Research Protocol
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Dentistry Section

Assessment of a New Regression Equation for Mixed Dentition Space Analysis in Paediatric Population of Wardha, Maharashtra, India- A Research Protocol

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ABSTRACT

Introduction: Prediction of the mesiodistal crown width of unerupted canines and premolars in mixed dentition analysis is crucial. When Tanaka-Johnston's equations, the most popular approach, are applied to diverse ethnic groups, their accuracy is questioned.

Aim: To derive a new regression equation of mixed dentition space analysis for predicting the size of unerupted canines and premolars teeth among paediatric population of Wardha, Maharashtra, India.

Materials and Methods: The study will be conducted in two phases. The study design for First phase is observational and second phase is interventional. Dental study casts of 400 patients aged 11-18 years will be selected in the first phase. A Digital Vernier Caliper (DVC) will be used to measure the mesiodistal crown dimension of all erupted permanent teeth up to first molar. Between four mandibular incisors and the canine-premolar segments of both arches, correlation and linear regression equations will be created. In the second phase, 30 children aged 6-11 years will be randomly selected. Analysis of Tanaka-Johnston's equations, Huckaba GW equation and the proposed equation will be compared and further statistical analysis will be carried out.

Results: New derived regression equation will allow the closer prediction of the size of unerupted canines and premolars in the paediatric population of Wardha.

Conclusion: This new equation will allow an accurate prediction of the width of unerupted canines and premolars at an earlier age in the said population.

Keywords: Canine, Children, Huckaba's analysis, Mesiodistal width, Permanent, Premolar, Tanaka-Johnston's analysis, Unerupted

INTRODUCTION

The study of mixed dentition is a significant part of an orthodontic diagnosis. In this analysis, mesiodistal width of unerupted permanent canines and premolars are predicted and space that is available is assessed if there is sufficient space for unerupted teeth. Treatment can be planned according to this prediction ranging from simple and conservative procedures that include constant follow-up and observation, space maintenance, eruption guidance, expansion and regaining space to a more complicated treatment plan that is serial extraction [1,2].

The earliest attempt to predict the tooth size was done by GV Black. However, due to high individual variability in tooth size the data was unreliable clinically [3]. A significant linear correlation between the mesiodistal size of the permanent canines and premolars and the mesiodistal size of the lower permanent incisors was observed by Carey CW [4]. Many attempts have been made since then to evaluate the sizes of unerupted permanent teeth [4-6].

Among various methods of mixed dentition space analysis, Tanaka-Johnston's method is the most commonly used in which the regression equation is based on the erupted permanent mandibular incisors [7]. The advantage of the method proposed by Tanaka and Johnston's method (1974) is that it does not require a radiograph. It is based on a prediction equation derived from mesiodistal width of erupted permanent teeth during the period of mixed dentition. However, the size of unerupted teeth is likely to be overestimated by this method [8]. The other method, which involves radiographs, has the advantage of being able to measure unerupted teeth and providing more precise results, but it exposes patients to ionising radiation and necessitates extra radiographs and expenditures [8].

Huckaba GW introduced the radiographic method in 1964. In this method, he used an equation related to the measurement of teeth that are erupted to their radiographic images to get proportionate sizes of unerupted teeth to overcome the effect of radiographic distortion [8].

Among different populations and civilizations, it was found that mesiodistal width of teeth varies considerably because of environmental and genetic factors. Moreover, according to some studies sexual dimorphism was seen in tooth sizes [9-12]. Therefore, accuracy may be uncertain in the published norms when they are applied to different ethnicities. Therefore, for each ethnic group, particular predictive data may be necessary. However, a good association between the dimension of canines and premolars and the dimension of permanent lower incisors is based on some predictive equation methods [13]. While, in a survey of the Syrian population, Nourallah AW et al., observed that there was an improvement in survey results when the sum of the width of upper first molars and lower central incisors as predictors was applied as compared to the total width of permanent mandibular four incisors [2].

