adjacent teeth in the distal area, mirroring the findings of the current study.

CONCLUSION

In conclusion, utilizing a digital surgical template for extracting deeply impacted teeth can significantly reduce the time needed for extraction, minimize intraoperative bleeding and surgical trauma, and provide protection for surrounding anatomical structures. This approach lowers surgical risks and leads to high patient satisfaction postoperatively.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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REFERENCES

1. Rossini, G., Cavallini, C., Cassetta, M., Galluccio, G., and Barbato. E. (2012): Localization of impacted maxillary canines using cone beam computed tomography. Review of the literature. Ann. Stomatol., 3(1):14-18.
2. Husain, J., Burden, D., McSherry, P., Morris, D. A., and Allen, M. (2012): National clinical guidelines for management of the palatally ectopic maxillary canine. Br. Dent. J., 213(4):171-176.
3. Grybienė, V., Juozėnaitė, D., and Kubiliūtė, K. (2019): Diagnostic methods and treatment strategies of impacted maxillary canines: A literature review. Stomatologija., 21(1), 3-12.
4. Stabryła, J., Plakwicz, P., Kukuła, K., Zadurska, M., and Czochrowska, E. M. (2021): Comparisons of different treatment methods and their outcomes for impacted maxillary and mandibular canines: A retrospective study. J. Am. Dent. Assoc., 152 (11):919-926.
5. Lee, J. W., Choi, B. J., Nam, O. H., and Kwon, Y. D. (2016): Minimal invasive treatment using patient-specific template for mandibular fractures in children:" Wing-splint" by CAD/CAM technology. Br. J. Oral. Maxillofac. Surg., 54(10):1140-1141.
6. Seruya, M., Borsuk, D. E., Khalifian, S., Carson, B. S., Dalesio, N. M., and Dorafshar, A. H. (2013): Computer-aided design and manufacturing in craniosynostosis surgery. J. Craniofac. Surg., 24(4): 1100-1105.
7. Sukegawa, S., Kanno, T., Kawakami, K., Shibata, A., Takahashi, Y., and Furuki, Y. (2015): Use of a piezosurgery technique to remove a deeply impacted supernumerary tooth in the anterior maxilla. Case. Rep. Dent., 2015:1-4.
8. Liu, J., Wang, X., Shan, P., Hu, S., Liu, D., Ma, J., and Nie, X. (2022): A randomized controlled trial: evaluation of efficiency and safety of a novel surgical guide in the extraction of deeply impacted supernumerary teeth in the anterior maxilla. Ann. Transl. Med., 10(6):292.
9. Bello, S. A., Adeyemo, W. L., Bamgbose, B. O., Obi, E. V., and Adeyinka, A. A. (2011): Effect of age, impaction types and operative time on inflammatory tissue reactions following lower third molar surgery. Head. Face. Med., 7:1-8.
10. Noureldin, M. G., and Melek, L. N. (2020): Clinical and radiographic outcomes of radicular cyst enucleation using piezosurgery versus conventional surgery. Egypt. Dent. J., 66:943-950.
11. Ibrahim, A. M., Khalil, M. M., and El Halawani, G. N. (2022): Evaluation Of Anterior Maxillary Horizontal Ridge Augmentation With Simultanous Implant Placement Using Cerabone® Versus Cerabone® Combined With Platelet Rich Plasma (Randomized Clinical Trial). Alex. Dent. J. 47(1):1-8.
12. Liu, M., Yang, X., Lv, K., and Li, Z. (2019): Minimally-Invasive Alternative to the Extraction of Deeply-Impacted Supernumerary Teeth Using a Computer-Designed Surgical Template. **Br. J. Oral. Maxillofac. Surg**., 57(3):285-287.
13. Retana, A., Emery, R. W., and Keir, V. (2019): Removal of Impacted Supernumerary Teeth Using a Dynamic Surgical Navigation System: A Case Report. J. Oral. Maxillofac. Surg., 77(6):1130-1134.
14. Hu, Y. K., Xie, Q. Y., Yang, C., and Xu, G. Z. (2017): Computer-designed surgical guide template compared with free-hand operation for mesiodens extraction in premaxilla using "trapdoor" method. Medicine., 96(26):e7310.
15. Xu, Q., Bai, X., Zhou, X., Chen, M., Li, Y., and Zhang, T. (2024): Feasibility Study of a Novel Digital Template-Guided Flapless Extraction for Maxillary Palatal Impacted Teeth. Clin. Oral. Investig., 28(6):1-8.
16. Kim, K. D., Ruprecht, A., Jeon, K. J., and Park, C. S. (2003): Personal Computer-Based Three-Dimensional Computed Tomographic Images of the Teeth for Evaluating Supernumerary or Ectopically Impacted Teeth. Angle. Orthod., 73(5):614-621.
17. Schulze, D., Heiland, M., Thurmann, H., and Adam, G. (2004): Radiation Exposure During Midfacial Imaging Using 4- and 16-Slice Computed Tomography, Cone Beam Computed Tomography Systems and Conventional Radiography. Dentomaxillofac. Radiol., 33(2):83-86.
18. Liu, D. G., Zhang, W. L., Zhang, Z. Y., Wu, Y. T., and Ma, X. C. (2007): Three-Dimensional Evaluations of Supernumerary Teeth Using Cone-Beam Computed Tomography for 487 Cases. Oral. Surg. Oral. Med. Oral. Pathol. Oral. Radiol. Endod., 103(3):403-411.

19. Nakajima, A., Sameshima, G. T., Arai, Y., Homme, Y., Shimizu, N., and Dougherty, H., Sr (2005): Two- and Three-Dimensional Orthodontic Imaging Using Limited Cone Beam-Computed Tomography. Angle. Orthod., 75(6):895-903.

20. Arakji, H., Shokry, M., and Aboelsaad, N. (2016): Comparison of Piezosurgery and Conventional Rotary Instruments for Removal of Impacted Mandibular Third Molars: A Randomized Controlled Clinical and Radiographic Trial. Int. J. Dent., 2016:8169356.

21. Vercellotti, T., Nevins, M. L., Kim, D. M., Nevins, M., Wada, K., Schenk, R. K., and Fiorellini, J. P. (2005): Osseous Response Following Resective Therapy with Piezosurgery. Int. J. Periodontics. Restorative. Dent., 25(6):543-549.

22. Rullo, R., Addabbo, F., Papaccio, G., D'Aquino, R., and Festa, V. M. (2013): Piezoelectric Device Vs. Conventional Rotative Instruments in Impacted Third Molar Surgery: Relationships between Surgical Difficulty and Postoperative Pain with Histological Evaluations. J. Craniomaxillofac. Surg., 41(2):e33-e38.

23. Keyhan, S. O., Fallahi, H. R., Cheshmi, B., Mokhtari, S., Zandian, D., and Yousefi, P. (2019): Use of Piezoelectric Surgery and Er: Yag Laser: Which One Is More Effective During Impacted Third Molar Surgery? Maxillofac. Plast. Reconstr. Surg., 41(1):1-10.