Journal of Orthodontics/Vol. 27/2000/169–173

Radiographic Factors Affecting the Management of Impacted Upper Permanent Canines

N. STIVAROS, B.D.S.

N. A. MANDALL, F.D.S., R.C.S. (ENG.), M.ORTH. (R.C.S. ENG.), PH.D.

Orthodontic Department, University Dental Hospital of Manchester, Higher Cambridge Street, Manchester M15 6FH, U.K.

Abstract. *The aim of the investigation was to evaluate which radiographic factors influenced the orthodontists' decision whether to expose or remove an impacted upper permanent canine and was a retrospective, cross-sectional design. The sample consisted of all radiographic records of patients referred to the Orthodontic Department at Manchester University Dental Hospital with impacted upper permanent canines between 1994–1998 (n = 44). The following canine position measurements were made from the OPG: angulation to the midline, vertical height, antero-posterior position of the root, overlap of the adjacent incisor, and presence of root resorption of adjacent incisor(s). The labio-palatal position of the impacted canine was assessed from the lateral skull radiograph. Whether the impacted canine had been exposed and orthodontically aligned or removed was also recorded.*

Stepwise logistic regression analysis showed that the labio-palatal position of the crown influenced the treatment decision, with palatally positioned impacted canines more likely to be surgically exposed and those in the line of the arch, or labially situated, removed ($P < 0{\cdot}05$). Additionally, as the canine angulation to the midline increased, the canine was more likely to be removed ($P < 0{\cdot}05$).

The orthodontists' decision to expose or remove an impacted upper permanent canine, based on radiographic information, seems to be primarily guided by two factors: labio-palatal crown position and angulation to the midline.

Index words: Impacted Canine, Lateral Skull Radiograph, OPG, Orthodontic Exposure, Surgical Removal, Radiographic Factors.

Introduction

Impaction of the permanent canine is a condition in which the tooth is embedded in the alveolus so that its eruption is prevented (Kasander, 1994) and the population incidence is between 1·7 and 2·2 per cent (Thilander and Myreberg, 1973; Ericson and Kurol, 1986). There are various treatment options open to a patient with an impacted permanent canine following a comprehensive evaluation of the occlusion. The options are:

1. Interceptive removal of the deciduous canine (Ericson and Kurol, 1988).
2. No treatment, but with periodic evaluation for pathologic changes.
3. Surgical removal and prosthetic replacement of the impacted canine.
4. Surgical exposure of the canine and orthodontic alignment (Bishara, 1992).
5. Autotransplantation of the canine (Shaw *et al*., 1981; Sagne *et al*., 1986).

An audit of patients referred to the Orthodontic Department at Manchester University Dental Hospital, 1994–1998, revealed that the most popular treatment options, for late intervention of an impacted maxillary canine, were either surgical exposure and orthodontic alignment (48·9 per cent), or surgical removal (51·1 per cent). However, before the treatment decision was made, a number of diagnostic patient and radiographic factors would have been considered including:

(1) patient age;
(2) general dental health and oral hygiene;
(3) whether space is available in the arch or can be made available for alignment of the permanent canine;
(4) the suitability of the first premolar to replace a permanent canine;
(5) how favourable the radiographic position is;
(6) patient motivation for orthodontic appliances;
(7) medical contra-indications for surgery.

It may be argued that factors, such as poor general dental status and lack of patient motivation, will preclude orthodontic alignment, although other clinical factors may be favourable. However, assuming that all other factors are acceptable, radiographic information is also important for treatment planning of these patients (Ericson and Kurol, 1986, 1987; Holmes and Nashed, 1990; Jacobs, 1996).

The relative diagnostic importance of radiographic factors such as canine angulation, height, and bucco-palatal position has not been evaluated. Therefore, the aim was to investigate which of the following radiographic factors might

Correspondence: Dr N. A. Mandall.

0301-228X/00/020000+00$02.00

influence the orthodontists' decision to expose, and align or remove an impacted upper permanent canine:

(1) canine angulation to the midline;
(2) vertical height of the canine crown;
(3) antero-posterior position of the canine root apex;
(4) canine crown overlap of the adjacent incisor;
(5) root resorption of adjacent incisor;
(6) labio-palatal position of the canine crown;
(7) labio-palatal position of the canine apex.

