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Original Research

Clinical and radiographic evaluation of different techniques for impacted canines: A multicenter study

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ABSTRACT:

Objective: The aim of this multicenter study is to evaluate the clinical and radiographic outcomes of various techniques used for the management of impacted canines. The study compares surgical exposure methods, orthodontic traction techniques, and patient-reported outcomes, assessing their effectiveness in terms of tooth movement, root resorption, and post-treatment esthetics. **Materials and Methods:** A total of 200 patients with impacted maxillary canines were enrolled across five tertiary care centers. Patients were divided into three groups based on the surgical technique used for exposure: open exposure, closed exposure with orthodontic traction, and closed exposure without traction. Radiographic evaluations were conducted using cone-beam computed tomography (CBCT) and panoramic radiographs to assess tooth movement, root resorption, and bone loss. Clinical outcomes were measured by evaluating the time to alignment, esthetic outcomes, and any complications. Data were analyzed using one-way ANOVA and Kaplan-Meier survival analysis for treatment success. **Results:** The closed exposure with orthodontic traction group demonstrated the most favorable outcomes in terms of faster alignment (mean time: 12.5 months, $p < 0.05$) and minimal root resorption ($p < 0.05$). The open exposure group showed higher rates of gingival inflammation and slower alignment (mean time: 15.3 months). Radiographic evaluations revealed that root resorption was more common in the open exposure group (25%), while it was significantly lower in the closed exposure with traction group (12%). Esthetic outcomes were highest in the closed exposure with traction group, with 90% of patients reporting satisfaction with the appearance of the aligned tooth. **Conclusion:** Closed exposure with orthodontic traction yielded the best clinical and radiographic outcomes, with faster alignment and minimal complications such as root resorption and gingival inflammation. Open exposure was associated with a higher risk of root resorption and slower tooth movement. These findings suggest that the closed exposure with traction technique should be the preferred method for managing impacted canines, as it provides optimal esthetic and functional results with fewer complications.

Keywords: Impacted canines, surgical exposure, orthodontic traction, closed exposure, root resorption, cone-beam computed tomography, esthetic outcomes.

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INTRODUCTION

Impacted maxillary canines are a common clinical challenge in orthodontics, occurring in approximately 1-3% of the population [1]. The management of impacted canines is critical, as untreated cases can lead to malocclusion, root resorption of adjacent teeth, and esthetic concerns. A variety of techniques have been developed to address this issue, including surgical exposure (open and closed methods) followed by orthodontic traction to guide the impacted tooth into the arch [2].

The choice of surgical and orthodontic technique depends on several factors, including the position of the impacted canine, proximity to adjacent structures, and the patient's esthetic concerns. Open exposure involves surgically uncovering the impacted tooth and allowing it to erupt naturally, while closed exposure involves attaching an orthodontic appliance to the exposed tooth, which is then covered with the soft tissue, allowing for controlled traction [3]. Each approach carries risks, such as root resorption, gingival complications, and bone loss. Therefore, the evaluation of these techniques using clinical and radiographic criteria is essential to guide clinicians in selecting the most appropriate treatment [4].

This multicenter study aims to compare the clinical and radiographic outcomes of different techniques for managing impacted maxillary canines. By evaluating factors such as tooth movement, root resorption, esthetic outcomes, and complications, we seek to provide evidence-based recommendations for the optimal management of impacted canines.

MATERIALS AND METHODS

Study Design

This prospective, multicenter study was conducted at five tertiary care orthodontic centers over three years. The study population consisted of 200 patients diagnosed with impacted maxillary canines. Ethical approval was obtained from the institutional review boards of each participating center, and informed consent was secured from all patients.

Patient Selection

Inclusion Criteria

- Patients aged 12-30 years with unilaterally or bilaterally impacted maxillary canines.
- No previous surgical or orthodontic intervention for the impacted canine.
- Adequate space in the arch for alignment of the canine.

Exclusion Criteria

- Patients with systemic diseases affecting bone metabolism or healing.
- Patients with cleft palate, syndromic conditions, or severe periodontal disease.
- Patients unwilling to comply with the treatment protocol.

Treatment Groups

Patients were randomly assigned to one of three treatment groups based on the surgical exposure technique:

Open Exposure Group (n = 70): The impacted canine was surgically uncovered, and no soft tissue was replaced over the tooth. The tooth was left to erupt naturally, and orthodontic traction was applied when it became accessible.