As mandibular incisors are the first teeth to erupt in the permanent teeth and if their dimensions could perhaps be used for predicting the width of unerupted teeth, then it may be advantageous for analysis of mixed dentition at an early age [13]. The concept of regression equations was suggested by different authors and was often applied to estimate the sizes of unerupted canines and premolars teeth. But these methods tend to overestimate or underestimate the size of tooth width, and a new regression equation need to be proposed for a more accurate prediction of these teeth [8].

Objectives

1. To derive a new regression equation for space analysis of mixed dentition for predicting the size of unerupted permanent canines and premolars teeth among paediatric population of Wardha, Maharashtra, India.
2. To assess the accuracy of the new regression equation by comparing the prediction values of the mesiodistal width of unerupted canines and premolars calculated by the Tanaka and Johnston's method and the Huckaba method.

MATERIALS AND METHODS

The study will be conducted in two phases. The study design of first phase will be a retrospective observational in which cast selection of the 400 patients who reported to the Department of Paediatric and Preventive Dentistry for the treatment will be done. The study design of second phase will be cross-sectional in which 30 children will be selected. There will be random selection of the patient according to selection criteria. Total time period required for the study will be two years. Ethical approval for the study was obtained from the Institutional Ethics Committee (Ref ID no. IEC/2022/758).

Phase-I

A retrospective observational phase in which first cast selection will be done. The dental study casts of 400 patients aged 11-18 years who will report to the Sharad Pawar Dental College for treatment will be chosen according to the selection criteria. An informed consent will not be taken in first phase. All casts should fulfill the selection criteria and will be included in the study.

Inclusion and Exclusion criteria: All the permanent teeth fully erupted in both jaws (upto first permanent molar on both sides) will be included in the study. All restorations or interproximal caries, previous orthodontic treatment, attrition, and changes in tooth shape, size, or number will be excluded from the study.

Sample size calculation:

Sample size (N)=$Z_{1-\alpha/2}\sigma^2/d^2$

Primary variable: Mandibular incisors Mean Score=23.20 Standard deviation= 1.52 (13).

$Z_{1-\alpha/2}$ at 5%=1.96

Margin for error d %=10% of mean=2.320

Minimum samples required=(1.96 * (1.52)^2)/2.320=385

Methodology: The highest mesiodistal widths of the crown of permanent teeth (including incisors, canines, premolars, and first molars) in both the upper and lower arches will be measured. The mesiodistal width of the teeth will be measured with a Digital Vernier Caliper (DVC) with a 0.01 mm repeatability, 0.02 mm accuracy, and 0.01 mm resolution (manufacturer standard). As a result, the interproximal contact points of the tooth's maximal width will be measured right angle to the tooth's long axis and parallel to the occlusal surface.

To check the reliability, the plaster casts will be measured by two investigators who will be blinded to the subjects and each other. The primary investigator (AB) will measure five pairs of models twice, separated by 24 hours, as part of the intraexaminer calibration method. The intraexaminer calibration will be done against a team of expert doctors who will measure the five model pairs twice, separated by 24 hours. Only 10 plaster casts will be measured and chosen at random. To determine measurement consistency, the intra-class correlation coefficient will be employed [14]. To generate equations, the linear regression method will be used for predicting the sum of the width of the canines and premolars in either jaw. The regression equation will be expressed as:

Y=a+bx

Where,

- Y is dependent variable which indicates the predicted sum of the mesiodistal widths (in millimetres) of the permanent canines and premolars on both sides.
- X is independent variable which indicates the sum of the m-d widths of the four mandibular permanent incisors.
- The constants 'a' and 'b' will be obtained for both genders from the population together as well as separately.

The Standard Errors of the Estimates (SEE), correlation coefficients (r), and coefficients of determination (r2) will also be calculated. The regression equation's prediction accuracy for Y based on X values is represented by r2 values. Otherwise, r2 values represent the regression models' power [13].

To predict the total mesiodistal widths of premolars and canines, new regression equations based on the total mesiodistal widths of four mandibular permanent incisors will be used. These teeth will be used as a reference due to their earlier eruption. Standard errors, correlation coefficients (r), and coefficients of determination (r2) will also be determined.

