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Localizing ectopic maxillary canines—horizontal or vertical parallax?

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SUMMARY This study compared the use of horizontal parallax (HP) and vertical parallax (VP) radiography for localizing ectopic maxillary canines (EMCs). The true positions of 43 EMCs were determined using the operative notes and subsequent study models following exposure and eruption. Thirty-four palatal and nine buccal EMCs were included in the study. Six experienced orthodontists examined the radiographs of the EMCs and were asked to localize each EMC using VP and HP on separate occasions.

The examiners recorded a diagnosis of 'unsure' in 12 per cent of cases using VP and in 5 per cent of cases using HP. The level of agreement of the diagnoses with the true position of the EMCs was significantly greater for HP. Eighty-three per cent of EMCs were correctly located with HP while only 68 per cent were correctly located with VP ($P < 0.05$). The diagnostic sensitivity for palatally placed canines was significantly greater for HP (88 per cent) than for VP (69 per cent). Both techniques performed poorly when used to localize buccal EMCs, with HP and VP each having a sensitivity of only 63 per cent.

It is concluded that HP is superior to VP in diagnostic accuracy, and that two peri-apical radiographs or one peri-apical and one anterior occlusal radiograph are the radiographs of choice for localizing EMCs.

Introduction

The prevalence of ectopic maxillary canines (EMCs) is approximately 1.7 per cent (Ericson and Kurol, 1986), with 85 per cent being palatally placed (Ericson and Kurol, 1987). Approximately 8 per cent of these patients have bilateral impaction (Bishara, 1992). Diagnosis and treatment planning requires precise localization of the unerupted canine which is usually achieved using a combination of clinical and radiographic examination. Clinical examination in cases with EMCs may reveal the absence of a labial canine bulge on palpation, with prolonged retention of the primary canine (Kuftinec *et al.*, 1995). The presence of a palatal bulge or distal tipping of the lateral incisor may be indicative of palatal EMCs (Bishara, 1992; Kuftinec *et al.*, 1995), while buccal EMCs may be associated with labial flaring of the lateral incisor (Kuftinec *et al.*, 1995).

The most recent United Kingdom guidelines on the use of radiographs for orthodontic diagnosis recommend that when a maxillary canine is unerupted and is not palpable, then radiographic examination is indicated (Isaacson and Thom, 2001). A dental panoramic radiograph (DPT) is commonly used for assessing the presence, position and morphology of unerupted teeth and can be used to determine the bucco-lingual position of EMCs based on the degree of magnification of the canine relative to adjacent teeth or the contralateral canine (Wolf and Mattila, 1979; Fox *et al.*, 1995; Mason *et al.*, 2001). However, this magnification technique is difficult to apply, particularly if the canine is rotated or in contact with an incisor root, or if the lateral incisor is tipped (Mason *et al.*, 2001). A DPT can also be used in conjunction with a lateral cephalometric film for localizing EMCs (Coupland, 1984). A more commonly used method for localizing unerupted maxillary canines is the parallax technique (Jacobs, 1999a). This requires the use of either two intra-oral films (peri-apical and/or anterior occlusal) for horizontal parallax (HP) or a DPT and an anterior occlusal film for vertical parallax (VP). Jacobs (1999a,b) recommended the use of occlusal rather than peri-apical films when localizing EMCs using HP. He suggested that occlusal films allow a larger tube movement between exposures, thus maximizing any image shift, and that occlusal films should show the entire canine tooth, which might not always be the case with peri-apical views.

Orthodontists have a responsibility to ensure that the radiographic techniques they employ provide accurate and reliable information. This is particularly true when the information obtained is used to plan combined surgical and orthodontic intervention. Anecdotal evidence suggests that the VP technique is more difficult to interpret than the HP technique due to problems with identifying reference points (Jacobs, 1999a). However, no previous studies have critically appraised the relative effectiveness of the two parallax techniques in localizing ectopic canines.

The current study was therefore designed to compare the diagnostic accuracy of the HP and VP techniques for localizing unerupted maxillary canines.

Method

A consecutive sample of cases was obtained following examination of the records of all EMCs which had been surgically exposed in the Belfast School of Dentistry between 1993 and 2001. For inclusion in the study, the case records were required to include study models, a DPT, at least one peri-apical radiograph (of the canine region) and one maxillary anterior occlusal radiograph of the EMC. The true position of each EMC was established using the study models and the operation notes.