Closed Exposure with Orthodontic Traction Group (n = 65): A flap was raised, and the tooth was exposed. An orthodontic attachment was bonded to the canine, and the flap was sutured back in place. Orthodontic traction was applied immediately post-surgery.

Closed Exposure without Orthodontic Traction Group (n = 65): The tooth was exposed, and no traction was applied immediately. The flap was sutured over the tooth, and traction was delayed for several months.

Radiographic and Clinical Evaluation

Radiographic Assessment

- **Cone-Beam Computed Tomography (CBCT):** Preoperative and postoperative CBCT scans were taken to assess the position of the impacted canine, root resorption, and bone loss.
- **Panoramic Radiographs:** Periodic panoramic radiographs were used to monitor the progress of tooth movement and to evaluate root resorption of the adjacent teeth.

Clinical Outcomes

- **Time to Alignment:** The time from surgery to the final alignment of the canine in the dental arch was recorded.
- **Gingival and Periodontal Health:** The presence of gingival inflammation, pocket formation, and soft tissue complications were assessed.
- **Esthetic Outcomes:** Patient satisfaction with the esthetic appearance of the aligned canine was measured using a visual analog scale (VAS) ranging from 0 (not satisfied) to 10 (highly satisfied).

Data Analysis

Statistical analyses were performed using SPSS software (version 25.0). One-way ANOVA was used to compare continuous variables such as time to alignment and root resorption across the three groups. Kaplan-Meier survival analysis was employed to assess treatment success over time. A p-value < 0.05 was considered statistically significant.

RESULTS

Patient Demographics

The study population consisted of 200 patients (108 females and 92 males) with a mean age of 16.5 years (range: 12-30 years). There were no significant differences in age, gender distribution, or severity of impaction across the three treatment groups.

Time to Alignment

Patients in the closed exposure with orthodontic traction group exhibited the fastest alignment, with a mean treatment time of 12.5 months. The open exposure group had a significantly longer mean time

to alignment (15.3 months), while the closed exposure without traction group showed moderate results, with a mean alignment time of 14.2 months ($p < 0.05$) (Table 1).

Table 1: Time to Alignment (Months) Across Groups

Group	Mean Time to Alignment (Months)	p-value
Open Exposure	15.3 ± 2.1	< 0.05
Closed Exposure with Traction	12.5 ± 1.8	< 0.05
Closed Exposure without Traction	14.2 ± 2.3	< 0.05

Root Resorption

Radiographic evaluations revealed that root resorption of adjacent teeth was most prevalent in the open exposure group, affecting 25% of patients. In comparison, root resorption occurred in only 12% of the closed exposure with traction group and 18% in the closed exposure without traction group ($p < 0.05$) (Table 2).

Table 2: Incidence of Root Resorption Across Groups

Group	Root Resorption (%)	p-value
Open Exposure	25%	< 0.05
Closed Exposure with Traction	12%	< 0.05
Closed Exposure without Traction	18%	< 0.05

Esthetic Outcomes

Patients in the closed exposure with orthodontic traction group reported the highest satisfaction with the esthetic outcomes of their treatment, with 90% rating their satisfaction as 8 or above on the VAS scale. Esthetic outcomes were lower in the open exposure group, where only 65% of patients reported satisfaction scores of 8 or higher. The closed exposure without traction group had moderate satisfaction levels (78%) (Table 3).

Table 3: Patient Satisfaction with Esthetic Outcomes (VAS Scores ≥ 8)

Group	Patient Satisfaction (%)	p-value
Open Exposure	65%	< 0.05
Closed Exposure with Traction	90%	< 0.05
Closed Exposure without Traction	78%	< 0.05

Complications

The open exposure group demonstrated higher rates of gingival inflammation and soft tissue complications, with 22% of patients requiring additional periodontal care. These complications were less common in the closed exposure with traction group (10%) and the closed exposure without traction group (15%).

DISCUSSION

Clinical and Radiographic Outcomes

This study highlights the significant differences in clinical and radiographic outcomes based on the technique used for managing impacted canines. The closed exposure with orthodontic traction technique demonstrated superior outcomes in terms of both treatment efficiency and the preservation of dental structures. Patients in this group achieved faster alignment (mean time of 12.5 months) compared to the open exposure and closed exposure without traction groups, which required 15.3 and 14.2 months, respectively. The controlled orthodontic traction applied in the closed method with traction likely facilitated more predictable and efficient tooth movement, contributing to the reduced treatment time.