Statistical analysis: To determine measurement consistency and interexaminer calibration, unpaired and paired t-tests will be performed. An unpaired t-test will be employed for the determination of right/left side and sex differences. The actual and predicted total width of permanent premolars and canines will also be compared using a paired t-test [15].

Phase-II

This phase will be cross-sectional in which 30 children (6-11 years old) with mixed dentitions (with the exception of 2nd and 3rd molars) will be randomly chosen from the Department of Paediatrics and Preventive dentistry of Dental College and written informed consent will be taken from the parents regarding participation in the study. Patients will be screened for the selection criteria.

Inclusion and Exclusion criteria: All patients with mixed dentition arch, which includes the four permanent mandibular incisors and complete record (including cast and periapical radiographs) were included in the study. All partially erupted mandibular incisors, congenital craniofacial anomalies and previous orthodontic treatment were excluded from the study.

Sample size calculation:

Sample size by correlation formula

$$n>=\left(\frac{Z^{1-\alpha}/2+Z_{1-\beta}}{\frac{1}{2}\log\frac{1+r}{2+r}}\right)^2$$

Dependent variable=The predicted sum of the m-d widths (in millimetres) of the permanent canine and premolars on both sides.

Independent variable=The sum of the mesiodistal widths of the four mandibular permanent incisors.

The predicted sum of the mesiodistal widths (in millimetres) of the permanent canine and premolars versus sum of the mesiodistal widths of the four mandibular permanent incisors; Pearson correlation (r)=0.7 [13]. Minimum sample size required N=14.

Methodology: High-quality alginate will be used for all impressions and study casts will be obtained. All the dental models will be made of high-grade orthodontic dental stone. The plaster models of mandibular and maxillary dental arches of 30 individuals aged 6-11 years old (both genders) will be fabricated. The first investigator will measure the required space using the two methods considered. The measurements will be repeated after 15 days, with each one being repeated twice in order to determine the reproducibility and repeatability conditions, as well as the random and systematic errors for each method. The present study will be conducted to determine the reliability of the actually derived formula, Tanaka and Johnston's method (based on the sum of permanent lower incisors), and the radiographic technique of Huckaba.

I) Tanaka-Johnston's space analysis: To anticipate tooth size, no additional radiographs or tables are required. It can be applied to both the arches [7].

- Mesiodistal width of unerupted mandibular canines and premolars will be calculated according to Tanaka-Johnson's method by the 'Sum of Half the Mesiodistal width of four lower incisors with 10.5 is equal to the Mesiodistal width of maxillary canines and premolars in one quadrant' [16].
- Mesiodistal width of unerupted maxillary canines and premolars will be calculated according to Tanaka-Johnson's method by the 'Sum of Half the mesiodistal width of four lower incisors with 11 is equal to the mesiodistal width of mandibular canines and premolars in one quadrant' [16].

II) Huckaba space analysis: The DVC will be used to measure the mesiodistal width of teeth. The Enlargement Ratio is calculated for each unerupted permanent tooth by first measuring the closest erupted tooth in the mouth and then in the radiograph [8].

Subsequently, the below-mentioned equation will be used [16]:

X=X'Y/Y'

Where,

Y' represents the Width of a primary tooth on IOPA,

X' represents the Width of its underlying successor on IOPA,

Y represents the Width of a primary tooth on the cast and

X represents the Width of an unerupted permanent tooth

X-ray mesiodistal width of deciduous×Real mesiodistal width of deciduous.

X-ray mesiodistal width of the permanent   Real mesiodistal width of the permanent

III) The new regression equation: Linear regression will be used to derive equations to predict the sum of the mesiodistal widths of the canines and premolars in either jaw. Individual regression equations for maxilla and mandible will be made based on the sum of incisors.

The regression equation will be expressed as Y=a+bX.

Calculation of R-value (Correlation coefficient): The linear relationship between different tooth-type combinations and the total of the unerupted canines and premolars will be evaluated by means of the Pearson correlation coefficient [17]. To compare the actual values of these teeth with the values generated from the prediction tables, a Student t-test, and correlation coefficients will be calculated. The size of each side's canines and premolars will be compared between sexes using a Student t-test [18].

