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A treatment difficulty index for unerupted maxillary canines

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SUMMARY The aim of this study was to produce a treatment difficulty index (TDI) for unerupted maxillary canines.

Thirty treated cases, each with an unerupted unilateral maxillary canine, were graded by 14 consultant orthodontists in terms of perceived alignment difficulty, and the four main factors which had contributed to each grade were listed in order of importance. The relationship between the grade and the contributory factors was then examined using regression analysis, and weightings were derived. These were applied to each factor, in order to derive a difficulty score total for each case.

Linear regression analysis of difficulty scores against consultant grades produced an R^2 value of 54.7 per cent using the original equation and an R^2 of 52.3 per cent using values rounded to the nearest half. Both indicated a moderate level of agreement between allocated difficulty grade and calculated difficulty scores.

The index provides a useful treatment planning aid for the management of impacted maxillary canines.

Introduction

The alignment of an unerupted maxillary canine may necessitate complicated and prolonged treatment and alternative treatment methods such as extraction of the displaced tooth must be considered if successful alignment is thought to be unlikely. Until now prediction of success has been based largely on clinical experience and anecdotal evidence, and a system that offered an improved assessment of the likely difficulty of aligning a displaced canine would be beneficial for both patient and clinician. A recent study has found significant variation amongst UK orthodontists with regard to the management of unerupted canines when orthodontic treatment was not planned (Ferguson and Pitt, 2004). It is likely that similar variation would exist with regard to treatment decisions.

The Index of Complexity, Outcome and Need (ICON) was designed to assess the complexity of a case regarding orthodontic correction in addition to treatment need and outcome (Daniels and Richmond, 2000). ICON assesses overall malocclusion and not one specific factor such as an impacted canine, although alignment of the latter may greatly extend treatment time.

The prognosis for alignment of an impacted maxillary canine is affected by several factors (McSherry, 1996):

Patient co-operation: Factors such as missed appointments and poor oral hygiene influence treatment duration (Fink and Smith, 1992; Beckwith *et al*., 1999).

Age of patient: The age of a patient at the start of treatment has been found to affect treatment time and, since this may be lengthy, older patients may find it to be unacceptable. The upper age limits suggested for successful alignment of an ectopic canine include 16 (McSherry, 1996) and 20 (Nordenram, 1987) years of age.

Presence of spacing or crowding: In 85 per cent of subjects with palatal displacement of a canine there is adequate space in the arch (Jacoby, 1983), whilst in crowded arches the canine is more likely to erupt in a buccal position (Oliver *et al*., 1989).

Position of canine: The angulation of the tooth, as well as the bucco-palatal, vertical and horizontal position, all influence treatment difficulty.

Canines angulated towards the horizontal are difficult to manage and have a poorer alignment prognosis (Kuftinec and Shapira, 1984). As angulation to the midline increases so does the likelihood of removal rather than attempted alignment (Stivaros and Mandall, 2000).

A bucco-palatal position of the canine crown also influences the treatment decision, with palatally impacted canines more likely to be exposed, and those in the line of the arch or buccally positioned more likely to be removed (Stivaros and Mandall, 2000). This may be due to the increased problems of managing the attached gingivae with buccally positioned canines compared with palatal impactions.

It has been reported that the higher above the occlusal plane the canine is positioned, the poorer the prognosis for alignment. McSherry (1996) described this as 'the vertical rule of thirds'. A good prognosis can be expected if the canine cusp tip is at the level of the amelocemental junction of the adjacent incisor. A fair prognosis would be predicted for a canine with its cusp tip at a level of half the root length of the adjacent incisor, whilst a canine with poor prognosis for alignment would be one where the cusp tip lay against the apical third of the adjacent incisor root. It has been suggested that when the canine tip is less than 14 mm above the occlusal plane, treatment takes on average 24 months; this increases

to 31 months for vertical displacements above 14 mm (Stewart *et al*., 2001).

Oral health, skeletal variation and the root morphology of adjacent teeth also affect the success of alignment (McSherry, 1996).

The objective of the present study was to produce a treatment difficulty index (TDI) that could be used to measure the difficulty that would be expected during the alignment of an unerupted maxillary canine. Complexity is not quite the same thing as difficulty since the latter makes reference to the skill of the operator.

