Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Applicability of Newer Regression Equations and Prediction Tables Among Various Populations for Mixed Dentition Analysis – A Systematic Review

Umapathy Thimmegowda[1], Pradnya Dhamnekar[2]

[1,2]Department of Pediatric and Preventive Dentistry, Rajarajeswari Dental College and Hospital, Bengaluru, Karnataka, India.

(Received: 16 June 2025 Revised: 20 July 2025 Accepted: 04 August 2025)

KEYWORDS

Moyer's analysis, Tanaka-Johnston's analysis, regression equation, prediction tables, mixed dentition

ABSTRACT:

Introduction: Mixed dentition analysis is an important aspect of early orthodontic assessment, helping to determine arch-length tooth-size discrepancies and the space required for aligning canines and premolars. This information helps determine the most suitable treatment options for space management. The most commonly used mixed dentition analysis methods are Moyer's and Tanaka-Johnston's methods.

Objectives: This research aims to evaluate the applicability of mixed dentition analysis methods, along with newer regression equations and prediction tables that have been developed.

Methods: A computerized search was conducted involving articles published on PubMed and Scopus between 2013 and 2023. Inclusion criteria included all permanent teeth, except for second and third molars, which should be present and fully erupted in the mandibular arch. The dental casts had to be of high quality, and the sample size needed to be greater than or equal to 40.

Results: A computerized search was conducted involving articles published on PubMed and Scopus between 2013 and 2023. Inclusion criteria included all permanent teeth, except for second and third molars, which should be present and fully erupted in the mandibular arch. The dental casts had to be of high quality, and the sample size needed to be greater than or equal to 40.

Conclusions: Based on the available literature, both Moyers' and Tanaka-Johnston's mixed dentition analyses must be used with caution, as the majority of the analyzed articles indicate that these methods are not as accurate as expected, necessitating the adaptation of probability levels depending on the population.

1. Introduction

Paediatric dentists have a great opportunity to encounter patients in their developmental stage of life.[1] Many malocclusions, especially crowding problems, originate during the mixed dentition period. Earlier diagnosis and management of developing malocclusions help resolve the problem effectively.[2]

During the mixed dentition stage, which lasts from six to twelve years, both permanent and deciduous teeth are present. This stage allows for predicting tooth crowding or spacing and making accurate forecasts about future dental growth.[3] Because it is the most dynamic phase in terms of occlusal alterations and the eventual dentoskeletal relationship outcome, it enables the prediction of the mesiodistal width of permanent canines and premolars that have not yet erupted.[4] In interceptive orthodontic treatment planning, it is crucial to predict the space needed and available for unerupted canines and premolars in the arch, and this determination must be made before the eruption of canines and premolars by a method called Mixed Dentition Space Analysis (MDSA).[3]

The MDSA is a crucial parameter for deciding whether the orthodontic treatment plan will include space maintenance, space regaining, guidance of eruption, serial extraction, or merely periodic patient observation. Accurately forecasting the mesiodistal width of the unerupted permanent teeth is necessary to determine the size-arch length disparity in mixed dentition.[1]

Three considerations must be made to complete an analysis of mixed dentition.

(1) the sizes of all the permanent teeth anterior to the first permanent molar; (2) the arch perimeter; and (3) expected changes in the arch perimeter which may occur with growth and development.[5]

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Several crucial elements make mixed dentition analysis more applicable, including the dentist's ease of use, the minimal amount of time needed, the possibility of a predictable methodical error, whether or not special tools are needed, and whether or not it can be performed directly on both the maxillary and mandibular dentitions.[5]

Space analysis in mixed dentition can be grouped into three categories: [6]

(1) those in which the sizes of the unerupted cuspids and premolars are estimated from measurements of the radiographic image; Moyers' 1958 and Tanaka Johnson's 1974 methods use a regression equation to calculate the mesio-distal width of erupted teeth; [1]

(2) those in which the sizes of the cuspids and premolars are derived from knowledge of the sizes of permanent teeth already erupted in the mouth (use of regression equation); Nance 1947, Bull 1959, and Huckaba 1964 methods use measurement of the unerupted teeth on the radiograph; and [1]

(3) combination of both methods; Hixon Oldfather 1958, Staley and Karber 1980 method, which uses a combination of the above two techniques.[1]

Of all the mixed dentition analyses, the regression equations based on already erupted permanent teeth are used most widely.

2. Objectives

This research aims to evaluate the applicability of mixed dentition analysis methods along with newer regression equations and prediction tables that have been developed.

3. Methods

A computerized search was conducted using research articles published from January 2013 to February 2024 on PubMed (http://www.ncbi.nlm. nih.gov/pubmed/), Scopus. The keywords used and the number of articles found are shown in Table 1. The keywords were inserted into the databases without restricting the period of publication of articles.

The inclusion criteria involved:

- Sample greater than or equal to 40.
- All permanent teeth (except second and third molars) should be present and fully erupted in the mandibular arch.
- The dental casts had to be of high quality.

Conversely, the exclusion criteria were:

- Those who had crowded, spaced, malformed, or missing teeth, interproximal caries, interproximal restorations, or had a history of orthodontic treatment.
- Dental casts of patients with some type of syndromes or cleft patients.
- Literature reviews, clinical case reports, and research carried out before 2013.

The reviewer independently assessed all the articles' abstracts. All the abstracts meeting the initial inclusion criteria were selected; those that did not provide enough information to determine the suitability to the inclusion criteria were also selected, so that the final decision would be made with the complete article. (Table 1)

Table 1: Articles collected using the keywords

Number	Keyword	PubMed	SCOPUS
1.	Mixed dentition analysis	1,005	59
2.	Moyers analysis	53	24
3.	Regression equation	82	20
4.	Tanaka Johnston's analysis	53	24

4. Results

The research resulted in a sample composed of 1064 articles. After analysing them according to the inclusion/exclusion criteria, articles were selected for analysis, 49 from the PubMed database, and 39 articles were selected from the Scopus database. The final total number of articles was 49, since all 39 articles from Scopus were duplicated in the search results. The number of selected articles and methodological criteria of the systematic review are shown in Table 2. The final number of articles that were considered for this review was 49.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Table 2: The total number of articles considered in the study

Keyword/ Pubmed Database	Studies included	Studies excluded	Total
Mixed dentition analysis	49	956	1005
Mixed dentition analysis AND Moyers analysis	25	28	53
Mixed dentition analysis AND Tanaka Johnston's analysis	25	28	53
Mixed dentition analysis AND regression equations	30	52	82
Keyword/ Scopus Database	**Studies included**	**Studies excluded**	**Total**
Mixed dentition analysis	39	20	59
Mixed dentition analysis AND Moyers analysis	20	4	24
Mixed dentition analysis AND Tanaka Johnston's analysis	22	2	24
Mixed dentition analysis AND regression equations	18	2	20

A total of 1015 articles were excluded. The reasons for exclusion and the number of excluded articles are listed in Table 3.

Table 3: Number of article that were excluded

Reasons for exclusion	Pubmed	Scopus	Total
Sample with less than 40 subjects	-	-	-
Moyers and tanaka analysis was not used	15	4	19
Research was not about predicting space	333	5	338
Literature review/ case reports	63	20	83
Research conducted prior 2013	545	30	575
Total excluded studies	956	59	1015

Most articles were excluded because they were not related to the prediction of unerupted canines and premolars, followed by articles published outside the stipulated period.

Among 49 articles, 48 articles were entirely read, except the article written 01, which had to be evaluated by the title and abstract in English.

Among 49 articles, 32 enabled the use of Moyers' analysis, and 36 used Tanaka-Johnston analysis.

Among the Moyer's, only 28 articles used a probability level of 75% in both arches and both genders.

In 13 articles, the probability table had to be adapted in order to make the Moyers' analysis appropriate to their population.

5. Discussion

Mixed dentition analysis is a crucial component of an early orthodontic assessment and aids in determining any tooth size-arch length discrepancy.[2] The use of an inappropriate method may hinder the entire treatment plan because both over-estimation and underestimation of crown diameters of unerupted canines and premolars can influence treatment planning, especially decisions regarding extractions.[4] Among the various methods, the radiographic methods had some drawbacks in terms of magnification errors, whereas the prediction equation and table tend to overestimate or underestimate the size of unerupted canines and premolars.[7]

The most widely utilised techniques are Tanaka and Johnston's prediction equation and Moyers' probability tables. The predictive accuracy of these techniques on populations of other races is questionable, though, given that they were created on Caucasian populations.

As a result, probability tables and prediction formulae for various populations were developed.[5]

Recent studies have shown that Moyers' prediction tables are not accurate or applicable to populations of different ethnic origins due to the 75% accuracy of the values obtained. The biggest clinical problem occurs when the predicted values underestimate the real values, causing insufficient space for proper tooth alignment. Overestimating the real values results in more space for posterior teeth, which is not considered a real clinical issue.[8]

Various studies have used Moyers and Tanaka-Johnston's methods for mixed dentition analysis. Among the 49 articles included in the review, 28 of the studies were conducted on the Indian population, whereas 21 studies were on the non-Indian population. Among the studies involved, 32 used Moyer's analysis method and 36 used Tanaka-Johnson's method.7,9-56 (Tables 4 and 5)

Moyers' analysis is used at various percentile intervals ranging from the 15th to – 90th percentile. Among the

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

studies reviewed in this article, the most commonly used percentile level is the 75th percentile. Various studies have found that Moyers' analysis gave adequate values[11,13,16,18,19,22,25,38,44] Whereas Moyers' probability tables underestimated the real values at various percentile values used in some populations.[10,24-26,33,45,49] Contrastingly, in other studies, the predicted values overestimated the real ones.[7,9,14-17,19,20,23-26,30-34,36,38,40,42,46,48,50,55] This means that Moyers' mixed dentition space analysis was not appropriate for most populations evaluated.