Materials and Methods

The sample of radiographs was obtained from patients, ≤ 16 years, referred to one of three consultants in the Orthodontic Department at Manchester University Dental Department between 1994 and 1998. The patients' names were taken from the waiting list for surgical admission to St Mary's Children's Hospital for operations involving either surgical removal or exposure of an impacted upper permanent canine(s).

Pre-operative lateral skull and OPG radiographs of each patient were randomly viewed and examined using a light box under standard conditions. The following variables were recorded from the OPG by examiner 1 (NS) according to the following criteria (Power and Short, 1993).

Canine Angulation to the Midline

A midline was constructed as shown in Figure 1 and a second line drawn through the canine root apex and canine tip. The angle between the two lines gave the impacted canine angulation to the midline that was grouped as:

Grade 1: 0–15°
Grade 2: 16–30°
Grade 3 ≥ 31°

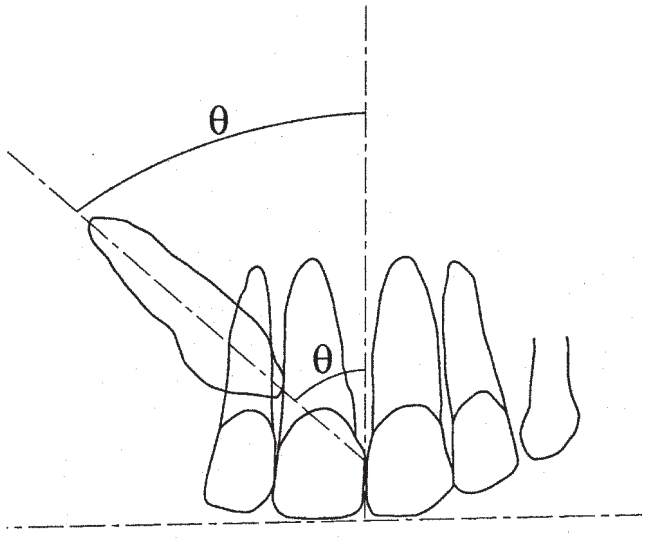

FIG. 1 The angulation of the canine to the midline.

Position of Canine Root Apex Antero-posteriorally

The canine root apex (Figure 2) was judged as being either:

Grade 1: Above the region of the canine position.
Grade 2: Above the upper first premolar region.
Grade 3: Above the upper second premolar region.

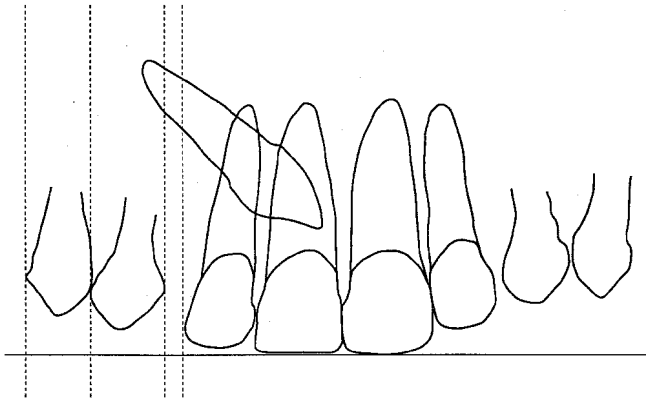

FIG. 2 The position of the canine root apex horizontally.

Vertical Canine Crown Height

The crown height was graded relative to the adjacent upper incisor (Figure 3):

Grade 1: Below the level of the cemento-enamel junction (CEJ).
Grade 2: Above the CEJ, but less than half way up the root.
Grade 3: More than half way up the root, but less than the full root length.
Grade 4: Above the full length of the root.

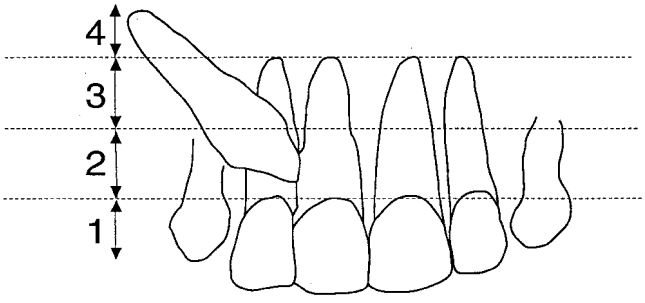

FIG. 3 The height of the canine vertically.