Materials and methods

There were two parts to the study. The first employed methodology similar to that used to derive the Peer Assessment Rating (PAR) Index (Richmond *et al*., 1992). Fourteen consultant orthodontists, mean age 53.5 years (SD 6.6 years), with an average time since appointment of 17 years (SD 8.1 years), were asked to assess the pre-treatment study models and radiographs of 30 successfully treated cases, each with one unerupted and displaced maxillary canine.

Additional information was also available as follows: total treatment time with fixed appliances, time taken to place the first rectangular wire, and the time that traction was applied to the canine before an archwire could be engaged into the bracket.

Using each set of records, the participants were asked to suggest a grade for the perceived difficulty of aligning the impacted canine by allocating a score based on a scale from 1 to 5 (1 = easy, 5 = extremely difficult). The mean grade for each case was calculated from those awarded by the 14 examiners.

The examiners were then asked to select, from a list of 10, up to four factors relating to the position of the unerupted canine which had contributed to the difficulty grade which they had allocated to the case, and to place them in order of decreasing importance. The factors were:

1. Rotation.
2. Angulation to midline.
3. Age of patient.
4. Coincidence of arch midlines.
5. Alignment and spacing of the upper labial segment.
6. Vertical height.
7. Bucco-palatal position.
8. Condition of primary canine.
9. Missing teeth.
10. Horizontal position.

The order in which these factors were presented on the scoring sheet was decided upon by the use of randomization tables in order to minimize bias.

A rank value from 4 (most important) to 1 (least important) was allocated to each factor according to its order in the list (Table 1). The scores recorded by all 14 examiners were then added together and the total divided by 14 to calculate the mean case score for each factor.

Table 1 Allocation of rank values.

Factors in decreasing order of importance	Rank value
6 – Vertical height	4
7 – Bucco-palatal position	3
4 – Midline	2
2 – Angulation to midline	1

The 30 case means for each of the 10 factors were added together and divided by 30 to produce mean rank values (MRVs) for each factor. The factors 'missing teeth' and 'condition of primary canine' each attracted a mean rank value of zero and these were not therefore carried forwards into the regression analysis, which was based upon difficulty grade as the dependent variable, with the MRVs for the remaining eight factors as independent variables.

Comparisons were also drawn between the TDI and allocated difficulty grade, and between the TDI and treatment time, time to rectangular wire, and traction time, respectively.

Results

Results of regression analysis

Regression of the MRVs as independent variables against difficulty grades as the dependent variables produced the following equation:

Difficulty score
= Constant –8.31 + Horizontal position 1.8 + Age 1.5
+ Vertical height 1.3 + Bucco-palatal position 1.3
+ Rotation 1.2 + Midline 1.1 + Angulation 1.0
+ Alignment 0.6

R^2 = 59.8 per cent; R^2 (adjusted) = 44.5 per cent.

Difficulty scores were then calculated for each of the 30 cases by multiplying the appropriate weighting, as calculated in the regression equation, with a severity grade allocated to each factor (Table 2). A sample calculation is shown in Table 3.

Pearson correlations were used to test whether or not the difficulty scores calculated from the regression equation reflected the opinions of the 14 consultants.

Comparisons were drawn between:

1. Difficulty score and the mean difficulty grade allocated by the consultants.
2. Difficulty score and treatment time.
3. Difficulty score and time to rectangular wire.
4. Difficulty score and traction time.

The correlation coefficient between difficulty score and perceived difficulty was 0.7, indicating good agreement, but

Table 2 Gradings allocated to each factor.

Factor	Score
Age	
Less than 12 years	1
12–15 years	2
15–18 years	3
Over 18 years	4
Angulation to midline	
Less than 30 degrees	1
30–45 degrees	2
Over 45 degrees	3
Vertical position	
Canine cusp tip at the level of the amelocemental junction of the adjacent incisor	1
Canine cusp tip at the middle of root of the adjacent incisor	2
Canine cusp tip within the apical third of the adjacent incisor	3
Canine cusp tip above the apical third of the adjacent incisor	4
Bucco-palatal position	
Buccal	1
Palatal	1
Horizontal position	
Canine overlapping up to half the width of the lateral incisor	1
Canine overlapping over half the width of the lateral incisor	2
Canine completely overlapping the lateral incisor	3
Canine overlapping up to half the width of the central incisor	4
Alignment of upper incisors	
Incisors spaced	1
Incisors well aligned	2
Incisors crowded	3
Space between upper lateral incisor and upper first premolar	
Over 7 mm	1
4–7 mm	2
2–4 mm	3
0–2 mm	4
Midline	
Midline coincident with lower	1
Midline displaced	2
Rotation	
Rotation absent	1
Rotation present	2

the coefficients between the other measures were weaker (Table 4).