Various studies were conducted in India to see the applicability of Moyers' probability table. Shah et al conducted Moyers' analysis in the Gujarati population and found that the probability tables overestimated the tooth size.[9] Ramesh N et al performed the analysis in Kodava and found that the tooth sizes were overestimated more in males than in females at a 75% level.[14] Kaur et al and Mittal S et al conducted studies on the Himachal population and concluded that at 50 % and 75%, the tooth dimensions were overestimated in both genders.[16,23] Goyal R K et al and Suruchi et al conducted Moyers analysis in the North Indian population, where the tooth size was overestimated for both genders at the 50th and 75th percentile, respectively.[17,20] Maroli et al analyzed the Keralite and Bengali populations at the 75th, 65th, and 50th percentiles.[19] Shobha MB et al conducted a study in Andhra Pradesh, where the analysis overestimated the values in males at the 75th percentile.[24] Baheti K et al concluded that Moyers overestimated the values at the 75th percentile in a study conducted in Jodhpur.[25] Kamatham R et al, Kakkar A et al, and Bhatnagar A et al concluded that Moyers' analysis overestimated the values when used at the 75th percentile in South Andhra Pradesh, Rajasthan, and Aligarh, respectively.[26,30,31] Ravinthar K et al tested the reliability of Moyers in the Chennai population and found that it overestimated the values in males.[32]

Table 4: The applicability and outcomes of these space analyses on the Indian population.

Sl. No	Author	Study population age (yrs)	Space analysis used	Percentile level used	Predicted value and Gender variation (mesiodistal widths of permanent canines and premolars)
1	Shah S et al 2013 [9]	Contemporary India (Gujarat population) 12-14	Moyer's	75th percentile confidence level	Moyers probability tables underestimate tooth sizes of the present Gujarati population
2	Singh V et al 2013 [10]	Himachal population	Moyer's	30th, 50th and 75th percentile confidence levels	Moyers probability tables underestimate tooth sizes of Himachal population
3	M. Manjula et al 2013 [11]	Nalgonda 13-16	Moyer's and Tanaka-Johnston's	5%, 15%, 25%, 35%, 50%, 65%, 75%, 85% and 95% levels	Can be used at all probability levels. Over-estimated the values in both the genders for both the arches.
4	Tikku et al, 2013 [7]	North India, 16-22	Proposed regression equation of the present study, Moyer's, Melgaco regression equation	75th percentile confidence level	The correlation and determination coefficients found in the recent study regression equation were highest, followed by Melgaco regression equation and the least in Moyer's probability chart.
5	Srivastava B et al 2013 [12]	Western UP 14-17	Tanaka-Johnston's analysis	-	Tanaka and Johnston's method of prediction showed an overestimation of the mesio-distal tooth widths in the western UP Indian population.
6	Kommineni NK et al 2014 [13]	Chennai, 2014	Moyer's analysis and Tanaka-Johnston's analysis	25%, 35%, 50%, 65% probability level	Can be applicable closer to 50% probability level Overestimated for both genders.
7	Ramesh N et al 2014 [14]	Kodava, 16-23	Moyer's analysis and Tanaka-Johnston's analysis	75% confidence level.	At 75%- overestimated values mores in males than females Overestimated for both genders.
8	Kadu A et al 2014 [15]	Haryana, Faridabad <21	Tanaka-Johnston's	-	The current findings suggest that the Tanaka and Johnston prediction method used in its original form is not accurate when applied to a population of mixed Indians
9	Kaur et al 2014 [16]	Baddi, Himachal Pradesh 2014	Moyer's analysis	30th, 50th and 75th percentile confidence levels	At 75% and 50% levels – overestimates the dimensions in both genders. 35% level – more appropriate estimate width values.
10	Goyal RK et al 2014 [17]	North India, 14-22	Moyer's analysis Tanaka-Johnston's	50th percentile Confidence level	Moyer's – at 50th percentile overestimates the values in both genders. Tanaka-Johnston's – overestimates the values by 3.2mm/arch in males and 4.0mm/arch in females.
11	Kondapaka V et al 2015 [18]	Nalgonda, 13-16	Tanaka-Johnston method; Moyer's method	75th percentile confidence level	Moyer's mixed dentition analysis method was found to be reliable method amongst the methods compared in children of Nalgonda population among all the methods
12	Maroli S et al 2015 [19]	Kolkata, Kerala, 12-14	Moyer's analysis	50th, 65th and 75th percentile confidence levels	At 75th percentile level- over predicted the values. At 65th percentile level – may be accepted in case for upper for Bengali male and female and also upper teeth in Keralite females. At 50th percentile level – accepted for Keralite male for both arches and lower arches for females.
13	Suruchi Juneja et al 2015 [20]	North India, 12-16	Moyer's, Tanaka-Johnston's and Bernabe-Flores Mir method	75th percetilr levels	Overestimation of values in both males and females.
14	Hambire CU et al 2015 [21]	Mumbai, 12-15	Tanaka-Johnston's analysis	-	The Tanaka-Johnston prediction method was not accurate for both males and females in Mumbai school children.
15	Umapathy Thimmegowda et al, 2015 [22]	Bangalore, 13-16	Moyer's analysis	50%, 75% confidence levels.	50% is more applicable to boys and 75% to girls
16	Mittal S et al 2016 [23]	Himachal 12-14	Moyer's and Melgaco	75th percentile level	Overpredicted the values However, Melgaco gave better prediction value comparatively. No significant gender difference noted.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

17	Shobha MB et al 2016[24]	Andhra Pradesh, 13-15	Moyer's Tanaka-Johnston's	50% and 75% levels	Males: 75% level - overestimation both arches 50% - approximate values Females: 75% underestimation for maxilla and overestimation in mandible 50% - underestimation Males: overestimated Females: overestimated
18	Baheti K et al. 2016[25]	Jodhpur, 13-16	Moyer's analysis	35th, 50th and 75th percentile levels	At 75th percentile- Overestimation At 50th and 35th percentile – Underestimates the actual values in both the genders.
19	Kamatham R et al 2017[26]	Nellore, 2017	Tanaka-Johnston's Moyer's analysis	35%, 50%, 65%, 75% levels	Tanaka-Johnston's – Overestimated for both the genders Moyer's – Overestimation at 75%, Underestimate at 35%.
20	Grover N et al 2017[27]	Lucknow, 11-15	Moyer's analysis Tanaka-Johnston's	75th percentile levels	Moyer's-Females: Underestimated Males: Overestimated Tanaka-Johnston's-Males: Underestimated Females: Overestimated
21	Umapathy Thimmegowda et al 2017[28]	Bangalore, 13-6	Tanaka-Johnston's method	-	Overestimated values for both upper and lower arches for both genders.
22	Bhatnagar A et al 2018[29]	Moradabad, 11-14	Tanaka-Johnston, Bernabe-Flores, Mir and Ling-Wong regression equations	-	Overestimated values in both genders.
23	Kakkar A et al 2019[30]	Sri Ganganagar 11-14	Moyer's, Tanaka-Johnston's and Bernabe-Flores Mir method	50th and 75th percentile levels	Overestimated values in both the genders and in the both the arches
24	Bhatnagar A et al 2019[31]	Aligarh 11-14	Moyer's, Tanaka-Johnston's	75th percentile level	Moyer's at 75% and Tanaka-Johnston's overestimated values in both the genders.
25	Ravinthar K et al 2020[32]	Chennai 11-13 years	Moyer's, Tanaka-Johnston's	75th percentile level	Males- Overestimated values by both the analyses. Females- Moyer's underestimated Tanaka- Johnston's overestimated
26	Doda et al 2021[33]	North Indian 12-15	Moyers's Tanaka-Johnston's	35th, 50th,65th, 75th and 85th percentile levels	Overestimated values in both the jaws of both the genders at all probability levels, except under-estimated in females mandibular arch only at 35% and 50% in maxillary arch Overestimated the values in both the jaws of both the genders.
27	Gaur S et al 2022[34]	Kanpur 12-15 years	Moyer's Tanaka-Johnston's	15% - 95% levels	50 and 65% probability levels for the upper jaw – male subjects At 65% probability levels and 75% in upper and lower jaws in females At 65% probability level for the upper and lower jaw in combined sample Couldn't foresee the mesiodistal the mesiodistal widths of canines and premolars
28	Bangi S L et al 2022[35]	North Karnataka 11-16	Tanaka-Johnston's	-	Overestimated values in both the genders and in the both the arches.

