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The Impact of Surgery on Gingival Aesthetics of Permanent Maxillary Ectopic Canines

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Abstract

Background: There is a lack of knowledge of how surgical management of permanent maxillary ectopic canines (PMECs) may affect the gingival aesthetics of those teeth. ***Objective:*** To investigate whether PMEC gingival aesthetics are associated with a) surgery technique; and b) original tooth position. ***Methods:*** Clinical audit and outcome survey of University of Otago, Faculty of Dentistry clinical records for patients who had undergone maxillary canine exposure surgery from 2011-2021. Included cases were PMEC cases managed by an open or closed exposure surgery technique. Clinical records, radiographs, and any intraoral/extraoral photographs taken were evaluated. Photographs of the exposed and contralateral canines were assessed by an orthodontist, a periodontist and a prosthodontist using the Maxillary Canine Aesthetic Index (MCAI). ***Results:*** Out of a total size of 305 patients, 61 consented to participate and were screened, with 29 meeting the inclusion criteria. Of these 29, 22 had been managed via open surgery, and 7 via closed surgery. Evaluation of the 29 cases varied between the specialists, with the orthodontist consistently scoring participants higher on the MCAI scale (i.e., more aesthetically critical) than the other two examiners. MCAI scores managed by closed exposure exhibited significantly better gingival aesthetics than those managed by open exposure. MCAI scores did not differ significantly according to buccal/palatal (original) positioning of the canine. ***Conclusions:*** This study found gingival aesthetic outcomes for the closed exposure technique to be more favourable than the open exposure technique. Inter-examiner differences in gingival aesthetic scores highlighted variation in case evaluation among practitioners.

Introduction

Permanent maxillary ectopic canines (PMEC) refer to those displaced from their standard position in the dental arch (Jain & Debbarma, 2019). Consequences of failed or interrupted eruption can include loss of arch space, canine/adjacent tooth pathology and poor aesthetics (Beadnell, 2012). Following wisdom teeth, PMECs are the next most commonly impacted teeth (Beadnell, 2012), with an estimated prevalence of 5.2% of the population having PMECs that face difficulty reaching the occlusal plane (Jain & Debbarma, 2019). PMECs are more than twice as common among females (1.2%) than males (0.5%) and occur bilaterally in 8% of all cases (Ericson & Kurol, 1988).

Treatment for impacted PMECs generally corresponds to the time of detection and the initial position of the tooth. Depending on the position of the PMEC cuspal tip, extraction of the primary canine can result in self-correction of the impaction (Ericson & Kurol, 1988). In severely displaced PMECs, or those detected late in development, surgical intervention followed by orthodontic correction is usually required (Zuccati et al., 2006). Gingivectomy is usually not indicated for labiolingually deep impactions (Mohanty et al., 2015). It involves full-thickness excision of the gingiva overlying the canine to reveal from half to two-thirds of its crown. Apically repositioned flap is usually indicated for buccally placed PMECs that are labiolingually superficial. A pedicle flap is raised, revealing the impacted crown beneath (Mohanty et al., 2015). The apically repositioned flap is sutured into the surrounding periosteum (Vanarsdall & Corn, 2004). The closed technique involves the exposure of the PMEC crown, before attaching an orthodontic bracket and eruption chain before suturing the flap in its original position (Beadnell, 2012). The tooth remains buried, and the chain extrudes out of the soft tissue for orthodontic manipulation (Beadnell, 2012). Typically less bone and dental follicle removal are required (Becker et al., 2010).

The open technique follows a similar workflow to closed, except a window is created and left patent for the tooth to erupt (Beadnell, 2012). In most cases, an orthodontic bracket and eruption chain is attached to provide traction of the tooth (Beadnell, 2012).

Other factors can also determine which technique is used. These can include: the relationship between the apical position and the mucogingival junction; the amount of keratinised tissue available (Mohanty et al., 2015). The culmination of all above factors determine which surgical technique is used. For example, a buccally impacted canine could be approached with an apically repositioned flap or gingivectomy, given it has adequate keratinised tissue, and is below the mucogingival junction (Mohanty et al., 2015).

