CLINICAL NOTE

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A model for the prediction of tooth wear in individuals

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Abstract

Background: Easily applied, age-specific standards are useful in assisting clinicians to decide whether the extent of tooth wear observed in a given patient at a specific age is acceptable or whether intervention is indicated.

Method: A simple method of scoring tooth wear and previously established mathematical relationships between tooth wear scores and age, provide the basis of a method for predicting tooth wear scores. In its most specific form, the method can be used to predict tooth wear scores for individual patients at subsequent ages. Alternatively, tables or graphs can be consulted to provide a less precise prediction of tooth wear that can assist clinicians to decide whether the amount of wear reflects high, moderate or low rates of wear at the specified age.

Conclusion: In cases where there is no reason to believe that aetiological factors have changed significantly over time, data obtained from the methods described can assist clinicians to plan appropriate management for patients presenting with unacceptable levels of tooth wear.

Key words: Tooth wear, attrition, erosion, abrasion, scoring.

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INTRODUCTION

With the changing age profiles resulting in a greater number of older individuals in most countries and with improving dental health, increasing numbers of patients are presenting with extensive tooth wear. This can result in discomfort when areas of dentine become exposed, and lead to unacceptable aesthetic changes associated with reduced crown height and, in some cases, compromised function.

Because the successful management of extensive tooth wear can be complex and expensive, it is in the patient's best interest that potential problems are identified as early as possible and appropriate preventive measures instituted to reduce the rate of loss of tooth substance.[1] In addition, it is sometimes difficult, even for experienced practitioners, to be certain whether observed changes are the result of attrition (i.e., tooth-to-tooth contact), erosion (due to action of exogenous or regurgitated acids), abrasion by consumed or environmental substances, or by some combination of these factors. Furthermore, there is a need for easily-applied, age-specific standards that can assist clinicians to decide whether the extent of tooth reduction observed in a given patient at a specific age is physiological or whether, in the absence of any intervention, the process is likely to progress to become a problem in later life.

The aim of this paper is to present a simple mathematical model of occlusal and incisal tooth reduction as a means for accurately predicting the progress of tooth wear in individuals over time.

METHODS

Tooth wear scores that are based on ratios of the area of exposed dentine to total crown area derived from standardized occlusal view photographs have been used to investigate the relationships between occlusal tooth reduction and age.[2-4] Although these previously established relationships are population specific, it has been shown consistently that there are linear relationships between age and scores for incisors and canines and non-linear relationships between age and scores for premolars and molars.[4] These relationships can be expressed as simple equations of the following forms:

$$\text{score} = a + b(\text{age})$$

for anterior teeth; and

$$\text{transformed score} = a + b(\text{age})$$

for premolars and molars where

$$\text{transformed score} = 1+0.5(\log_{10}\text{score})$$

The transformation applied to the score for premolars and molars compensates for the non-linear nature of the relationship and preserves a score in the range zero to one. These simple relationships would be expected to apply when attrition and abrasion predominate and would be modified to some extent by erosion that is more likely to act episodically and at specific sites.

Accurate tooth wear scores can be derived from standardized photographs of dental casts following previously described methods[3] or, alternatively, approximate scores can be obtained by reference to

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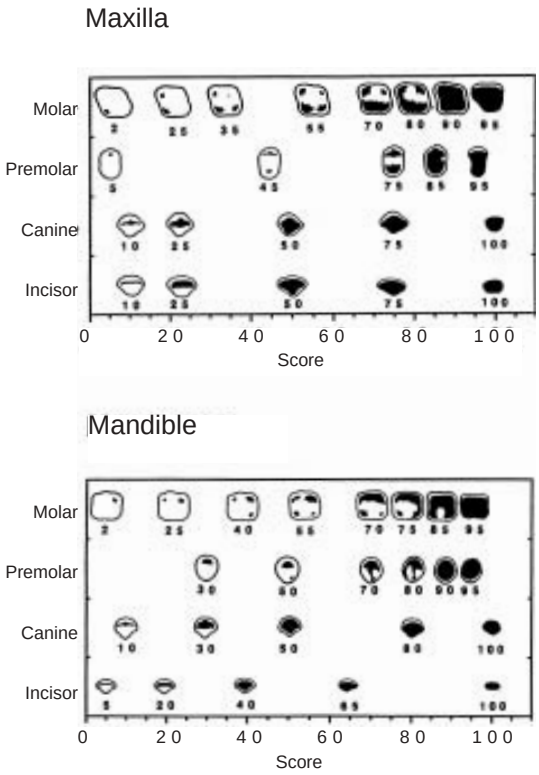