Doda et al found that Moyers' analysis overestimates the values at all levels except at the 35th percentile.[33] Gaur S et al concluded that Moyers' analysis overestimated the values at the 50th and 65th percentile in the maxilla in males, whereas at the 65th and 75th percentile for both arches in females.[34]

Singh V et al concluded that Moyers' probability tables underestimate the tooth size at the 75th percentile in the Himachal population.[10] Shobha MB et al found that the analysis underestimated the values in females at the 75th percentile.[24] Whereas in a study by Baheti et al found that the values were underestimated in both genders at the 50th and 35th percentiles.[25] Kamathan et al and Doda et al found that in the south Indian population, the values were estimated at the 35th percentile, and in the population, it was underestimated in females for mandible at the 35th percentile and for maxilla at both the 35th and 50th percentiles.[26,33]

Manjula et al found that Moyers' analysis can be used at all probability levels (5% to 95%) in the Nalgonda population.[11] Kommineni et al found that the Moyers prediction table was applicable at the 50th percentile in the Chennai population.[13] Study by Kondappa et al concluded that the values were most reliable at the 75th percentile in the Nalgonda region.[18] In a study by Kaur et al, the values gave appropriate values at the 35th percentile in the Himachal population.[16] Maroli et al found that at 65th percentile may be accepted in case of upper teeth in Bengali males and females, and also in Keralite females, whereas the values at 50th percentile were accepted for Keralite males in both arches and lower arches for females.[19] Umapathy et al found that the values at the 50th percentile were applicable in boys, whereas values at the 75th percentile were applicable in girls.[22] Baheti et al found that in the Jodhpur population, the values were most reliable at the 50th percentile in females and 65th percentile in males.[25]

Studies verifying the applicability of Tanaka-Johnston's analysis found that in a few studies, the predicted values underestimated the real values.[18,27] In other studies, the predicted values overestimated the real ones.[11,12-15,17, 20,21,24,26-34] This means that Tanaka-Johnston's mixed dentition space analysis was not appropriate for most populations evaluated. (Table 4)

Various studies have been conducted to check the reliability of Tanaka-Johnston's analysis. Studies conducted by various researchers in different Indian populations found that the Tanaka-Johnston method overestimated the values in both genders.[11-13, 15, 20, 21, 24, 26, 28-34] Also a study by Ramesh et al found that the Tanaka-Johnston method overpredicted the values in the maxillary arch in both genders in the Kodava population.[14] Another study by Goyal R K et al in the North Indian population overestimates the values by 3.2mm/arch in males and 4.0mm/arch in females.[17] Grover et al found that Tanaka-Johnston's method overpredicted the values only in female children in

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Lucknow.[27] In contrast to the above studies, research conducted by Kondappa V et al. found that Tanaka-Johnston's method underestimated the values in both genders in Nalgonda, whereas Grover et al. found the values to be overestimated only in male children in the Lucknow population.[18,27]

Various studies have been conducted in foreign populations to assess the reliability of Moyers and Tanaka-Johnston's methods on different ethnic groups. (Table 5) A study by Bugaighis et al in Libyan school children found that Moyers' analysis overestimated the values in both male and female children at the 35th, 50th, and 75th percentiles.[36] A study by Brito F C et al in Brazil found that at the 75th percentile, the values were overestimated by 1.4mm in males and 1.9 mm in females.[40] Another study by Burhan A S et al in the Iranian population found that at the 75th percentile, the values were overestimated in females, but were comparable with males, whereas at the 50th percentile, the values were underestimated in males, but comparable with females.[38]

Table 5: Applicability and outcomes of these space analyses in non- Indian population are summarized and tabulated.

Sl. no	Author	Study population age (yrs)	Space analysis used	Percentile level used	Predicted value and Gender variation (mesiodistal widths of permanent canines and premolars)
1	Bugaighis et al 2013[36]	Libya 12-17	Moyer's and Tanaka-Johnston's	35%, 50%, 75%, levels	Underestimated at 35th percentile and overestimated at 50th and 75th percentile for both genders. Overestimated the values in both maxillary and mandibular arches
2	Toodehzaeim MH et al 2013[37]	Iran 14-25	Tanaka-Johnston's	-	Overestimated the values in males and females in both arches.
3	Burhan A S et al 2014[38]	Syrian 18-21	Moyer's and Tanaka-Johnston's	50th and 75th percentile levels	Males: underestimated the values at 50th percentile whereas comparable values at 75th percentile. Females: underestimated the values at 75th percentile whereas comparable values at 50th percentile. Overestimate the actual values of the sum of the mesiodistal widths of the permanent canines and premolars for both genders.
4	Tayyab M et al 2014[39]	Peshawar 15-27	Tanaka-Johnston's	-	Tanaka and Jhonston method is valid for predicting the size of unerupted canine and premolars in both jaws for males as well females.
5	Brito F C 2014 [40]	Brazil	Moyer's and Tanaka-Johnston's	75th percentile levels	At 75%- overestimate the actual values of the sum of nbthe mesiodistal widths of the permanent canines and premolars. Overestimate the actual values of the sum of the mesiodistal widths of the permanent canines and premolars for both genders.
6	Asiry A M et al 2014[41]	Saudi Arabia 13-20	Tanaka-Johnston's	-	overestimated the sum of mesiodistal widths of mandibular and maxillary canines and premolars for male and female patients.
7	Al-Kabab F A et al 2014[42]	Yemen 12-14	Moyers	35th, 50th and 75th percentile	overestimate the mesio-distal widths of the un-erupted permanent canine and premolars of Yemeni in almost all percentile levels, including the commonly used 50% and 75% levels.
8	Da Cruz B S et al 2014[43]	Brazil 6-11	Tanaka-Johnston's and	-	A good correlation was noted in the Tanaka-Johnston's analysis.
9	Sherpa et al 2015[44]	Chinese 16-21	Moyer's and Tanaka-Johnston's	5th – 95th percentile levels	Could be used at 85th percentile for the maxilla and the 75th percentile in the mandible for males; and the 75th percentile for the mandible in female. Overestimates the values, although is more precise for the upper arch in males.
10	Parades et al 2015[45]	Spain 11- 19	Moyer's and Tanaka-Johnston's	5th – 95th percentile levels	Under estimates the values Overestimates the values
11	Yousef H. Al-Dlaigan et al 2015[46]	Saudi Arabia 13-20	Moyer's	50th, 60th and 75th percentile	Overestimated the values in males for all percentiles No significant difference at 50th percentile in maxilla and at 65th and 75th percentile for mandible.
12	Alzubir et al 2016[47]	Sudan 13-19	Tanaka-Johnston's	-	Overestimated the values for both males and females.
13	Gyawali et al 2017[48]	Kathmandu,	Moyer's and Tanaka-Johnston's	50th and 75th percentile	The prediction equations of Tanaka-Johnston's and the charts of Moyer's (50% or 75% level of probability) did not accurately predict the values.
14	Giri et al 2018[49]	Nepal	Moyer's Tanaka-Johnston's	50th and 75th percentile	Significant differences seen except at 75th percentile in maxilla for females. Overestimates the values in both the arches for both the arches.
15	Kareem F A et al 2020[50]	Kurdish population 14-20	Moyer's	-	Moyers method to predict the width of PMCs and permanent maxillary premolars has been shown to be inaccurate in a Kurdish population
16	Chong. S.Y et al 2021[51]	Taipei, Taiwan, 12-35	Tanaka-Johnston's	-	Overestimated the values in the upper and lower arches of both the genders in Taiwanese population, except for female lower arches.
17	Hafsa Mahida et al 2021[52]	Karachi, Pakistan 12-30	Tanaka-Johnston's	-	Tanaka and Johnston Method are reliable for analyzing the mixed dentition in a Pakistani population
					with minor, statistically insignificant differences between actual and predict values, and those between the genders.
18	Dahaq WAM et al 2021[53]	Yemen 2021	Tanaka-Johnston's	-	Overestimated the sum of mesiodistal widths of mandibular and maxillary canines and premolars for male and female patients.
19	Kerre et al 2022[54]	Kenyan population 13-17	Tanaka-Johnston's	-	Not accurate in estimating the values in Kenyan population However, inclusion of mandibular permanent molar as predictor tooth resulted in high correlation coefficients.
20	Rehan S A et al 2023[55]	Pakistan 13-18	Moyer's	-	The prediction charts of Moyers in a sample of Pakistani adolescents, was unable to predict the MDWs of unerupted canines and premolars.
21	Salem G A et al 2023[56]	Egyptian population 13-16	Tanaka-johnston's	-	Tanaka and Johnston analysis could not be an accurate diagnostic aid for Egyptian children as overestimated the values.

A study by Al Kabab F A et al conducted in the Yemeni population found that the values were overestimated at all the levels (including 50th and 75th percentile).[42] Another study by Yousef Al-Daigan et al that Moyers' analysis in the Saudi population overestimates at all the percentiles for all the males, whereas no significant difference was seen in females at the 50th percentile for maxilla and at 65th and 75th percentiles for mandible.[45] A study by Gyawali et al found that the values were overpredicted at the 50th and 75th percentiles in the Nepalese population.[48] Studies by Kareem et al and

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Rehan S et al found that the Moyers method was unable to predict and inaccurate in Kurdish and Pakistani population respectively.[50,55]Contratsingly, a study by Sherpa et al in Chinese population predicted appropriate values in males at 85th percentile (maxilla) and 75th percentile (mandible), whereas in females at 75th percentile (mandible) but none of the percentile were precise for maxilla in females.[44] A study by Parades et al Spanish population underestimates the actual values except at the 75th percentile for mandible for both genders and at 85th percentile in males and 90th percentile in females, respectively, in mandible.[45] Another study by Giri et al found that the Moyers method was acceptable only for maxilla in females at the 75th percentile in the Nepali population.[49]

Various studies have been done to assess the reliability of Tanaka-Johnston's method in non-Indian populations. Studies conducted by various researchers in different non-Indian populations found that the Tanaka-Johnston method overestimated the values in both genders.[36-38,40,41,44,45,47,49,52-54] A study by Tayyab et al found that Tanaka-Johnston's method was valid for both genders in Peshawar.[39] Another study by Da Cruz et al in the Brazilian population showed that Tanaka-Johnston's analysis showed a good correlation between the values in both genders.[43] Contrastingly, a study by Chong et al found that the values were underestimated except for the mandible in females in the Taiwanese population.[51] (Table 5)