The ultimate goals of PMEC management should not only ensure the eruption of the canine into the correct position but warrant aesthetic and functional gingival contours on the palatal and particularly buccal aspects (Beadnell, 2012). A pleasing appearance of the gingival margin is a critical aesthetic outcome in orthodontic treatment. The published literature is scarce on assessing the gingiva or periodontal health at either (1) soft tissue recovery after surgical exposure or (2) after orthodontic traction and completion of treatment. Periodontal health (plaque, bleeding on probing, pocket depths) has been assessed

to measure success after surgery. However, despite being an important criterion for clinician and patient satisfaction, gingival margin aesthetic appraisals haven't been typically included in the outcome assessments of ectopic canine exposure surgery.

The present study was designed to evaluate the gingival margin aesthetics following surgically assisted orthodontic management of PMECs. Current research is limited and conflicting in this topic, so the findings would offer valuable insight into treatment outcomes and indicate pathways for patient care improvement.

Thus, this study investigated whether the gingival margin aesthetics at the treatment completion would be impacted by the initial position (buccal or palatal displacement) of the ectopic canine tooth and whether the orthodontic traction was facilitated by having a closed surgical exposure or an open surgical exposure.

Methods

Category A ethical approval was obtained from the University of Otago Human Ethics Committee (Number H22/004). A Māori consultation was completed in alignment with the university's policy on research. The research approach followed the steps below.

(1) Sample screening

Clinical records between were obtained via the electronic and paper file databases. The sampling frame comprised patients who received surgical exposure of unerupted tooth or surgical exposure and attachment of device for orthodontic traction at the University of Otago Faculty of Dentistry from 2011 to 2021. Initial screening of data identified in 305 patients who had received such a procedure, and this was then further screened using the inclusion and exclusion criteria below to establish the study sampling frame (n=178).

Inclusion criteria

Patients must have an email or phone number supplied in patient details. Further, they must have had either an unilateral or bilateral PMEC. Bilateral PMEC were counted as two samples. Only those who had received an closed or open exposure surgery procedure for a buccally or palatally displaced maxillary canine were eligible. Finally, at time of investigation the orthodontic care for the PMEC must have been complete (i.e. the PMEC had reached final planned position in the dental arch)

Exclusion criteria

Participants were excluded if an email or phone number was not supplied in the patient details. If the PMEC beginning position was mid-alveolar, they were also excluded. If post-treatment photographs were not taken by the orthodontist, these participants were also excluded.

(2) Contact with patients and consent

Eligible patients were provided an information sheet about the research and invited to participate via email, followed up by a text message notification. Participants provided consent via email or text message. Following participant consent, additional data were sought for patients who had been referred to the Faculty of Dentistry for surgery by private orthodontists. Treatment details and photographs were requested from referring orthodontists, where appropriate.

(3) Analysis of participant pictures: Aesthetic assessment of gingival margin

Once photographs were collected of all participants, the aesthetics of the gingival margin was assessed using a modified version of the Maxillary Canine Aesthetic Index (MCAI) (Grisar et al., 2018). An examiner from three different disciplines (orthodontics, periodontics and prosthodontics) was invited to assign a MCAI score to each patient. The three examiners were blinded to the surgical technique and initial tooth position, but did not have specific expertise in exposure surgery.

The original MCAI assesses the following factors of the previously impacted PMEC: mesial and distal papilla presence; marginal gingiva; recession; marginal gingival thickness; mesiodistal crown angulation; buccolingual angulation crown according to neighbouring teeth. The index also compares the previously impacted PMEC to the contralateral canine. It assesses curvature of the marginal gingiva, soft tissue colour and texture, root convexity, tooth morphology, and vertical tooth position. A score is given to each item assessed and tallied up into a final score to be measured against set parameters (Grisar et al., 2018). The use of photographs in this study design meant some MCAI items could not be viably collected. Hence, a modified MCAI was created for this current study **(Table 1)**. The final totalled score parameters were also adjusted accordingly.