Canine Overlap of the Adjacent Incisor Root

Judged relative to the adjacent incisor root (Figure 4):

Grade 1: No horizontal overlap.
Grade 2: Less than half the root width.
Grade 3: More than half, but less than the whole root width.
Grade 4: Complete overlap of root width or more.

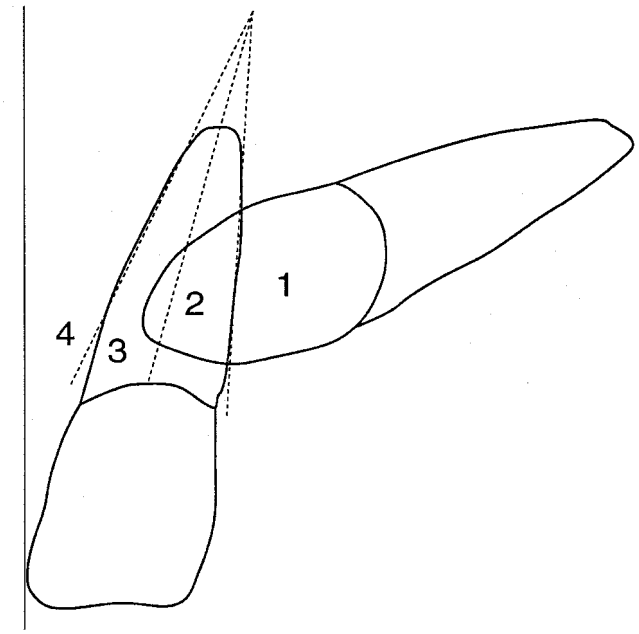

FIG. 4 Canine overlap to the adjacent incisor.

Presence of Root Resorption of the Adjacent Incisor

The presence or absence of root resorption of the adjacent upper incisor was recorded as judged from examination of the OPG, although, a further 50 per cent of patients may have bucco-lingual root resorption that is not diagnosed by routine radiography (Ericson and Kurol, 1987).

Labio-palatal Position of the Canine Crown and Root

Examiner 2 (NM) recorded the labio-palatal position of the canine crown and root from the lateral skull radiographs.

If there were two impacted upper canines, the radiographic variables were measured for both teeth, but only the data for the worst tooth were recorded. The examiners were blind as to whether the canine(s) had been surgically exposed or removed to avoid systematic bias.

Intra-examiner Reliability

The radiographic variables were remeasured 2 weeks' later by the same examiner.

Simple summary statistics and chi-square analysis were carried out. This was followed by a stepwise logistic regression analysis with the dependent variable as the treatment decision (surgical exposure or removal). The independent variables were the radiographic measurements from the OPG and the lateral skull radiograph. At this stage, the canine angulation to the midline was entered into the stepwise logistic regression as a continuous variable to increase its sensitivity. Intra-examiner reliability was assessed using the weighted Kappa statistic.

Results

Reliability

The intra-examiner reliability for all variables ranged from very good to perfect agreement. The weighted kappa values ranged from 0·74 (95 per cent confidence interval 0·50–0·97) to 1.00 for the radiographic variables measured.

Summary Statistics

The observed frequencies for radiographic variables are summarized in Tables 1–7. Generally, the canine angulation tended to be greater than 16 degrees with the root apex either above the region of the canine or first premolar. Most impacted canines lay within the vertical root length of the adjacent incisor with only 2 per cent lying higher than this. However, the overlap of the adjacent incisor root was more towards the severe end of the grading with 55 per cent exhibiting complete or greater than complete adjacent root overlap. Eighty per cent of impacted canines were judged as being palatal and adjacent incisor root resorption was seen in 22·2 per cent of all cases.

The treatment decision, whether to expose or remove the impacted canine, was roughly equivalent with 48·9 per cent exposed and 51·1 per cent removed. Of the 22 canines that

TABLE 1 *The impacted canine angulation to the midline*

Angulation to midline	% Cases
0–15°	9·1
16–30°	24·4
> 30°	65·9

TABLE 2 *The position of the canine root apex antero-posteriorally*

Position of canine root apex	% Cases
Above the canine region	20·5
Above the upper 1st premolar	63·6
Above the upper 2nd premolar	15·9

TABLE 3 *The position of the canine crown vertically relative to the adjacent upper incisor*

Position relative to the adjacent upper incisor	% Cases
Above the CEJ*	4·5
Above the CEJ but ≤ ½ root length	68·2
> Half-way ≤ full root length	25
> Full root length	2·3

*Cemento-enamel junction.