Racial and Ethnic Differences in Tooth Size

Research indicates that tooth size varies within different racial and ethnic groups, and it is related to genetic, epigenetic, and environmental factors. Since Moyer and Tanaka, and Johnston's prediction equation and tables were developed for North American Caucasian children.[3] So, its applicability in populations of other racial and ethnic origins has been studied and doubted by many researchers.[7,9-56]

Among the various articles reviewed from the studies done Indian population, the MDW sum of unerupted canines and premolars in the maxilla ranged from 23.48 mm in Lucknow population 19.80 mm in people from Uttar Pradesh, whereas MDW sum of unerupted canine and premolars in in mandible ranged from 23.29 mm to 19.87 mm in people from Lucknow and Uttar Pradesh respectively.[17,27]

Among the studies conducted on the non-Indian population, the MDW width in the maxilla ranged from 23.92 mm in the Taiwanese population to 19.16mm in the Yemeni population. Whereas in the mandible, it ranged from 23.25 mm to 17.95 mm in the Taiwanese and Yemeni populations, respectively.[42,51]

The primary factor influencing tooth size is inherited genetic traits passed down through generations. Also, different dietary needs across populations may have led to variations in tooth size and shape over time. Research has shown that individuals of African descent generally have larger teeth, compared to those of European descent, with East Asian populations sometimes falling in between.[8]

Gender Difference in Tooth Size

These methods were not developed for both genders separately, while literature shows that tooth size varies among both males and females, with males having larger teeth than females. Various authors reported that the sex component should also be added as an extra predictor for the estimation of the MDW sum of unerupted canines and premolars based on sexual dimorphism.[3] Females have smaller teeth than males because of sexual dimorphism, meaning males typically have larger body sizes and therefore larger teeth to match, reflecting the need for greater biting force to consume tougher foods; this is a natural evolutionary adaptation where males often require stronger jaws for hunting or chewing hard foods.[57,58] Also there is strong evidence that tooth size is expressed through X-linked inheritance, hypothesizing that the 2 X chromosomes in females might provide a measure of control lacking in males. The significant sex differences in mesiodistal tooth sizes emphasize the importance of developing mixed dentition prediction aids separately for male and female patients, so that a more accurate tooth size prediction can be made during the MDSA.[2] So, regression equations and or tables must be made separate for both males and females.[3]

Many studies have shown sexual dimorphism concerning the sum of mesiodistal width of unerupted canines and premolars, wherein males have larger teeth than their female counterparts.[7,10.12-15,16,20-22,24-28,32,34-38,41,42,44,47,47-52,54] A study by Parades et al found that the mesiodistal width of unerupted canines and premolars in males was greater than in females, but the mesiodistal width of the lower incisors is equal in both male and female

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

populations.[45] **Table 6:** Mesiodistal crown widths from a few studies of different racial groups in India are tabulated below.

Sl. no	Study	Sex	Sample size (n)	Arch	Mean (mm)	SD (mm)
1	Shah et al (Gujarat population)[8] 2013	M	60	LI	25.240±	1.8659
				LCPM	44.61±	2.454
				LIM1	48.508±	2.4807
		F	60	LI	24.800±	1.7139
				LCPM	44.13±	2.423
				LIM1	47.380±	2.7624
2	Singh V et al (Himachal population)[16] 2013	M	100	LI	23.47	1.08
				UCPM	20.73	1.03
				LCPM	20.73	1.17
		F	100	LI	23.05	0.97
				UCPM	20.61	0.85
				LCPM	20.33	.03
3	Tikku et al (North Indian population)[12, 7] 2013	M	100	LI	23.71	3.59
				LCPM	40.79	2.29
				LIM1	44.80	2.39
		F	100	LI	21.70	1.21
				LCPM	38.88	2.26
				LIM1	42.68	2.75
		M+F	200	LI	22.70	2.86
				LCPM	39.76	2.64
				LIM1	43.73	2.77
4	Kommineni NK et al (Chennai, India)[7, 13] 2014	M	343		23.18±	1.43
				Upper teeth	21.66±	0.95
				Lower teeth	21.65±	0.91
				Upper teeth	21.20±	0.87
				Lower teeth	21.28±	0.89
		F	127	Upper teeth	22.75±	1.25
				Lower teeth	20.52±	0.56
				Upper teeth	20.48±	0.50
				Lower teeth	20.44±	0.74
					20.44±	0.79
5	Namitha Ramesh et al (Kodava, India)[14] 2014	M	30	LI	22.39	1.28
				UCPM	20.65	0.85
				LCPM	21.01	0.89
		F	30	LI	21.57	1.35
				UCPM	19.93	0.96
				LCPM	20.68	1.09
6	Kadu et al (Indian population)[15] 2014	M+F	251	LI	22.85	1.39
				UCPM	21.31	1.14
				LCPM	20.26	1.11
7	Kaur et al (Himachal population)[16] 2014	M	66	LI	22.339±	1.4644
				UCPM	20.64±	1.008
				LCPM	20.365±	1.0235
		F	54	LI	21.504±	1.5140
				UCPM	19.88±	1.17
				LCPM	19.45±	1.164
8	Goyal et al (North India)[17] 2014	M	80	LI	22.08	1.28
				UCPM	20.34	1.19
				LCPM	19.87	1.04
		F	80	LI	21.52	1.27
				UCPM	19.80	1.29
				LCPM	19.27	1.19
9	Maroli S et al (Bengali and Keralite population)[19] 2015	Kerala				
		M	45	Upper teeth	21.35	0.159
				Lower teeth	20.698	0.125
		F	37	Upper teeth	20.92	0.133
				Lower teeth	20.44	0.118
		Bengali				
		M	5	Upper teeth	21.82	0.147
				Lower teeth	20.105	0.154
				Upper teeth	20.96	00.123
		F	13	Lower teeth	20.45	0.133
12	Umapathy Thimmegowda et al (Bangalore, India)[22] 2015	M	200	LI	23.87	2.15
				UCPM	21.89	0.89
				LCPM	21,36	0.63
		F	200	LI	23.51	1.43
				UCPM	21.81	0.90
				LCPM	21.18	0.95
13	Shobha et al (Andhra Pradesh, India)[24] 2016	M	50	LI	24.69	0.76
				UCPM	22.44	0.83
				LCPM	21.62	0.96
		F	50	LI	22.65	0.82
				UCPM	21.56	1.1
				LCPM	20.69	1.15
14	Baheti et a (Marwari population, Rajasthan) [25] 2016	M	100	LI	22.10	1.886
				UCPM	21.42	1.342
				LCPM	20.86	1.512
		F	100	LI	21.98	1.824
				UCPM	20.84	1.248
				LCPM	20.25	1.478
16	Grover et al (Lucknow, India)[27] 2017	M	100	Upper right	23.39	2.13
				Upper left	23.48	2.24
				Lower right	23.23	5.36
				Lower left	23.29	5.29
		F	100	Upper right	21.45	1.63
				Upper left	21.30	1.54
				Lower right	20.81	1.56
				Lower left	20.89	1.55
17	Umapathy Thimmegowda et al (Bangalore, India)[28] 2017	M	200	LI	23.87	2.15
				UCPM	21.37	0.63
				LCPM	21.89	0.89
		F	200	LI	23.52	1.43
				UCPM	21.18	0.95
				LCPM	21.82	0.90
18	Ravinthar K et al (Chennai, India)[32] 2020	M	500	Upper right	21.45	1.6
				Upper left	21.36	1.81
				Lower right	20.46	1.48
				Lower left	20.44	1.54
		F	500	Upper right	22.47	2.66
				Upper left	22.37	2.47
				Lower right	22.52	3.77
				Lower left	22.50	3.39
19	Doda et al (North Indian population)[33] 2022	M	100	LI	22.28	1.34
				UCPM	20.54	1.19
				LCPM	19.87	1,14
		F	100	LI	21.96	1.20
				UCPM	20.62	1.19
				LCPM	19.87	1.29
		M+F	200	LI	22.12	1.8
				UCPM	20.58	1.19
				LCPM	19.87	1.22

In contrast to the above-mentioned studies, others found that the mesiodistal width of unerupted canine and premolars showed no significant difference between male and female participants of the respective population.[9,11,19,30,33]

In the Indian population, the greatest MDW measured in the maxilla is around 23.48 mm (Lucknow) in boys, whereas in girls it is around 22.47 mm (Chennai). The minimum value of MDW in the maxilla is around 20.34 mm (Uttar Pradesh) in boys, whereas in girls it is 19.80 mm (Uttar Pradesh).[17,32] Mandibular MDW ranged from 23.29 mm (Lucknow) to 19.87 mm (Uttar Pradesh) in boys, and that of girls ranged from 22.52 mm (Chennai) to 19.27 mm (Uttar Pradesh).[17,27,32]

In the non-Indian population, the greatest MDW measured in the maxilla is around 23.92 mm (Taiwanese) in boys, whereas in girls it is around 23.16 mm (Taiwanese).[51] The minimum value of MDW in the maxilla is around 19.59 (Yemen) mm in boys, whereas in girls it is 19.16 mm (Yemen).[42,53] Mandibular MDW ranged from 23.25 mm (Taiwanese) to 18.27mm (Yemen) in boys, and that of girls ranged from 22.56 mm (Yemen) to 17.95 mm (Yemen).[42,51,53]

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Table 7: Mesiodistal crown widths from a few studies of different non-Indian racial groups are tabulated below