(4) Participant categorisation

All participants in the study sample were grouped into four categories based on their surgery technique and original tooth position:

1. Originally buccally placed PMEC, treated with open exposure surgery
2. Originally palatally placed PMEC, treated with open exposure surgery
3. Originally buccally placed PMEC, treated with closed exposure surgery
4. Originally palatally placed PMEC, treated with closed exposure surgery

(5) Statistical analysis

Data were analysed using Stata v17 SE. Inter-examiner reliability was analysed using Cohen's kappa values to compare each individual component of the MCAI. The intraclass correlation coefficient (ICC) was used to compare inter-examiner reliability for the overall MCAI score. The Mann-Whitney test was used to assess statistically significant of difference in medians MCAI score between the open and closed exposure groups. MCAI score was log transformed for regression modelling.

Results

A total of 305 of patients underwent PMEC exposure surgery at the University of Otago Faculty of Dentistry between 2011– 2021. However, only 178 of these had valid contact details. All 178 patients were contacted by email followed by a text message, and 61 consented to be included in the study. Further screening against the inclusion and

Table 1. Scoring system for MCAI, alongside modified MCAI for this current study.

Parameters investigating the previously impacted canine			
	Absent	*Incomplete*	*Complete*
Mesial papilla	5	1	0
Distal papilla	5	1	0
Marginal gingiva	5	1 (<3mm)	0 (>3mm)
Recession	5 (apical to mucogingival junction)	1 (coronal to mucogingival junction)	0 (no recession)
Marginal gingival thickness	Thin 1	N/A	Thick 0
Mesiodistal crown angulation	Distal 2	Straight 1	Mesial 0
Parameters investigating comparison between both canines			
	Major discrepancy	*Minor discrepancy*	*No discrepancy*
Curvature of marginal gingiva	2	1	0
Soft tissue colour and texture	2	1	0
Root convexity	2	1	0
Tooth morphology	2	1	0
Vertical tooth position	2	1	0
Parameters investigating relation previously impacted canine and neighbouring teeth			
Buccolingual angulation crown according to neighbouring teeth	2	1	0

Total	**Original MCAI Parameters**		**Modified MCAI Parameters**	
	Excellent	0-3	Excellent	0-3
	Good	4-8	Satisfactory	4-13
	Moderate	9-13	Poor aesthetics	14 or more
	Poor aesthetics	14 or more		

[a] Items highlighted in red were unable to be assessed via a photograph and were not considered

exclusion criteria resulted in a final sample size of n=29. Of the final sample, 22 participants underwent open exposures, while seven had closed exposures. Twenty-three (23) canines were palatally placed before exposure surgery, and six were buccally placed. Seven participants were still undergoing orthodontic treatment when post-operative photographs were taken, but in each case, the canine that was operated on was already aligned to its final position in the dental arch.

Participant characteristics are summarised in **Table 2.** There were approximately twice the number of female participants compared to males. There was a higher representation of New Zealand European participants (79.3%) than any other ethnicities. Most participants commenced exposure treatment between the ages of 10 to 20 years old (93.1%), and the majority were between 10 and 15 years of age (55.2%) at the start of their treatment. Just over 10% of participants had a bilateral PMECs. Only 20.7% of canines were buccally placed to begin with, while 79.3% were palatal.

Inter-examiner reliability for some categorial items in the MCAI scale fell between 'Fair' to 'Moderate' strength of agreement, but many items had poor or no agreement (marginal gingiva, tooth morphology). Agreement between the periodontist and prosthodontist was consistently higher than either with the orthodontist for most components of the MCAI. The ICC for MCAI score showed 'Good' reliability between the periodontist and prosthodontist (ICC = 0.84), while reliability was 'Moderate' for the agreement between the orthodontist and the other two specialists.