TABLE 4 *Horizontal overlap of the impacted canine over the adjacent upper incisor root*

Amount of overlap of the adjacent incisor root	% Cases
No overlap	13·6
≤ Half the root	15·9
> Half root, but ≤ complete root width	13·6
> Complete root overlap	55·6

were exposed, 16 were successfully aligned, four were referred back to their General Dental Practitioner for alignment and two refused orthodontic treatment.

The Influence of the Radiographic Variables on the Orthodontist Decision to Remove or Expose and Align an Impacted Upper Maxillary Canine

Initial chi square analysis revealed that none of the three consultant orthodontists were more likely to favour either exposure of removal of an impacted canine within this sample ($P > 0.05$).

TABLE 5 *The presence of root resorption associated with an impacted upper permanent canine*

Root resorption	% Cases
Present	22·7
Absent	77·3

TABLE 6 *The labio-palatal position of the impacted canine crown*

Labio-palatal position	% Cases
Labial	4·5
Line of arch	34·1
Palatal	61·4

TABLE 7 *The labio-palatal position of the impacted canine root*

Labio-palatal position	% Cases
Labial	2·3
Line of arch	15·9
Palatal	81·8

TABLE 8 *The labio-palatal position of the impacted canine crown and the orthodontists' decision to remove or expose and align*

	Treatment of impacted canine	
Labio-palatal position of crown	Exposed (%)	Removed (%)
Labial	0	100
Line of arch	20	80
Palatal	66·7	33·3

P value < 0.05, 2d.f.

Further chi-square analysis revealed that none of the radiographic factors measured from the OPG were statistically significantly related to the decision to remove or expose an impacted maxillary canine. The labio-palatal position of the crown was important, with those situated labially or in the line of the arch being more likely to be removed ($P < 0.05$; Table 8). The same treatment decision was also made based on the labio-palatal position of the root ($P < 0.05$).

These findings were generally supported by the stepwise logistic regression analysis, (Table 9), however, when the effect of all the radiographic independent variables together was taken into account, the labio-palatal position of the canine crown, but not the root, was statistically significant ($P < 0.05$). Additionally, when the canine angulation to the midline was entered as a continuous variable, rather than ordinal data as for chi square analysis, its effect was found to be statistically significant. As the canine angulation to the midline increased, the canine was more likely to be removed, rather than exposed ($P < 0.05$).

Discussion

Although a large amount of information may be obtained regarding impacted canine position from radiographs, this does not seem to be a major influence on the decision to surgically expose or remove an impacted canine. It was remarkable that only labio-palatal position of crown and the canine angulation to the midline statistically significantly influenced the treatment decision.

The Lack of Influence of Most of the OPG Variables on the Decision to Expose or Remove Impacted Permanent Canine

It is usually considered that the prognosis for orthodontically aligning an impacted permanent canine is worse if, for example, the crown overlaps more than half the adjacent incisor root or the canine crown is very high. It would seem, from our results, that these criteria, although a useful guide, do not unduly influence the clinical treatment decision. Reasons for this might include:

1. The canine positions derived from the OPG may all have been considered acceptable and, therefore, not considered in the treatment planning. This is not supported by the results of this study as there was a range of canine positions recorded for each variable.
2. With current fixed orthodontic techniques, it may be considered possible to align an impacted canine even from a difficult radiographic position, although the treatment time may be more protracted.

TABLE 9 *Logistic regression analysis to investigate the influence of the radiographic variables on the orthodontists' decision to remove or expose and orthodontically align an impacted maxillary canine*

Dependent variable	Statistically significant independent variable	B value	SE B	*P* value	Exp B (Odds ratio)
Decision to expose or remove impacted canine	Labio-palatal crown position	–2·7	0·90	<0.05	0.07
	Canine angulation to midline	0.08	0.03	<0.05	1·1

Key: Decision to expose or remove impacted canine: 1 = expose, 2 = remove. Labio-palatal crown position: 1 = labial/line of arch, 2 = palatal.

3. There are other diagnostic factors such as dental health, oral hygiene and patient motivation that may have greater importance than radiographic factors during the treatment planning decision. For example, a more difficult canine position might still be considered for orthodontic alignment if other factors are favourable.