Fig 1. Wear scores for representative stages of tooth wear of maxillary and mandibular teeth. Approximate scores for individual teeth can be obtained by interpolating between illustrated stages. Premolar and molar scores have been transformed to accommodate the non-linear relationship between scores and age.

simple charts (Fig 1). In these charts, the original scores and transformed scores have been multiplied by 100 to simplify calculations.

The co-efficients 'a' and 'b' estimate the age at which dentine is first exposed and the rate of dentine exposure respectively. By using values calculated previously for 'a' and 'b' co-efficients[4] together with data obtained from either specific patients or from a clinician's assessment of what is an acceptable amount of wear at specific age, it is possible to develop mathematical models of tooth wear. These models can then be applied to the observed extent of dentine exposure for any tooth in any population in the following manner.

Firstly, a theoretical dentine exposure score at the time the tooth emerges into the oral cavity ($score_0$) can be estimated by substituting the average emergence time for the tooth into the previously-derived equations. This theoretical score will always be negative as it is related to the amount of enamel reduction that must occur between the time of the tooth emergence and first exposure of dentine. This calculation provides one point on a linear graph that describes the relationship between age and tooth wear scores. A second point on the line ($score_1$) can be obtained in two ways: either a patient's age and corresponding tooth wear score can be used when the

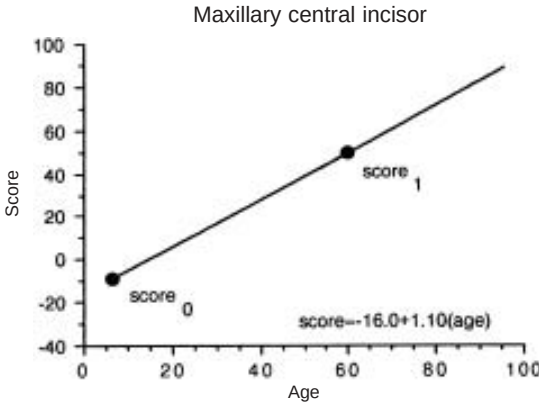

Fig 2. Graph for a patient aged 65 years with a wear score 50 for the maxillary central incisor, illustrating the case-specific relationship and the predicted wear scores at subsequent ages.

model is applied to a specific case or, alternatively, scores that clinicians or patients are prepared to accept at given ages can be used to provide a more general model of tooth wear.

In the case of a maxillary central incisor, for example, a theoretical dentine exposure score ($score_0$) at an emergence time of 7.4 years can be obtained by re-arranging terms and substituting in the previously established equation[4] as follows:

$$score = -17.5+1.3(age)$$

From this relationship the value of $score_0$ for the maxillary central incisor can be calculated as:

$$score_0 = -17.5+1.3(7.4) = -7.9$$

A second point ($score_1$) can be obtained, in the case of a specific patient, by substituting their known age and corresponding observed score. For example, if 50 per cent of the surface of the central incisor displays exposed dentine when viewed incisally and the patient's age is 60 years, then the slope (b) of the line describing the relationship between age and wear Fig 2 would be:

$$b = (score_1-score_0)/(age_1-age_0)$$
$$= (50+7.9)/(60-7.4)$$
$$= 1.10$$

and the intercept (a) would be:

$$a = score_0 – b(age_0)$$
$$= -7.9 – 1.1(7.4)$$
$$= -16$$

giving the resultant, patient-specific equation:

Maxillary central incisor score = -16 + 1.10(age)