The median MCAI score, averaged between the three examiners, was significantly different between the closed and open groups (z = -2.505, p = 0.010). Closed exposures scored lower on the MCAI, and therefore showed a statistically significant superior difference in gingival aesthetics compared to open exposures. To further assess whether the two techniques had a statistically significant aesthetic difference, a linear regression model was applied after a normalisation of MCAI scores by log transform and evaluation of residual plots. After adjusting for potential covariates, the open techique was associated with less favourable MCAI outcome (84% higher/worse) than the closed technique (β_{log}=0.61; 95% CI 0.08-1.14) while the initial PMEC position was not associated with MCAI outcome (β_{log}=-0.02; -0.58, 0.54).

Discussion

This study investigated whether PMEC exposure surgery technique would impact the gingival aesthetics. A secondary goal was to investigate whether the initial PMEC position would also impact gingival aesthetics. Gingival aesthetics was assessed by three examiners using the MCAI to score photographs of participants who had completed PMEC management. When statistically analysed, these scores found the closed technique offered greater gingival aesthetics than the open technique, and it seemed the initial PMEC position did not impact the final gingival aesthetics. Only a very limited amount of literature currently explores this relationship. This study's results may help orthodontists or oral surgeons decide which technique to choose for their patients.

Table 2. Characteristics of included participants by surgery technique

	All Participants n (%)		Open Exposure n (%)		Closed Exposure n (%)	
Sex						
Female	20	(69.0)	15	(68.2)	5	(71.4)
Male	9	(31.0)	7	(31.8)	2	(28.6)
Ethnicity						
NZ European	23	(79.3)	18	(81.8)	5	(71.4)
Māori	1	(3.4)	1	(4.5)	0	(0)
Pacific	0	(0)	0	(0)	0	(0)
Asian	1	(3.4)	0	(0)	1	(14.3)
MELAA	1	(3.4)	1	(4.5)	0	(0)
Other/unknown	3	(10.3)	2	(9.1)	1	(14.3)
Age at Start of Treatment						
<10 years old	0	(0)	0	(0)	0	(0)
10-15 years old	16	(55.2)	12	(54.5)	4	(57.1)
15-20 years old	11	(37.9)	9	(40.9)	2	(28.6)
>20 years old	2	(6.9)	1	(4.5)	1	(14.3)
Medical Status						
Any medical condition	8	(27.6)	5	(22.7)	3	(42.9)
No medical condition	20	(69.0)	16	(72.7)	4	(57.1)
Unknown	1	(3.4)	1	(4.5)	0	(0)
Exposure Tooth						
13	17	(58.6)	11	(50.0)	6	(85.7)
23	12	(41.4)	11	(50.0)	1	(14.3)
Exposures per Person						
Unilateral	23	(79.3)	17	(77.3)	6	(85.7)
Bilateral	6	(20.7)	5	(22.7)	1	(14.3)
Exposure Surgery Technique						
Open	22	(75.9)				
Closed	7	(24.1)				
Initial Canine Position						
Buccal	6	(20.7)	5	(22.7)	1	(14.3)
Palatal	23	(79.3)	17	(77.3)	6	(85.7)
Total	**29**		**22**		**7**	

The characteristics of the participant sample in this study were consistent with published literature. Ericson & Kurol (1998) found that PMECs were twice as common in females than males, while this study also had little more than twice the number of females compared to males. Ethnicity demographics were difficult to compare as currently there is no published literature of PMEC prevalence in New Zealand European compared to Māori, Pacifica and other ethnicities in New Zealand. The most common and ideal time for PMEC exposure reported is about 10-20 years old, which is also reflected in the present study. This study included more open exposures than closed ones. Open exposure is seemingly the popular choice by New Zealand orthodontists and oral surgeons. This current study, overall, found that the majority of canines were initially placed palatally (79.3%). However, studies that used 3-dimensional radiography have shown that 45.2% are buccally ectopic compared to 40.5% being palatal and 14.3% placed midalveolar (Liu et al., 2008). Despite a smaller sample size than anticipated, the present study's participant characteristics seemed reflective of recent literature studying the epidemiology of PMECs. While generalising the findings to the wider population seems plausible, further study using a larger sample size would be invaluable.