Examination procedure

Six examiners participated in the investigation. All were experienced orthodontists (four consultants and two senior registrars). Each examiner was briefed about the study and was provided with written guidance on the principles of the VP and HP techniques (see Appendix). The radiographs of the sample of cases were assessed twice by each examiner in a random order, initially using a series of films for VP for each case (DPT and anterior occlusal radiographs) and then using a series of films for HP for each case (anterior occlusal and peri-apical radiographs). The anterior occlusal films used in the study had been recorded using the same tube position and angulation as a peri-apical view of the central incisors. The HP technique was therefore applied using the anterior occlusal film and the peri-apical view of the canine region. The films were examined in a darkened room using a Velopex mini viewer (Velopex International Inc., St. Cloud, USA). All film identification marks (including names and/or hospital numbers) were masked out. Each examiner was asked to classify the position of each unerupted canine as buccal, palatal, or in the line of the arch. If the examiner felt unable to classify the position confidently this was recorded as 'unsure'.

Statistical analysis

The agreement between the examiners' assessment of canine position and the true position was assessed for each examiner and each technique using the weighted kappa statistic. Wilcoxon tests on the kappa scores were then used to determine whether there was any difference between the accuracy of the two techniques in correctly identifying the true canine position. The 'unsure' and line of the arch diagnoses were added together when carrying out the kappa calculations.

The proportions of correct diagnoses were calculated for each examiner and each technique, and in addition the sensitivity of each technique was calculated for each examiner for palatally and buccally ectopic canines. The number of 'unsure' diagnoses was compared using the Wilcoxon test.

Reproducibility

Two weeks after the initial examination, 10 cases were randomly selected and the examiners were asked to assess the EMC positions again using each technique. The intra-examiner agreement for diagnosis for each technique was assessed using the weighted kappa statistic and a combined kappa statistic for both techniques was also calculated. A Wilcoxon test was used to compare the reproducibility of the examiners when using each radiographic method.

Results

Thirty-nine eligible patients with EMCs were identified from operating records. Their mean age was 14 years and 11 months (range 12 years and 1 month to 28 years and 2 months). Four patients had bilateral EMCs, thus giving a final sample of 43 EMCs. Assessment of the study models and operation notes revealed that the true position of the EMCs was palatal in 34 cases and buccal in nine cases.

The number of diagnoses reported as 'unsure' by each examiner is shown in Table 1. The Wilcoxon test revealed that there were significantly more 'unsure' diagnoses with VP than with HP: 12 and 5 per cent, respectively ($P < 0.05$). The VP and HP intra-examiner reproducibility kappa scores are shown in Table 2. The kappa scores did not differ significantly between techniques and the combined kappa scores indicated that the intra-examiner agreement was in the substantial to good range (greater than 0.6) for five of the examiners.

The kappa scores showing the strength of agreement of the HP and VP technique diagnoses with the true canine positions are shown in Table 3 for each of the six examiners. The best level of agreement was for examiner A using HP (kappa score = 0.86). The lowest level of agreement with the true canine positions was seen for examiner A using VP (kappa score = 0.47). A Wilcoxon

Table 1 The number of diagnoses reported as 'unsure' by each examiner ($n = 43$ cases).

Examiner	Horizontal parallax	Vertical parallax
A	0	0
B	7	8
C	0	4
D	0	3
E	1	3
F	5	15

Table 2 Kappa values for reproducibility (n = 10 cases).

Examiner	Horizontal parallax	Vertical parallax	Combined
A	1.00	0.55	0.74
B	0.73	0.58	0.66
C	0.86	0.39	0.61
D	0.63	1.00	0.80
E	0.69	1.00	0.86
F	0.67	0.47	0.59

Table 3 Kappa values for agreement between diagnosed and true canine positions for each examiner using the horizontal and vertical parallax techniques (n = 43 cases).

Examiner	Horizontal parallax	Vertical parallax
A	0.86	0.47
B	0.56	0.48
C	0.79	0.64
D	0.79	0.50
E	0.54	0.48
F	0.62	0.48

test revealed that the kappa scores were significantly higher for HP than for VP ($P < 0.05$).

The mean proportion of correct diagnoses was 83 per cent using HP and 68 per cent for VP (Table 4). The difference between the techniques was statistically significant ($P < 0.05$). The diagnostic sensitivity values for palatal and buccal canines are shown in Table 5. The mean diagnostic sensitivity for the six examiners for palatally placed canines with HP (88 per cent) was significantly higher than with VP (69 per cent, $P < 0.05$). The mean sensitivity for diagnosis of buccally placed canines was the same for VP and HP (63 per cent). Although the sensitivity was significantly higher for palatal than buccal canines with HP ($P < 0.05$), there was no significant difference between palatal and buccal canines when VP was used.

Table 4 The proportion of correct diagnoses for each examiner for the horizontal and vertical parallax techniques (n = 43 cases).

Examiner	Horizontal parallax (per cent)	Vertical parallax (per cent)
A	93	74
B	70	60
C	88	74
D	88	67
E	81	70
F	77	60
Mean	83	68

Table 5 Sensitivity for palatal and buccal canines with the horizontal and vertical parallax techniques.