	Study	Sex	Sample size (n)	Arch	Mean (mm)	SD (mm)
1	Bugaighis et al (Libyan population)[36] 2013	M	169	LI	23.00	1.46
				UCPM	21.70	1.17
				LCPM	21.33	1.13
		F	174	LI	22.67	1.40
				UCPM	21.55	1.06
				LCPM	21.16	0.99
2	Toodehzaeim MH et al (Iranian population)[37] 2013	M	60	LI	23.40	1.71
				UCPM	21.85	1.25
				LCPM	21.45	1.29
				LCIM1	31.87	1.92
		F	60	LI	22.99	1.29
				UCPM	21.47	1.07
				LCPM	20.86	1.06
				LCIM1	31.66	1.51
		M+F	120	LI	23.20	1.52
				UCPM	21.66	1.18
				LCPM	21.15	1.22
				LCIM1	31.76	1.73
3	Asiry et al (Saudi population)[41] 2014	M	202	LI	21.45	1.34
				UCPM	20.51	1.21
				LCPM	20.22	1.26
		F	207	LI	21.57	1.70
				UCPM	20.04	1.25
				LCPM	19.69	1.28
4	Al-Kabab et al (Yemeni population)[42] 2014	M	200	LI	20.68	1.92
				UCPM	19.59	1.06
				LCPM	18.27	1.09
		F	200	LI	20.27	1.31
				UCPM	19.16	1.17
				LCPM	17.95	1.23
5	Sherpa et al (Northeast Han Chinese)[44] 2015	M	65	LI	23.55	1.09
				UCPM	22.67	0.93
				LCPM	22.03	0.83
		F	65	LI	22.90	0.88
				UCPM	22.01	0.95
				LCPM	21.29	0.93
6	Paredes et al (Spain)[45] 2015	M	169	LI	23.04	1.46
				UCPM	22.31	1.06
				LCPM	21.82	1.11
		F	190	LI	23.03	1.44
				UCPM	21.92	1.04
				LCPM	21.40	1,09
		M+F	359	LI	23.04	1.45
				UCPM	22.11	1.07
				LCPM	21.60	1.12
7	Al-Dlaigan YH et al (Saudi population)[46] 2015	M+F	410	LI	21.50	1.63
				UCPM	19.96	1.30
				LCPM	20.27	1.25
8	Alzubir et al (Sundanese population)[47] 2016	M	118	LI	22.82	1.41
				UCPM	22.21	1.05
				LCPM	21.79	1.11
		F	132	LI	22.28	1.51
				UCPM	21.48	1.18
				LCPM	21.00	1.15
		M+F	250	LI	22.53	1.49
				UCPM	21.83	1.17
				LCPM	21.38	1.19
9	Giri et al (Nepalese Mongoloids)[48] 2018	M	50	LI	23.22	1.60
				UCPM	22.54	1.11
				LCPM	21.63	1.11
		F	50	LI	22.45	1.53
				UCPM	21.45	1.26
				LCPM	20.62	1.18
10	Chong S Y et al (Taiwanese population)[51] 2021	M	100	UCPM	23.92	0.92
				LCPM	23.25	1.01
		F	100	UCPM	23.16	1.24
				LCPM	22.21	1.23
		M+F	200	UCPM	23.54	1.16
				LCPM	22.73	1.24
11	Mahida et al (Pakistani population)[52] 2021	M	60	UCPM	21.80	1.35
				LCPM	20.60	1.51
		F	60	UCPM	22.37	0.96
				LCPM	20.81	1.73
12	Dahaq WAM et al (Yemeni population)[53] 2021	M	106	LI	24.61	1.5
				UCPM	23.52	1.18
				LCPM	23.22	1.26
		F	121	LI	24.14	1.5
				UCPM	22.91	1.26
				LCPM	22.56	1.56
13	Kerre et al (Kenyan Population)[54] 2022	M	400	LI	21.66	1.63
				UCPM	22.25	1.16
				LCPM	21.94	1.63
		F	200	LI	21.24	1.35
				UCPM	21.18	1.16
				LCPM	20,90	1.26

Combination of Groups of Teeth Used as a Predictor

The sum of mesiodistal width of four mandibular incisors has been most widely used to develop a regression equation to accurately predict the size of unerupted canine & premolars specific to their population by many researchers.[7,9,10,13-17,19,22,24,25,27,28,32,33,36,37,41,42,44-47,49,51-54.]

The mandibular permanent incisors are a good predictor variable because they erupt early in the mixed dentition, are easy to measure, have little size fluctuation, and are right in the middle of most space-management issues.[2]

In addition to mandibular incisors, combinations of other erupted permanent teeth (e.g, mandibular first molar, maxillary first molar, and maxillary incisors) also have been used by some researchers to accurately predict the size of unerupted canine & premolars. Fonseca (1961) first introduced an additional combination of teeth (the sum of maxillary first molar and maxillary four permanent incisors) to develop a multiple regression equation.[59,]

To predict the mesiodistal width of unerupted permanent canines and premolars, other teeth, in addition to incisors, have also been evaluated. Recent research has shown that the sum of the mesiodistal width of permanent mandibular incisors is not the best predictor.[3]

- The sum of the mesiodistal width of permanent mandibular incisors and mandibular first molar has been used.[7,9,23,37]
- The sum of the mesiodistal width of maxillary central incisor and mandibular first molar is said to be the best predictor to estimate MDW of permanent canine & premolars in the Spanish and Egyptian population.[3]

Regression equation

Moyer's and Tanaka-Johnston's methods have been applied broadly because of their minimum systematic error, are easy and simple to use, reliable, and can be employed for both maxilla and mandible. Moyer's probability tables were developed at the University of Michigan based on the odontometric data of American White subjects of North-western European descent. Moyer's prediction tables are predicated on a link between the mandibular incisors' total width and the mandibular canine and premolars' combined width. Assessing the mesiodistal dimension of unerupted

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

canines and premolars is made simple, accurate, and non-radiographic by employing the multiple regression equation approach with mandibular permanent incisors as a predictor value. Various studies have demonstrated the differences in regression and prediction equations for assessing unerupted teeth.[25]

As the Moyer's predicted values are not applicable for each and every population in the world, various studies have been done for ages to develop regression equations applicable for a particular population. (Tables 10 and 11) The regression equations for maxilla ranged from 17.204+.174(X) (Bangalore) to 2.9+0.40(X) (Uttar Pradesh) in boys and that for girls ranged from y = 18.87 + 0.08x (North Karnataka) to 0.56+0.45(x) (Uttar Pradesh).[17,22, 35] Whereas in mandible it ranged from y = 19.98 + 0.11x (North Karnataka) to 3 .91+0.37(X) (Uttar Pradesh) in boys whereas in girls it ranged from y = 24.49 – 0.17x (North Karnataka) to 1.14+0.42(x) (Uttar Pradesh).[17,35]

In the non-Indian population, the regression equations for maxilla ranged from 15.99+0.33(X) (Taiwanese) to Y = 0.64X+07.57 (Northeast Han Chinese) in boys, and that for girls ranged from Y = 16.580+0.208(X) (Pakistan) to Y = 0.81X+3.39 (Northeast Han Chinese).[44,53,55] Whereas in mandible it ranged from Y = 14.408+0.358(X) (Yemen) to 4.60+0.71(X) (Nepalese) in boys, whereas in girls it ranged from Y = 12.56+0.414(X) (Yemen) to Y = 12.56+0.414(X) (Northeast Han Chinese).[44,48,53]

The reason for the variations in the regression equations is due to the variations in the size of the teeth in different populations, and one particular regression equation cannot be applied to every population in the world.

Based on the regression equation developed in various studies, probability tables have been developed by a few researchers, which makes the space analysis easier.[10,14,16,22,25,28,42,45,46,48,49,55] The Indian populations for whom probability tables were developed are the Himachal, Bangalore, Kodava, and Marwari populations.[10,14,16,22,25,28] (Table 8) The non-Indian populations for whom probability tables were developed are Yemeni, Spanish, Saudi, Nepalese, and Pakistani populations. [42,45,46,48,49,55](Table 9)

Table 8: Regression equations developed in various studies performed in the Indian population