The Maxillary Canine Aesthetic Index was chosen as a previously validated scale (Grisar et al., 2018). However, the inter-examiner reliability in this current study did not reflect the agreement that was found in Grisar et al. (2018). Fleiss' kappa agreement values for examiners in the Grisar study ranged between 0.52-0.91 ('moderate agreement' to 'almost perfect agreement'). In contrast, this study achieved Cohen's kappa inter-examiner reliability between -0.23-0.68 ('no agreement' to 'good agreement'). Fleiss' kappa in principle is similar to Cohen's, except it is designed for more than two groups. In Grisar's research, all examiners underwent training and calibration before the rating exercise. However, in the current study the raters (practising specialists) were given instructions on the rating system but were not calibrated, showing how in clinical practice these scores and interpretations can vary widely. Examiners in Grisar's study were blinded to whether the case had received any PMEC treatment. This study blinded examiners to which surgery technique

was used; however, the examiners were aware which teeth had been previously ectopic. Grisar's examiners also carried out ratings under a standardised environment where all examiners were at an equal distance to a projector screen in a room of dimmed light. This study allowed examiners to assess the photographs from their computer screen or on hard copy paper. Two examiners (orthodontist and prosthodontist) opted for hard copy paper versions, while the periodontist assessed photographs on screen. Grisar's publication also stated the intraoral images used were all standardised, however there is no mention of the standardisation details.

In this study, the closed technique was associated with significantly better aesthetic outcomes than the open technique, and this is consistent with other publications in the same field. Studies on this topic are scarce; however, some authors have reported the closed technique to result in 'excellent' aesthetics, while aesthetic outcomes for open technique were only rated as 'good' (Luyten et al., 2020). The Luyten et al. (2020) study is the only study that reflects a similar methodology to this one and also utilised MCAI. It had 53 participants, 28 closed and 25 open. Although the closed technique showed superior gingival aesthetics in both this current study and the Luyten et al. (2020) study, they found teeth exposed using the closed technique had more discolouration. Thus, gingival aesthetics versus tooth aesthetics is another outcome in canine exposure research that needs investigation.

A systematic review that included three studies showed there were no differences between the two surgical techniques when used for palatal PMECs; however, the assessments were self-deemed to be low- to very low-quality evidence (Parkin et al., 2017). Another systematic review included nine studies (Sampaziotis et al., 2018). Two of the nine studies included assessed aesthetics, and the results showed no difference between the two surgery techniques. However, the results were inconsistent, and there were large discrepancies in agreement between studies (Sampaziotis et al., 2018). Another study focused on particular aspects of aesthetics, including colour, tooth position in the arch, and crown inclination (Smailiene et al., 2013). This study also found no difference between open and closed exposures for palatally displaced PMECs (Smailiene et al., 2013). With such limited literature and a diverse range of the conflicting results, it is difficult to definitively conclude whether the open or closed technique is superior in aesthetic outcomes. Also, much of the published literature assessing PMEC management focuses on outcomes that do not involve aesthetics.

The current study is one of the first to explore the relationship between surgery technique and gingival aesthetics. Further, it is the first to investigate if there is any relationship between initial PMEC placement and surgery technique. Gingival health (e.g. probing depth) has been examined in similar publications (Luyten et al., 2020). However, aesthetics are probably a more important outcome for the patient, and is often overlooked. Although the sample size was small, the demographics reflected similar studies that investigated the epidemiology of PMECs. Hence, the study sample could be representative of the wider population, arguing that its results could be generalised to the wider population. The current study used MCAI, a well-recognised and widely used index for assessing PMECs. The examiners were blinded to the surgery technique to eliminate systematic bias in scoring participant photographs. All photographs used for the current study were taken with digital single-lens reflex (DSLR) cameras. Thus, they were all of good quality with sufficient detail, allowing examiners to assess the canines and surrounding tissues accurately.