Examiner	Horizontal parallax (per cent)		Vertical parallax (per cent)	
	Palatal (n = 34)	Buccal (n = 9)	Palatal (n = 34)	Buccal (n = 9)
A	94	89	68	100
B	74	56	65	44
C	91	78	74	78
D	94	67	74	44
E	91	44	71	67
F	85	44	65	44
Mean	88	63	69	63

Discussion

Sixty-eight per cent of diagnoses with the VP technique were correct. However, a large proportion of VP diagnoses were reported as 'unsure' and one examiner stated that they were unsure of the canine position using VP in more than one-third of the cases. In a previous investigation which compared VP with a DPT magnification technique, Mason *et al.* (2001) concluded that 76 per cent of VP diagnoses were correct. Although Southall and Gravely (1989) reported that 87 per cent of VP diagnoses were correct, the study method used dried skulls with steel ball bearings to simulate canines, which makes comparison with the present clinical study difficult. In the current investigation, five of the six examiners had kappa scores of less than 0.6 for VP, which indicated only a moderate level of agreement with the actual canine position. Only one judge achieved a kappa score in the substantial agreement range. Mason *et al.* (2001) also evaluated six examiners and found that the highest value for the kappa statistic for VP was only 0.51. The present study and previous work therefore support the view that assessing EMC position using VP is unlikely to achieve the level of accuracy normally expected from a clinical diagnostic test.

The diagnostic accuracy of the examiners was much better when using the HP method, with four of the six examiners achieving kappa scores of more than 0.6, indicating substantial or good agreement with the true canine position. The proportion of correct diagnoses was also higher for HP compared with VP.

Palatal versus buccal canines

The current results indicate that the sensitivity of HP for palatal EMCs was 88 per cent while that for VP was 69 per cent. For buccal EMCs, the diagnostic sensitivities were 63 per cent for both HP and VP. Although the number of buccal EMCs in the study was small, this finding indicates that HP had no apparent advantage

over VP in locating buccal EMCs. It therefore appears that the superiority of HP over VP with regard to improvements in the proportions of correct diagnoses is a reflection of the increased ability of HP to locate palatal EMCs. From a clinician's viewpoint, the finding that more than one-third of buccal EMCs will be misdiagnosed with either technique is of some concern. A low success rate in correctly locating buccal EMCs radiographically has also been reported by Mason *et al.* (2001) who calculated a sensitivity of only 46 per cent for VP when used to locate buccal EMCs. In agreement with the opinion of Mason *et al.* (2001), it is fortunate that buccal EMCs can often be palpated clinically, which may obviate the need to localize using radiographic techniques.

HP versus VP

Overall reproducibility was in the substantial to good range for almost all of the examiners, and there was no evidence of any difference in reproducibility between the two parallax techniques. However, with palatal EMCs, VP resulted in almost three times the number of 'unsure' or incorrect diagnoses than HP (31 and 12 per cent, respectively). Jacobs (1999a,b, 2000) argued that VP was the technique of choice for localizing EMCs on the basis that a DPT radiograph is often taken initially by orthodontists and the use of only one additional radiograph with VP would minimize the overall radiation dose. However, this latter study did not compare the diagnostic accuracy of the different radiographic techniques. Clearly, to be valid, any comparison of radiographic techniques such as HP and VP must consider diagnostic accuracy as well as radiation exposure. Orthodontists should make every effort to use the minimum radiation dose that is consistent with diagnostic accuracy. It is questionable whether the routine use of DPT radiographs is appropriate when dealing with suspected cases of EMCs. The results of this study confirm that HP is superior to VP in diagnostic accuracy, which means that two peri-apical radiographs or one peri-apical and one anterior occlusal radiograph are the radiographs of choice.

Conclusions

1. Localization of EMCs was significantly more successful with HP than with VP.
2. Only 69 per cent of palatal EMCs were correctly located with VP, while 88 per cent were correctly located with HP.
3. Both radiographic techniques were poor at localizing buccal EMCs. Only 63 per cent of buccal EMCs could be localized correctly with either technique.
4. There were significantly more 'unsure' diagnoses with the VP technique.
5. To help to minimize radiation exposure to patients, it is suggested that a DPT should not be taken routinely when dealing with maxillary canine ectopia. Instead, only radiographs which allow the use of the HP technique should be taken.

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Appendix

Guidance on the parallax technique for localizing ectopic canine teeth

The parallax technique uses the apparent movement of the image of an object relative to the image of a reference object caused by altering the angulation of the X-ray beam.

The image of the object which is furthest away from the X-ray tube moves in the same direction as the tube and is therefore palatally positioned, whereas the image of an object closer to the X-ray tube will move in the opposite direction, and is situated buccally. Changing the horizontal or vertical angle of the tube will determine which technique is used (horizontal or vertical parallax).

By applying the horizontal and vertical parallax techniques to the following pairs of radiographs, please record the position of the ectopic canine as either:

1. buccally placed
2. palatally placed
3. in the line of the arch
4. unsure.