Sl. no	Study	Sex	Arch	Prediction equations Y =	Development of probability tables
1	Shah S et al (contemporary Indian Population)[9]	M F M+F	Both arches	Y = 10.417 + 0.705X Y = 9.802 + 0.725X Y = 10.692 + 0.702X	-
2	Singh V et al (Himachal population)[10]	M F	Maxilla Mandible Maxilla Mandible	Y=9.79+0.99x Y=12.97+0.82x Y=8.99+0.81x Y=11.4+.50x	Probability tables developed
3	Manjula M et al (Nalgonda population)[11]	M F	Maxilla Mandible Maxilla Mandible	Y = 11.0 + 0.500(X) Y = 10.4 + 0.506(X) Y = 11.1 + 0.495(X) Y = 10.4 + 0.502(X)	-
4	Tikku T et al (North Indian population)[12, 7]	M F M+F	Both arches	Y =7.70+.7386(X) Y = 13.0+.6065(X) Y = 7.15+.7450(X)	-
5	Srivastava B et al (UP Indian population)[12]	M F M+F	Maxilla Mandible Maxilla Mandible Maxilla Mandible	Y=9.6+0.40X Y=9.3+0.42X Y=9.4+0.37X Y=8.9+0.46X Y=9.52+0.42X Y=9.12+0.49X	-
6	Ramesh N et al (Kodava population)[14]	M F M+F	Maxilla Mandible Maxilla Mandible Maxilla Mandible	Y = 12.05+0.40(X) Y = 10.40+0.32(X) Y = 12.56+0.37(X) Y = 9.29+0.49(X) Y = 12.25+0.39(X) Y = 10.20+0.45(X)	Probability tables developed
7	Kadu et al (Haryana, Faridabad)[15]	M+F	Maxilla Mandible	Y = 9.89+ 0.5(X) Y = 8.84 +0.5(X)	-
8	Kaur a et al (Himachal population)[16]	M F	Maxilla Mandible Maxilla Mandible	Y=10.761+.442(X) Y = 9.524+.485(X) Y = 10.135+.442(x) Y = 9.142+.479(X)	Probability tables developed
9	Goyal RK et al (North Indian population)[17]	M F	Maxilla Mandible Maxilla Mandible	Y = 2.9+0.40(X) Y = 3.91+0.37(X) Y = 0.56+0.45(x) Y = 1.14+0.42(x)	-
10	Suruchi Juneja et al (North Indian Population)[20]	M F	Maxilla Mandible Maxilla Mandible	Y = 9.783+0.511(X) Y = 8.415+0.546(X) Y = 10.029+.467(X) Y = 8.796+0.496(X)	-
11	Umapathy Thimmegowda et al (Bangalore population)[22]	M F	Maxilla Mandible Maxilla Mandible	Y = 17.204+.174(X) Y = 13.431+.330(X) Y = 16.904+.209(X) Y = 15.627+.263(X)	Probability tables developed
12	Mittal S et al (Himachal population)[23]	M+F	Maxilla Mandible	Y = 13.48 + 0.614X	-
13	Shobha M B et al (Andhra Pradesh population)[24]	M F M+F	Maxilla Mandible Maxilla Mandible Maxilla Mandible	Y = 13.22+.37(X) Y = 11.25+.42(X) Y = 6.68+..65(X) Y = 8.28+.54(X) Y = 10.95+.46(X) Y = 10.06+.69(X)	-
14	Baheti et al (Marwari population)[25]	M F	Maxilla Mandible Maxilla Mandible	Y = 10.52+0.46(X) Y = 9.45+0.48(X) Y = 11.67+0.45(X) Y = 11.58+0.32(X)	Probability tables developed
15	Grover N et al (Lucknow population)[27]	M F	Maxilla Mandible Maxilla Mandible	Y = 15.935+.315(X) Y = 8.556+.620(X) Y = 15.133+.269(X) Y = 11.350+.403(X)	-
16	Umapathy Thimmegowda et al (Bangalore population)[28]	M F	Maxilla Mandible Maxilla Mandible	Y = 16.90+0.21(X) Y = 17.20+0.17(X) Y = 15.63+0.26(X) Y = 13.43+0.33(X)	Probability tables developed
17	Kakkar et al (Rajasthan population)[30]	M F	Maxilla Mandible Maxilla Mandible	Y = 9.06+0.38(X) Y = 8.35+0.33(X) Y = 9.79+0.32(X) Y = 7.98+0.31(X)	-
18	Doda et al (North Indian population)[33]	M F	Maxilla Mandible Maxilla Mandible	Y = 8.745 + 0.529X Y = 9.833 + 0.451X Y = 8.745 + 0.529X Y = 7.703 + 0.554X	-
19	Bangi S L et al (North Karnataka population)[35]	M F	Maxilla Mandible Maxilla Mandible	Y = 13.54 + 0.37X Y = 19.98 + 0.11X Y = 18.87 + 0.08X Y = 24.49 – 0.17X	-

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Table 9: Regression equations developed in various studies performed in the Non-Indian population

Sl. no	Study	Sex	Arch	Prediction equations Y =	Development of probability tables
1	Bulgaighis et al (Libyan population)[36]	M F	Maxilla Mandible Maxilla Mandible	Y = 9.63+0.53(X) Y = 9.29+0.52(X) Y = 11.71+0.43(X) Y = 11.84+0.41(X)	-
2	Toodehzaeim MH et al (Iranian population)[37]	M+F	Maxilla Mandible	Y = 7.28+0.45(X) Y = 6.06+0.48(X)	-
4	Brito F C et al (Brazilian population)[40]	M+F	Maxilla Mandible	Y + 5 0.96X	-
5	Asiry M et al (Saudi population)[41]	M F	Maxilla Mandible Maxilla Mandible	Y=10.3+0.49X Y=11.7+0.37X Y=9.7+0.49X Y=11.3+0.39X	-
6	Al-kabab et al (Yemeni population)[42]	M F	Maxilla Mandible Maxilla Mandible	Y = 13.55 + 0.29X Y = 9.97 + 0.40X Y = 14.04 + 0.25X Y = 9.56 + 0.41X	Probability tables developed
7	Sherpa et al (Northeast Han Chinese population)[44]	M F	Maxilla Mandible Maxilla Mandible	Y = 0.64X+07.57 Y = 0.47X+10.81 Y = 0.81X+3.39 Y = 0.72X+4.59	-
8	Paredes et al (Spanish population)[45]	M F	Maxilla Mandible Maxilla Mandible	Y = 12.68+0.42(X) Y = 11.71+0.44(X) Y = 12.06+0.43(X) Y = 10.7+0.46(X)	Probability tables developed
9	Yousef H. Al-Dlaigan (Saudi population)[46]	M F M+F	Maxilla Mandible Maxilla Mandible Maxilla Mandible	Y = 10.27+0.48(X) Y = 9.71+0.49(X) Y = 11.7+0.39(X) Y = 11.28+0.39(X) Y = 11.22+0.42(X) Y = 10.75+0.43(X)	Probability tables developed
10	Alzubir et al (Sundanese population)[47]	M F M+F	Maxilla Mandible Maxilla Mandible Maxilla Mandible	Y = 11.66+0.46(X) Y = 10.78+0.48(X) Y = 9.67+0.53(X) Y = 8.67+0.55(X) Y = 9.94+0.53(X) Y = 8.91+0.55(X)	-
11	Gyawali et al (Nepalese population)[48]	M	Maxilla Mandible	Y = 8.91+0.56(X) Y = 4.60+0.71(X)	Probability tables developed
		F M+F	Maxilla Mandible Maxilla Mandible	Y = 3.65+0.78(X) Y = 5.58+0.67(X) Y = 6.34+0.67(X) Y = 4.90+0.71(X)	
12	Giri et al (Nepalese population)[49]	M F	Maxilla Mandible Maxilla Mandible	Y = 10.72+0.51(X) Y = 10.56+0.47(X) Y = 9.51+0.53(X) Y = 6.87+0.61(X)	Probability tables developed
13	Kareem F A et al (Kurdish population)[50]	M F	Maxilla Mandible Maxilla Mandible	Y =0.28(X) +7.8 Y = 0.27(X) = 7.33	-
15	Chon. S.Y et al (Taiwanese population)[51]	M F	Maxilla Mandible Maxilla Mandible	Y = 15.99+0.33(X) Y = 11.75+0.47(X) Y = 8.42+0.62(X) Y = 6.73+0.65(X)	-
14	Duhaq WAM et al (Yemeni population)[53]	M F	Maxilla Mandible Maxilla Mandible	Y = 14.854+0.354(X) Y = 14.408+0.358(X) Y = 15.133+0.322(X) Y = 12.56+0.414(X)	-
16	Rehan S A et al (Pakistani population)[55]	M F	Maxilla Mandible Maxilla Mandible	Y = 15.677+0.257(X) Y =11.869+0.413(X) Y = 16.580+0.208(X) Y = 8.764+0.534(X)	Probability tables developed
17	Salem G a et al (Egyptian population)[56]	M+F	Maxilla Mandible	Y = 15.258+1.186(X) Y = 18.841+1.01(X)	

Table 10: Prediction table for the Himachal population

Prediction table in Himachal population[10]				
LI	LCPM		UCPM	
	males	Females	Males	females
19.5	20.8	20.5	21.6	21.3
20.0	20.7	20.7	20.7	20.7
20.5	21.3	21.3	21.5	21.1
21.0	20.4	21.5	20.3	19.9
21.5	21.8	20.7	2.5	21.0
22.0	21.2	20.7	21.1	21.1
22.5	21.3	20.8	21.3	20.9
23.0	21.7	20.8	21.1	21.7
23.5	22.1	20.8	21.5	21.9
24.0	20.7	20.3	21.9	21.2
24.5	19.3	21.2	21.4	21.2
25.0	20.5	22.5	20.9	21.5
25.5	22.3	22.3	21.5	21.5