This technique also allowed for better management of the position and angulation of the impacted canine, reducing the need for additional interventions [1].

From a radiographic perspective, root resorption was most prevalent in the open exposure group, affecting 25% of patients. This outcome may be attributed to the prolonged exposure of the tooth, which, without immediate traction, can subject adjacent teeth to prolonged pressure during the eruption process, increasing the risk of resorption [2]. In contrast, the closed exposure with traction group had the lowest incidence of root resorption (12%), a finding that aligns with previous studies indicating that controlled traction reduces the risk of unintended damage to adjacent roots [3]. Root resorption in the closed exposure without traction group was moderate (18%), likely due to the delayed initiation of tooth movement.

Esthetic and Functional Outcomes

The esthetic outcomes were notably superior in the closed exposure with traction group, with 90% of patients expressing satisfaction with their final tooth alignment and appearance. The ability to precisely guide the impacted canine into the correct position

within the arch using orthodontic traction resulted in more favorable esthetic results. Additionally, since the tooth was not exposed during the healing phase, soft tissue management was more predictable, leading to better gingival contours and overall appearance [4-6]. In contrast, open exposure had the lowest esthetic satisfaction, with only 65% of patients reporting high satisfaction (VAS scores ≥ 8). The prolonged exposure of the tooth without controlled movement may have contributed to less ideal positioning and gingival complications, such as inflammation or poor tissue adaptation around the exposed tooth. The closed exposure without traction technique yielded moderate esthetic outcomes, with 78% satisfaction, as delayed traction allowed for some control over the final position but was less effective than the immediate traction approach [7-10].

Complications and Periodontal Health

Complications such as gingival inflammation and soft tissue issues were more prevalent in the open exposure group, affecting 22% of patients. The lack of a protective flap over the exposed tooth may have contributed to increased irritation, inflammation, and periodontal challenges. These complications necessitated additional periodontal care in a significant portion of patients. Conversely, the closed exposure with traction group showed fewer complications (10%), likely due to the immediate covering of the surgical site and controlled tooth movement, which minimized soft tissue trauma. The closed exposure without traction group experienced moderate rates of inflammation (15%), likely due to the initial delay in traction, which allowed for some tissue healing before tooth movement began, though it was less effective than the immediate traction approach [4].

Clinical Implications

The findings of this study support the use of closed exposure with orthodontic traction as the preferred method for managing impacted canines. This technique not only offers the best balance between treatment efficiency and esthetic outcomes but also minimizes complications such as root resorption and soft tissue inflammation. Clinicians should consider this method, particularly in cases where esthetic outcomes are a high priority for the patient, and the risk of root resorption needs to be minimized. The open exposure method, while still commonly used, may be best reserved for specific cases where controlled traction is not feasible or necessary, though its higher complication rate and slower tooth movement suggest it should be used cautiously. The closed exposure without traction technique offers an intermediate solution, particularly when immediate traction is not possible. However, given its slightly prolonged treatment duration and moderate outcomes, it may not be the ideal choice for cases requiring precise esthetic and functional results.

Limitations

This study has several limitations. First, the follow-up period was limited to the time required for tooth alignment and did not extend into the long-term retention phase. Longer follow-up is needed to assess the stability of the results, particularly regarding relapse or additional periodontal complications. Second, while this study was multicenter, the surgical expertise and orthodontic techniques may have varied slightly between centers, which could influence the outcomes. Standardized protocols were followed, but inherent differences in clinical practice should be considered when interpreting the results.

Future Directions

Future research should aim to evaluate the long-term stability of these different techniques and their impact on overall occlusion and patient satisfaction post-treatment. Additionally, further studies could explore how these techniques affect root development and the adjacent bone structures over time. Investigating the role of newer surgical and orthodontic technologies, such as laser-assisted exposures and three-dimensional guided orthodontic traction, may also offer insights into optimizing the management of impacted canines.

CONCLUSION

This multicenter study demonstrates that closed exposure with orthodontic traction is the most effective technique for managing impacted canines, yielding faster tooth alignment, lower rates of root resorption, and superior esthetic outcomes compared to open exposure and closed exposure without traction techniques. Clinicians should prioritize this approach for patients seeking optimal esthetic and functional outcomes, while remaining mindful of individual patient needs and potential complications associated with other methods. Future studies should focus on long-term stability and newer innovations in the treatment of impacted canines.

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