This equation could then be used to predict specific tooth reduction scores for subsequent ages. For example, in the absence of intervention, the patient's score by age 75 years would be calculated as 66.5 in the following way:

Maxillary central incisor score = -16 + 1.10(75)=66.5

To develop a more general model, wear scores that clinicians might be prepared to accept at given ages can be used to develop equations. For example, it may be

Table 1. Constants ($score_0$) derived for maxillary and mandibular teeth

Tooth	Maxilla	Mandible
Central incisor	- 7.9	- 7.4
Lateral incisor	-12.0	-10.0
Canine	-25.9	-12.7
First premolar	- 3.4	- 9.2
Second premolar	-15.6	-19.5
First molar	-11.7	-12.8
Second molar	- 4.9	- 8.9

considered that a score of 25 for the maxillary central incisor represents the maximum amount of tooth wear a patient would be prepared to accept by the age of 70 years. In such a case, $score_0$ at the time of tooth emergence would be the same as in the above example whereas $score_1$ would be 25 at age 70 years. The slope of the line (b) is calculated as:

$$b = (score_1\text{-}score_0)/(age_1\text{-}age_0)$$
$$=(25\text{-}7.9)/(70\text{-}7.4)$$
$$=0.54$$

and the intercept (a) is:

$$a = score_0 - b(age_0)$$
$$= -7\text{-}1.10(-7.4)$$
$$= -16$$

to give the equation:

Maxillary central incisor score = -11.9 + 0.54(age)

From this equation, expected scores for patients of any age can be calculated.

Having obtained tooth wear scores, the model can then be applied in any one of three ways, depending on the circumstances.

In its most specific form, calculations can be made for individual teeth using custom-derived equations obtained from population-specific emergence times and $score_0$ data (Table 1) in the manner outlined. This process is easily automated using a personal computer. Appropriate spreadsheets for calculating scores in this manner are available on request from the authors.

To obtain less specific information, a table of representative wear rates can be derived and consulted as necessary to give information about approximate scores and ages. Table 2 provides an example of representative data for the maxillary central incisor, and tables providing corresponding data for other teeth are also available from the authors.

In its least specific but most easily applied form, a single graph depicting predetermined acceptable and unacceptable rates of wear can be consulted to provide an indication of whether or not the amount of wear observed falls within acceptable limits (Fig 3). It is possible to apply a single set of equations in this general manner because, over long time-spans and especially when approximate tooth wear scores derived from charts are used, the tooth-specific calculation of $score_0$ values, emergence times (age_0) and rates of dentine exposure (b) do not differ sufficiently to necessitate recalculation of the relationships for specific teeth.

Table 2. Tooth wear scores for the maxillary central incisor calculated to give scores of 20, 40, 60, 80 and 100 at age 70 years

Age	Predicted wear scores				
20	0	2	6	10	14
30	2	9	17	24	31
40	7	17	27	38	48
50	11	25	38	52	66
60	16	32	49	66	83
70	20	40	60	80	100
80	24	48	71	94	100
90	29	55	82	100	100
100	33	63	94	100	100

In using the tables, a clinician should scan down the left column to the patient's approximate age, move across the table to find a figure nearest to the observed wear score for the tooth being considered, and then read down that column to estimate how scores will increase with age. For example, Fig 4a shows the occlusal surface of the maxillary left first molar of a 26-year-old male. By referring to the wear score chart, Fig 1, an approximate score of 20 would be assigned to this tooth (two small areas of exposed dentine are evident on the cusp tips). The relevant scoring chart (Table 3) can then be consulted to predict how wear will progress with age. In this case, the clinician would look down the age column to the nearest age (in this case 30 years) and then scan across the columns to find the score nearest to 20 (in this case the fourth column containing the score 22). Scores for subsequent ages can then be obtained by reading down the column where a score of 37 is predicted at age 40 years, 51 at age 50 years, 66 at age 60 years and so on.