Table 11: Prediction table for Kodava population

Prediction table for Kodava popualation[14]												
Maxillary canine and premolars												
LI	20.0		21.0		22.0		23.0		24.0		25.0	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
95%	21.28	20.69	20.71	20.35	21.89	21.58	22.13	22.01	22.76	22.45	22.96	-
85%	21.9	20.65	20.70	20.33	21.86	21.51	21.63	21.00	22.75	22.43	22.54	-
75%	21.60	20.50	20.64	20.28	21.58	21.21	21.38	21.56	22.73	22.50	22.50	-
65%	20.49	20.41	20.62	20.14	21.33	21.33	21.21	21.11	22.18	22.00	22.7	-
50%	20.32	19.98	20.82	19.79	20.95	20.89	21.10	21.04	21.36	21.36	21.82	-
35%	19.55	19.45	19.78	19.38	20.54	20.78	20.76	20.66	21.32	21.20	21.56	-
25%	19.11	19.00	19.50	19.12	20.31	20.50	20.72	21.72	21.30	20.79	21.42	-
15%	19.00	18.68	19.47	18.99	20.14	20.10	20.48	20.38	21.18	20.45	21.27	-
5%	18.84	18.59	18.95	18.80	20.13	20.09	20.33	20.30	20.98	20.24	21.12	-
Mandibular canine and premolars												
LI	20.0		21.0		22.0		23.0		24.0		25.0	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
95%	20.36	20.20	20.47	20.88	22.23	22.17	22.96	22.28	21.59	21.85	22.46	-
85%	20.30	20.00	20.38	20.78	22.19	21.53	21.57	21.18	21.40	21.84	22.35	-
75%	20.23	19.59	20.35	20.66	21.64	21.60	20.77	20.10	21.38	21.80	22.39	-
65%	20.15	20.15	20.33	20.22	21.18	21.46	20.63	20.89	21.14	21.49	22.24	-
50%	20.04	19.40	19.95	19.41	20.66	20.17	20.42	20.65	20.76	20.97	21.86	-
35%	19.24	19.10	19.57	18.63	20.35	20.03	20.32	19.95	20.59	20.49	21.47	-
25%	18.72	18.21	19.60	18.25	20.15	19.81	20.28	19.80	20.48	20.18	21.33	-
15%	18.67	17.63	19.53	18.16	19.82	19.55	20.06	19.50	20.45	20.10	21.20	-
5%	18.50	17.33	19.40	18.06	19.80	19.07	19.52	19.42	20.43	20.06	21.01	-

Prediction tables were developed at the 75th percentile among different populations, which are from Himachal, Bangalore, Marwari, Yemen, Spanish, Saudi, Nepalese Brahmins/Chhetris, and Pakistani populations.[10,22,25,28,42,45,46,48,49,55] (Table 10,13-21) Ramesh N et al developed a prediction table from 5% to 95% for the Marwari population.[14] (Table 11) Whereas Kaur et al developed prediction tables for the Himachal population at 35%, 50% and 75%.[16] (Table 12)

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Table 12: Prediction table for the Himachal population

Prediction values for Himachal population [16]												
	Maxillary arch						Mandibular arch					
LI	35th %		50th %		75th %		35th %		50th %		75th %	
	male	female	male	female	male	female	male	female	male	female	male	female
19.5	19.3	19.2	19.7	19.6	20.3	20.4	19.0	18.2	19.5	18.7	20.4	19.6
20.0	19.6	19.4	19.9	19.8	20.5	20.5	19.3	18.5	19.7	19.0	20.6	19.8
20.5	19.9	19.5	20.2	19.9	20.8	20.6	19.5	18.8	20.0	19.2	20.8	20.1
21.0	20.1	19.7	20.4	20.1	21.0	20.8	19.7	19.0	20.2	19.5	21.0	20.3
21.5	20.4	19.8	20.7	20.2	21.3	20.9	20.0	19.3	20.4	19.8	21.2	20.6
22.0	20.6	19.9	20.9	20.3	21.5	21.0	20.2	19.6	20.6	20.0	21.4	20.8
22.5	20.9	20.1	21.2	20.5	21.8	21.2	20.4	19.8	20.9	20.3	21.6	21.1
23.0	21.1	20.2	21.5	20.6	22.0	21.3	20.6	20.1	21.1	20.5	21.9	21.3
23.5	21.4	20.4	21.7	20.8	22.3	21.5	20.9	20.3	21.3	20.8	22.1	21.6
24.0	21.6	20.5	22.0	20.9	22.5	21.6	21.1	20.6	21.5	21.1	22.3	21.9
24.5	21.9	20.6	22.2	21.0	22.8	21.8	21.3	20.9	21.7	21.3	22.5	22.1
25.0	22.1	20.8	22.5	21.2	23.0	21.9	21.5	21.1	22.0	21.6	22.8	22.4
25.5	22.4	20.9	22.7	21.3	23.3	22.1	21.7	21.4	22.2	21.8	23.0	22.7

Table 13: Prediction table for Bangalore population

Prediction table in Bangalore population[22]				
Sum of LI	LCPM		UCPM	
	Males	Females	Males	Females
19	20.51	19.70	20.88	20.62
19.5	20.60	19.87	20.98	20.76
20.0	20.68	20.03	21.08	20.89
20.5	20.77	20.20	21.19	21.02
21.0	20.86	20.36	21.29	21.15
21.5	20.95	20.53	21.40	21.28
22.0	21.03	20.69	21.50	21.41
22.5	21.12	20.86	21.61	21.54
23.0	21.21	21.02	21.71	21.68
23.5	21.29	21.19	21.82	21.81
24.0	21.38	21.35	21.92	21.94
24.5	21.47	21.52	22.02	22.07
25.0	21.55	21.68	22.13	22.20
25.5	21.64	21.85	22.23	22.33
26.0	21.73	22.01	22.34	22.47
26.5	21.82	22.18	22.44	22.60
27.0	21.90	22.34	22.55	22.73
27.5	21.99	22.51	222.65	22.86
28.0	22.08	22.67	22.76	22.99
28.5	22.16	22.84	22.86	23.12
29.0	22.25	23	22.97	23.25

Table 14: Prediction table in the Marwari population

Prediction table in Marwari population[25]				
LI	LCPM		UCPM	
	males	females	males	females
19.5	19.31	19.17	19.84	19.75
20.0	19.42	1938	20.14	19.92
20.5	19.68	19.61	20.52	20.21
21.0	19.86	19.82	20.62	20.46
21.5	20.18	20.15	20.86	20.59
22.0	20.45	20.28	21.02	20.81
22.5	20.72	20.41	21.35	20.97
23.0	20.92	20.68	21.61	21.15
23.5	21.15	20.91	21.82	21.34
24.0	21.46	21.06	22.15	21.54
24.5	21.83	21.31	22.34	21.74
25.0	21.97	22.46	22.61	21.95
25.5	22.18	21.71	22.78	22.21

Table 15: Prediction table for Bangalore population

Prediction table in Bangalore population[28]				
Sum of LI	LCPM		UCPM	
	Males	Females	Males	Females
19	20.43	19.70	20.89	20.57
19.5	20.52	19.87	21.00	20.70
20.0	20.60	20.03	21.10	20.83
20.5	20.69	20.20	21.21	20.96
21.0	20.77	20.36	21.31	21.09
21.5	20.86	20.53	21.42	21.22
22.0	20.94	20.69	21.52	21.35
22.5	21.03	20.86	21.63	21.48
23.0	21.11	21.02	21.73	21.61
23.5	21.20	21.19	21.84	21.74
24.0	21.28	21.35	21.94	21.87
24.5	21.37	21.52	22.05	22.00
25.0	21.45	21.68	22.15	22.13
25.5	21.54	21.85	22.26	22.26
26.0	21.62	22.01	22.36	22.39
26.5	21.71	22.18	22.47	22.52
27.0	21.79	22.34	22.57	22.65
27.5	21.88	22.51	22.68	22.78
28.0	21.96	22.67	22.78	22.91
28.5	22.05	22.84	22.89	23.04
29.0	22.13	23	22.99	23.17

Table 16: Prediction table for the Yemen population

Prediction table in Yemen population[42]				
Sum of LI	LCPM		UCPM	
	Males	Females	Males	Females
19.5	17.8	19.87	19.2	18.9
20.0	18.0	20.03	19.4	19.0
20.5	18.2	20.20	19.5	19.2
21.0	18.4	20.36	19.6	19.3
21.5	18.6	20.53	19.8	19.4
22.0	18.8	20.69	19.9	19.5
22.5	19.0	20.86	20.1	19.7
23.0	19.2	21.02	20.2	19.8
23.5	19.4	21.19	20.4	19.9
24.0	19.6	21.35	20.5	20.0
24.5	19.8	21.52	20.7	20.2
25.0	20.0	21.68	22.8	20.3
25.5	20.3	21.85	22.9	20.4

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Table 17: Prediction table for the Spanish population

Prediction table for spain population[45]						
LI (mm)	UCPM(mm)			LCPM(mm)		
	T	M	F	T	M	F
19	20.32	20.66	20.23	19.72	20.07	19.45
19.5	20.53	20.87	20.45	19.95	20.29	19.68
20	20.74	21.08	20.66	20.17	20.51	19.91
20.5	20.95	21.29	20.88	20.40	20.73	20.14
21	21.16	21.50	21.09	20.62	20.95	20.37
21.5	21.37	21.71	21.31	20.85	21.17	20.60
22	21.58	21.92	21.52	21.07	21.39	20.83
22.5	21.79	22.13	21.74	21.30	21.61	21.06
23	22.00	22.34	21.95	21.52	21.83	21.29
23.5	22.21	22.55	22.17	21.75	22.05	21.52
24	22.42	22.76	22.38	21.97	22.27	21.75
24.5	22.63	22.97	22.60	22.20	22.49	21.98
25	22.84	23.18	22.81	22.42	22.71	22.21
25.5	23.05	23.39	23.03	22.65	22.93	22.44
26	23.26	23.60	23.24	22.87	23.15	22.67
26.5	23.47	23.81	23.46	23.10	23.37	22.90

Table 18: Predicted values for the Saudi population

Predicted values for Saudi population[46]		
LI	Predicted width	Predicted width
32324142	Maxillary Canine Premolars	Mandibular Canine Premolars
19.5	19.21	18.78
20.0	19.63	19.21
20.5	19.81	19.40
21.0	20.04	19.64
21.5	20.25	19.86
22.0	20.45	20.07
22.5	20.65	20.27
23.0	20.87	20.50
23.5	21.08	20.71
24.0	21.27	20.92
24.5	21.47	21.13
25.0	22.09	21.78