STATISTICAL ANALYSIS

For phase II all analyses will be performed on Statistical Package for Social Sciences (SPSS,Chicago: SPSS Inc) version 16.0 software. Data will be summarised as mean±Standard Deviation (SD). Analysis Of Variance (ANOVA) of the regression equations will be performed while independent groups will be compared by Independent student's t-test. A simple linear regression will be used to assess the relative association between the variables considering the sum of all three values, the independent variable (X) and the actual width as the dependent variable (Y) [14,19].

RESULTS

Expected outcome: New derived regression equation will allow the closer prediction of the size of unerupted canines and premolars in the paediatric population of Wardha.

DISCUSSION

Based on mixed dentition analysis, two regression equations and their applicability was evaluated by Bhatnagar A et al., and a New Regression Equation (NRE) for predicting the size of unerupted permanent canines and premolars teeth in school children utilising the permanent mandibular incisors and first molars as predictors was proposed and evaluated. Dental study casts of 100 children aged 11-14 years (50 males and 50 females) from Moradabad, Uttar Pradesh, India, were used. An electronic DVC was used to measure the mesiodistal widths of mandibular and maxillary first molars, canines and premolars and permanent incisors. The intraexaminer calibration was done. The analysis of Bernabe Flores-Mir, Tanaka Johnston, and the proposed equation was verified on the casts. Bernabe's Flores-research Mir and Tanaka Johnston's analysis tended to overestimate the canines and premolars mesiodistal crown width. The proposed equation was overstated as well, although the mean difference was closer to the actual observed values than the other two equations [14].

In an Iranian population, Toodehzaeim MH et al., created an NRE in mixed dentition, to calculate the mesiodistal width of the crown of unerupted canines and premolars. A total of 120 Iranian patients with complete permanent teeth were chosen and dental casts were made. A digital caliper was used to calibrate mesiodistal widths of teeth. The study began with the development of correlation and linear regression equations between the C-PM segments of both upper and lower arches and four mandibular incisors (modified Tanaka-Johnston equation). The second portion of the study generated correlation and linear regression equations between the total of maxillary first molars, canines and premolars segments, and mandibular central incisors as a novel technique. The correlation coefficients between the sum of maxillary first molars- mandibular central incisors and the mandibular and maxillary canine-premolars segments were more than the correlation coefficients between the four mandibular incisors and maxillary and mandibular canines and premolars segment. New linear regression equations were derived. The sum of upper first molars and lower central incisors was found to be a stronger predictor of unerupted canines and premolars than the sum of maxillary first molars and central incisors of the mandibular arch. This unique method allows for early estimation of the width of unerupted canines and premolars [13].

In the Bengali population, Dasgupta B et al., conducted a comparison of the two mixed dentition space analyses. Dental casts of mandibular and maxillary arches with permanent dentitions were made for a total of seventy Bengali children. The mesiodistal crown measurements of all erupted canines and premolars and incisors were calibrated using a digital caliper. For a certain number of mandibular incisors, Tanaka-mixed Jhonson's dentition arch analysis and Moyer's analysis were performed, followed by statistical analysis. The mean, standard deviation, minimum and maximum values, correlation coefficient "r" and unpaired t-tests were all calculated and summed together as descriptive statistics. The mesiodistal width of permanent canines and premolars were underestimated by Tanaka and Johnston's regression formulae. In the Bengali population, however, no statistically significant variations were found between actual canines and premolars mesiodistal widths and predicted widths using the Moyers formula at the 50% level for the maxillary and mandibular arches. With slight changes to their regression models, both Moyer's and Tanaka-Johnston's mixed dentition arch analyses were found to be relevant in the Bengali population [7].

Limitation(s)

The study limited to a small geographic area with smaller sample size in interventional group.

CONCLUSION(S)

A new regression equation will be proposed for better representation of the size of unerupted canines and premolars in the population of Wardha. The study will also assess the validity of the new regression equation in comparison with Tanaka Johnston's and Huckaba's analysis.

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