The Labio-palatal Crown Position and Canine Angulation to the Midline

The labio-palatal position of the crown was seen to be important and 100 per cent of labially positioned canines were removed, as were 80 per cent of those in the line of the arch. This may be due to the difficulty in managing the attached gingivae with labial gingival flap access compared with palatal flaps where fenestration of the mucosa is less critical. Additionally, a closed eruption technique (Kokich, 1993), sometimes used for labially impacted canines, is more difficult to manage if the bonded attachment fails, as there is no access for rebonding.

Alternatively, canines situated labially or in the line of the arch may have been removed because they were in a more difficult position, than palatal canines, in terms of canine angulation, adjacent incisor overlap or vertical height. Further chi-square analysis of the data did not support this. There were no statistically significant differences between the exposed and removed canine groups, for any of the OPG variables ($P > 0.05$).

The influence of an increased canine angulation to the midline was probably not surprising as a more horizontally positioned canine is considered more difficult to orthodontically align. Therefore, an increased probability of such canines being removed supports long-held clinical belief.

Methodological Issues

Two-thirds of palatally positioned canines were surgically exposed and orthodontically aligned. Perhaps the *degree* of palatal positioning also influences the orthodontists' decision, however, this was not measured on this study because of the recognized potential errors in classifying labio-palatal position from a lateral skull radiograph.

The difficulty in more objective labio-palatal classification lay in the uncertainty relative to the anterior curvature of the upper arch. This could explain why the kappa values for reliability were slightly lower than for the other variables. However, further work is needed to assess labio-palatal canine position more objectively, possibly using the amount of overlap of the central incisor root on the lateral skull radiograph.

An attempt was made to minimize the subjectivity normally associated with examining an OPG by categorizing the variables with an ordinal scale (Power and Short, 1993). Measurement of canine position to in millimetres (interval data) was not feasible because of magnification and distortion that occurs with the OPG, and lateral skull radiographs. For this reason, a measurement of follicular enlargement and/or cystic change around an impacted canine was not addressed, although it is also a radiographic factor that is taken into consideration when treatment planning for impacted maxillary canines.

Conclusions

The orthodontists' decision to expose or remove an impacted upper permanent canine, based on radiographic information, seems to be primarily guided by its labio-palatal position and it angulation to the midline.

References

Bishara, S. E. (1992)
Impacted maxillary canines: a review,
American Journal of Orthodontics and Dentofacial Orthopedics, **101,** 159–171.

Ericson, S. and Kurol, J. (1986)
Radiographic assessment of maxillary canine eruption in children with clinical signs of eruption disturbances,
European Journal of Orthodontics, **8,** 133–140.

Ericson, S. and Kurol, J. (1987)
Radiographic examination of ectopically erupting maxillary canines,
American Journal of Orthodontics and Dentofacial Orthopedics, 91, 483–492.

Ericson, S. and Kurol, J. (1988)
Early treatment of palatally erupting maxillary canines by extraction of primary canines,
European Journal of Orthodontics, **10,** 283–295.

Holmes, A. and Nashed, R. R. (1990)
Radiographic localisation of canines in General Dental Practice,
Dental Update, February, 29–33.

Jacobs, S. G. (1996)
The impacted maxillary canine. Further observation on aetiology, radiographic localization, prevention/interception of impaction and when to suspect impaction,
Australian Dental Journal, **41,** 310–316.

Kasander, T. (1994)
The impacted canine: diagnosis and treatment,
Journal of Clinical Orthodontics, **5,** 13–21.

Kokich, V. G. and Mathews, D. P. (1993)
Surgical and orthodontic management of impacted teeth,
Dental Clinics of North America, **37,** 181–204.

Power, M. and Short, B. E. (1993)
An investigation into the response of palatally displaced canines to the removal of deciduous canines and an assessment of factors contributing to favourable eruption,
British Journal of Orthodontics, **20,** 215–223.

Sagne, S., Lennartsson, B. and Thilander, B. (1986)
Transalveolar transplantation of maxillary canines,
American Journal of Orthodontics and Dentofacial Orthopedics, **90,** 149–157.

Shaw, B., Schneider, S. S. and Zeyer, J. (1981)
Surgical management of ankylosed impacted maxillary canines,
Journal of American Dental Association, **102,** 497–500.

Thilander, B. and Myrberg, N. (1973)
The prevalence of malocclusion in Swedish school children,
Scandinavian Journal of Dental Research, **81,** 12–20.