The principal limitation of the current study stems from being retrospective. Thus, the study team couldn't control many variables and potential confounders. Examiners received instructions on how to utilise the MCAI score correctly, but no trial cases or training was given before rating the PMECs on photographs. Secondly, there was 'no gold standard' examiner, thus leading to difficulties in deeming which examiner was the most accurate, a challenge observed during statistical analysis. Although the periodontist and prosthodontist had higher agreement, it does not mean they also had the most accurate MCAI scoring. Intra-examiner reliability could also have been assessed by asking the three examiners to rate the same photographs again later in time. This would also have provided more information on rating accuracy. One weakness of the MCAI is its inability to assess bilateral canines reliably. The principle of MCAI is to assess one canine and then compare it to the other side as a reference. Three participants in this current study had bilateral PMECs managed and were considered six separate cases for the purposes of this current study.

Table 3. Inter-examiner consistency in reporting of aesthetic parameters of canines

Item	Periodontist Kappa (% agreement)	Prosthodontist
Mesial papilla		
Prosthodontist	0.53 (75.9)	
Orthodontist	0.25 (51.7)	0.23 (51.7)
Distal papilla		
Prosthodontist	0.68 (89.7)	
Orthodontist	0.20 (69.0)	0.44 (79.3)
Marginal gingiva		
Prosthodontist	0.00 (44.8)	
Orthodontist	-0.05 (37.9)	-0.09 (69.0)
Recession		
Prosthodontist	-0.35 (31.0)	
Orthodontist	0.44 (79.3)	-0.23 (37.9)
Mesiodistal Crown Angulation		
Prosthodontist	-0.07 (37.9)	
Orthodontist	0.21 (55.2)	0.34 (65.5)
Curvature of Marginal Gingiva		
Prosthodontist	0.44 (65.5)	
Orthodontist	0.11 (41.4)	-0.07 (27.6)
Tooth Morphology		
Prosthodontist	0.06 (58.6)	
Orthodontist	-0.06 (41.4)	0.07 (62.1)
	ICC (95% CI)	ICC (95% CI)
MCAI score (overall)		
Prosthodontist	0.84 (0.65, 0.92)	
Orthodontist	0.68 (0.33, 0.85)	0.63 (0.19, 0.83)

Since half of the components of the modified MCAI require comparison to the contralateral canine, when cases were bilateral, the comparison was carried out against another canine that was also ectopic. This is a known limitation of the MCAI (Grisar et al., 2018).

Factors such as lighting, angles, and camera settings of the photographs were not standardised, as photographs were not captured for the sole purpose of this current study. A study has argued that small variations in photography angle can impede an examiner's ability to assess Angle's classification and midline deviation (Jackson et al., 2019). Further, two examiners (the orthodontist and prosthodontist) assessed the photographs via a hard copy print out, while the third examiner (periodontist) was able to assess the photographs electronically. This may have created differences between the assessment interfaces. Despite these potential variations in the assessment interface, examiners were blinded to surgical type, so there was no reason for systematic bias towards a particular technique.

Despite 61 people giving consent for participation, only 29 remained in the study sample after the application of inclusion and exclusion criteria. Most were excluded due to lack of record keeping that led to inability to determine sufficient treatment details. Record keeping is a medico-legal requirement that is essential for patient safety, practitioner information and in this case, research (Glasper, 2011). It has been recommended that comprehensive medical records should follow the acronym "CIA": Clear, Intelligible, and Accurate (Glasper, 2011). Many records that were accessed in this study failed to meet these guidelines, and may not meet practice standard requirements for New Zealand. Therefore, this study strongly recommends a quality audit to ensure the quality of care when exposing ectopic canines. A culture of continuous evaluation and development of a healthcare service is crucial when aiming for patient-centred care.

Conclusion

This study found superior gingival aesthetics for cases treated with the closed surgical technique than those treated by the open surgical technique. No difference in gingival aesthetics were observed according to original PMEC position. However, issues with quality or completeness of patient records resulted in limitations to this research. More work should be conducted to investigate and improve quality of routine dental record-keeping and to investigate practitioner variability.

Author contribution statement

All authors designed the work – all authors
Data collection – RW
Data analysis – RW, JB
Interpretation of analyses – all authors
Drafting the manuscript–RW
Critical revision of the article – JB, HDS, RDS
Final approval of the version to be published – all authors

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Competing interests

The authors declare no conflicts of interest

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