To simplify calculation of a treatment difficulty score, regression coefficients were rounded to the nearest half to produce the regression equation:

Difficulty score
= Constant –8 + Horizontal position 2.0 + Age 1.5
+ Vertical height 1.5 + Bucco-palatal position 1.5
+ Rotation 1.0 + Midline 1.0 + Angulation 1.0
+ Alignment 0.5.

Factor weightings from this equation were used to calculate a second set of difficulty scores. Correlation between scores calculated using rounded regression coefficients and the allocated difficulty grades was again good, at 0.7.

Discussion

The difficulty gradings upon which the regression analysis was based were made by 14 consultant orthodontists who had been in post for a mean time of 17 years. Eleven were based in regional hospitals and three at the Birmingham Dental Hospital. Between them they possessed a breadth of clinical experience that can reasonably be claimed to represent current thinking on the management of unerupted canine teeth in the United Kingdom.

An unerupted canine may be displaced from its correct position in three dimensions: horizontally, vertically or bucco-palatally. In many instances it is necessary to extract a sound premolar in order to provide sufficient space for canine realignment, although Jacoby (1983) suggested that adequate space existed in 85 per cent of cases where the canine was palatally displaced. The vertical rule of thirds described by McSherry (1996) was used in the present study to classify vertical displacements.

The regression equation suggests that a horizontal position, as measured by the degree of overlap of the lateral and central incisors by the crown of an unerupted canine, is the most important factor in determining the difficulty of aligning the unerupted tooth. Patient age is the next most important factor, followed by vertical height and bucco-palatal position in equal third place. These factors therefore carried weightings above unity when the regression equation values were rounded to the more convenient nearest halves.

Attempts to simplify the regression equation by stepwise omission from the analysis of independent variables with low MRVs produced lower R^2 values than when all eight were included. This is a common finding when regression analysis is used and reflects the fact that each of the eight independent variables makes a worthwhile contribution to the model. However, these results must be treated with some caution: as there were only 30 cases, eight independent variables are therefore more than would normally be included.

Correlation between the calculated difficulty scores and allocated difficulty grade was 0.74, indicating a high degree of correlation. Correlation coefficients using the calculated difficulty score and treatment time, time to rectangular wire and traction time were lower, although that between difficulty score and time to rectangular wire was in the 'good' range at 0.54, $P = 0.003$.

The R^2 value produced as a result of the analysis between the allocated difficulty and the calculated difficulty score was 54.7 per cent. The value produced for analysis between the allocated difficulty and the rounded scores was lower at

Table 3 A worked example showing calculation of a case score using actual and rounded regression coefficient values.

Factor	Grade	Regression coefficient (actual)	Component score	Regression coefficient (rounded)	Component score
Age	3	1.5	4.5	1.5	4.5
Angulation	1	1	1	1	1
Vertical height	2	1.3	2.6	1.5	3.0
Bucco-palatal position	1	1.3	1.3	1.5	1.5
Horizontal position	1	1.8	1.8	2	2
Alignment of upper incisors	2	0.6	1.2	0.5	1
Midline	1	1.1	1.1	1	1
Rotation	1	1.2	1.2	1	1
Total difficulty score			14.7		
Total rounded difficulty score					15

Table 4 Correlation coefficients for difficulty score, orthodontist perceptions and other factors.

	Pearson correlation	*P* value
Perceived difficulty/difficulty score	0.7	0.000
Perceived difficulty/rounded difficulty score	0.7	0.000
Difficulty score/treatment time	0.5	0.012
Difficulty score/time to rectangular wire	0.5	0.003
Difficulty score/traction time	0.3	0.089

52.3 per cent. This decrease in R^2 value is to be expected when using rounded values, although it is still encouraging.

Conclusion

Regression analysis indicated that horizontal position, age of patient, vertical height and bucco-palatal position, in descending order of importance, are the factors which determine the difficulty of canine alignment. Treatment difficulty scores calculated using the regression equation showed good correlation with the initial clinical judgements of a panel of 14 consultant orthodontists when these were recorded on a 1–5 grade scale of difficulty. It appears, therefore, that the proposed TDI for impacted maxillary canines could make a worthwhile contribution to treatment planning by non-specialists.

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