Using the simplest method, the graph Fig 3 can be consulted to assess scores. For example, Fig 4b shows the occlusal surface of the maxillary right first molar of a 64-year-old male. The wear score obtained for this tooth from the scoring chart Fig 2 is approximately 85 (i.e., the score is more than 80 because enamel has been

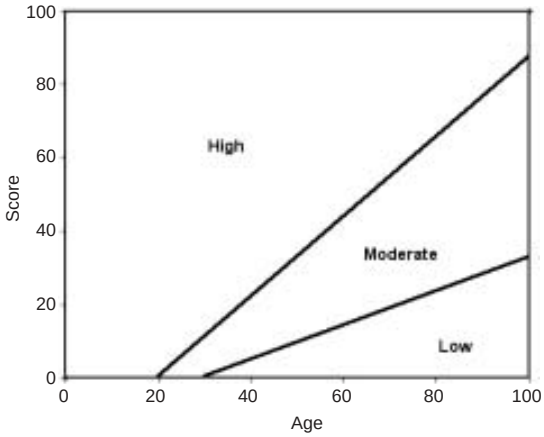

Fig 3. Graph for estimation of low (scores of less than 30 by age 100 years), moderate (scores between 30 and 90 by age 100 years), and high (scores greater than 90 by age 100 years) wear rates.

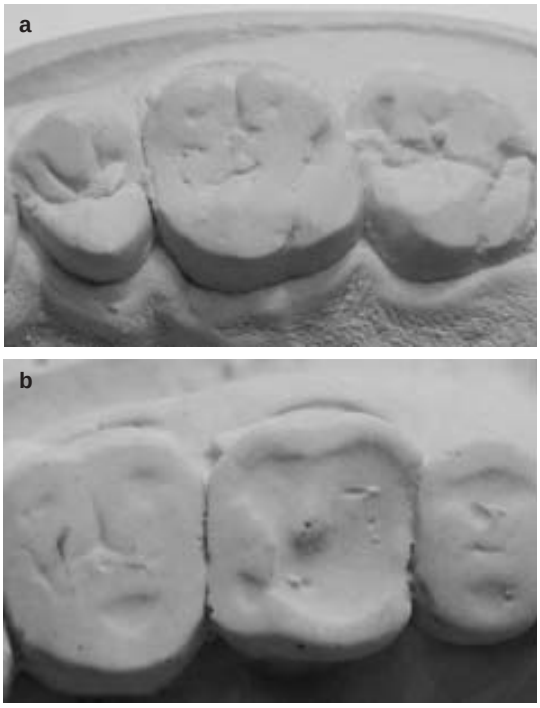

Fig 4. Occlusal views of the maxillary left first molar of a 26-year-old male with a wear score of approximately 20 (a) and of the maxillary right first molar of a 64-year-old male with a score of approximately 85 (b).

lost from all four cusps and the areas of exposed dentine have merged, but the score is less than 90 because there is still some remaining enamel on the occlusal surface). By referring to Fig 3 this patient can be assigned to the 'high wear' group. Future wear scores can be estimated using this method by projecting a straight line with its origin at approximately age=20 and score=0 through a point corresponding to the patient's current age and score.

CONCLUSION

Established relationships between age and tooth wear scores enable mathematical models to be formulated that describe the relationships between age and tooth wear scores. These models can be used to calculate expected wear scores at subsequent ages, or to establish whether observed patterns of wear are acceptable, given a patient's age. The reliability of these estimates and predictions is dependent on the continuation of previously acting aetiological factors. In cases where there is no reason to believe that aetiological factors have changed significantly over time, data obtained from the models described can assist clinicians to plan appropriate treatment for patients presenting with problems associated with tooth wear. However, the prediction of rates of progress of tooth wear is a complex problem that is made more difficult by the episodic nature of many of the possible aetiological factor such as erosion resulting from intrinsic and extrinsic factors.

Table 3. Tooth wear scores for the maxillary first molar calculated to give scores of 20, 40, 60, 80 and 100 at age 70 years

Age	Predicted wear scores				
20	0	0	4	8	12
30	0	8	15	22	30
40	5	16	26	37	47
50	10	24	37	51	65
60	15	32	49	66	82
70	20	40	60	80	100
80	25	48	71	94	100
90	30	56	83	100	100
100	35	64	94	100	100

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