Table 19: Prediction table for Nepalese Brahmins/Chhetris

Prediction table for Nepalese Brahmins/Chhetris[48]				
LI (mm)	Male		Female	
	∑ CP1P2 Maxilla (mm)	∑ CP1P2 Mandible (mm)	∑ CP1P2 Maxilla (mm)	∑ CP1P2 Mandible (mm)
18.0	19.0	17.7	17.5	17.6
18.5	19.3	18.1	17.9	17.9
19.0	19.6	18.5	18.3	18.3
19.5	19.9	18.8	18.7	18.6
20.0	20.2	19.2	19.1	18.9
20.5	20.5	19.5	19.4	19.3
21.0	20.7	19.9	19.8	19.6
21.5	21.0	20.3	20.2	19.9
22.0	21.3	20.6	20.6	20.3
22.5	21.6	21.0	21.0	20.6
23.0	21.9	21.4	21.4	20.9
23.5	22.1	21.7	21.7	21.3
24.0	22.4	22.1	22.1	21.6
24.5	22.7	22.5	22.5	21.9
25.0	23.0	22.8	22.9	22.3
25.5	23.3	23.2	23.3	22.6
26.0	23.5	23.6	23.7	23.0
26.5	23.8	23.9	24.1	23.3
27.0	24.1	24.3	24.4	23.6
27.5	24.4	24.7	24.8	24.0
28.0	24.7	25.0	25.2	24.3

Table 20: Prediction values for the Nepalese population

Prediction values for Nepalese population[49]				
	Male		Female	
	Σ CP1P2 (mm) Maxilla	Σ CP1P2 (mm) Mandible	Σ CP1P2 (mm) Maxilla	Σ CP1P2 (mm) Mandible
18	19.9	19.1	19.1	17.9
18.5	20.1	19.4	19.3	18.2
19	20.4	19.6	19.6	18.5
19.5	20.6	19.9	19.9	18.8
20	20.9	20.1	20.1	19.1
20.5	21.2	20.3	20.4	19.4
21	21.4	20.6	20.7	19.7
21.5	21.7	20.8	20.9	20.0
22	21.9	21.0	21.2	20.3
22.5	22.2	21.3	21.5	20.7
23	22.4	21.5	21.7	21.0
23.5	22.7	21.8	22.0	21.3
24	22.9	22.0	22.3	21.6
24.5	23.2	22.2	22.5	21.9
25	23.4	22.5	22.8	22.2
25.5	23.7	22.7	23.1	22.5
26	24.0	23.0	23.3	22.8
26.5	24.2	23.2	23.6	23.1
27	24.5	23.4	23.9	23.4
27.5	24.7	23.7	24.1	23.7
28	25.0	23.9	24.4	24.0
28.5	25.2	24.1	24.7	24.3
29	25.5	24.4	24.9	24.6

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Table 21: New Probability tables established for the Pakistani population

New Probability tables established for Pakistani population.[55]				
LI	Male		Female	
	Ucpw	Lcpw	Ucpw	Lcpw
19	20.56	19.71	20.53	18.91
19.5	20.68	19.92	20.63	19.17
20	20.81	20.12	20.74	19.40
20.5	20.94	20.33	20.84	19.71
21	21.07	20.54	20.94	19.97
21.5	21.20	20.74	21.05	20.24
22	21.33	20.95	21.15	20.51
22.5	21.45	21.16	21.26	20.77
23	21.58	21.36	21.36	21.04
23.5	21.71	21.57	21.46	21.31
24	21.84	21.78	21.57	21.58
24.5	21.97	21.98	21.67	21.84
25	22.10	22.19	21.78	22.11
25.5	22.23	22.40	21.88	22.38
26	22.35	22.60	21.98	22.64
26.5	22.48	22.80	22.09	22.91
27	22.61	23.02	22.19	23.18
27.5	22.74	23.22	22.30	23.44
28	22.87	23.43	22.40	23.71
28.5	23.00	23.63	22.50	23.98
29	23.13	23.84	22.61	24.25

CONCLUSION

Space analysis is crucial for orthodontic diagnosis and treatment planning in mixed dentition. Proper space evaluation can help early intervention of developing malocclusions. However, old literature and factors like age, gender, and ethnicity can affect the accuracy and applicability of Moyers and Tanaka-Johnston's analysis. Data from ethnic groups may not be accurate for other groups, affecting treatment planning and outcomes. Newer regression equations and probability tables can help develop appropriate solutions for specific populations, improving treatment planning and outcomes.

References

1. Dasgupta B, Zahir S. Comparison of two non-radiographic techniques of mixed dentition space analysis and evaluation of their reliability for Bengali population. Contemp Clin Dent 2012; 3(2); 146-50.
2. Philip NI, Prabhakar M, Arora D, Chopra S: Applicability of the Moyers mixed dentition probability tables and new prediction aids for a contemporary population in India. Am J Orthod Dentofacial Orthop 2010; 138(3): 339-45.
3. Butt S, Chaudhry S, Javed M, Wahid A, Ehsan A, Malik S, Khan AA. Mixed dentition space analysis: a review. Pak Oral Dent J 2012;32: 502-7.
4. Patidar D, Patidar DC. Applicability of Mixed Dentition Analyses on Indian Population: A Literature Review. Asian J. Den. Sci. 2023;6(1):155-60.
5. Buwembo W, Kutesa A, Muwazi L, Rwenyonyi CM. Prediction of width of un-erupted incisors, canines and premolars in a Ugandan population: A cross sectional study. BMC Oral Health 2012; 12:23.
6. Irwin, R. D., Herold, J. S., Richardson, A. Mixed dentition analysis: A review of methods and their accuracy. Int J Ped Dent.1995; 5: 137-42.
7. Tikku T, Khanna R, Sachan K, Agarwal A, Srivastava K, Yadav P. A new proposed regression equation for mixed dentition analysis using the sum of permanent mandibular four incisors and first molar as a predictor of width of unerupted canine and premolars in a sample of North Indian population. J Orthodont Sci. 2013; 2:124-9.
8. Altherr ER, Koroluk LD, Phillips C. Influence of sex and ethnic tooth-size differences on mixed-dentition space analysis. Am J Orthod Dentofacial Orthop. 2007;132(3):332-9.
9. Shah S, Bhaskar V, Venkataraghvan K, Choudhary P, Mahadevan G, Trivedi K. Applicability of regression equation using widths of mandibular permanent first molars and incisors as a predictor of widths of mandibular canines and premolars in contemporary Indian population. J Indian Soc Pedod Prev Dent 2013;31:135-40
10. Singh V, Singla A, Mahajan V, Bawa T. Development Of A Prediction Equation For The Mixed Dentition In A Himachal Population. Indian Journal of Dental Sciences 2013;5(1):40-43.
11. Manjula M, Rani ST, David SR, Reddy ER, Sreelakshmi N, Rajesh A. Applicability of tooth size predictions in the mixed dentition space analysis in Nalgonda population. J NTR Univ Health Sci 2013; 2:269-74
12. Srivastava B, Bhatia HP, Singh R, Singh AK, Aggarwal A, Gupta N. Validation of Tanaka and Johnston's analysis in western UP Indian

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

population. J Indian Soc Pedod Prev Dent 2013;31:36-42.

13. Kommineni NK, Reddy CV, Chandra NS, Reddy DS, Kumar AK, Reddy MV. Mixed dentition analysis - Applicability of two non-radiographic methods for Chennai school children. J Int Soc Prev Community Dent. 2014;4(2):133-8.

14. Ramesh N, Reddy MS, Palukunnu B, Shetty B, Puthalath U. Mixed dentition space analysis in kodava population: a comparison of two methods. J Clin Diagn Res. 2014; S8(9):ZC01-6.

15. Kadu A, Londhe SM, Kumar P, Datana S, Singh M, Gupta N. Estimating the size of unerupted canine and premolars in a mixed Indian population. J Dent Res Rev 2014;1:62-5.

16. Kaur A, Singh R, Mittal S, Sharma S, Bector A, Awasthi S. Evaluation and applicability of Moyers mixed dentition arch analysis in Himachal population. Dent J Adv Stud. 2014;02(02):096–104

17. Goyal RK, Sharma VP, Tandon P, Nagar A, Singh GP. Evaluation of mixed dentition analyses in north Indian population: A comparative study. Contemp Clin Dent 2014;5:471-7

18. Kondapaka V, Sesham VM, Neela PK, Mamillapalli PK. A comparison of seven mixed dentition analysis methods and to evaluate the most reliable one in Nalgonda population. J Indian Orthod Soc 2015;49:3-9.

19. Maroli S, Ali H, Chakkarayan J, Vijayan V, Chinthan G. A comparative evaluation of Moyers mixed dentition analysis among Bengali and Keralite population. J Int Oral Health 2015;7(12):38-43.

20. Juneja S, Mahajan N, Kaur H, Verma KG, Sukhija M, Bhambri E. Comparative evaluation of three mixed dentition analyses and formulation of regression equations for north Indian population: A cross-sectional study. Biomed J. 2015;38(5):450-5.

21. Hambire CU, Sujan S. Evaluation of validity of Tanaka-Johnston analysis in Mumbai school children. Contemp Clin Dent 2015;6:337-40.

22. Thimmegowda U, Sarvesh SG, Shashikumar HC, Kanchiswamy LN, Shivananda DH, Prabhakar AC. Validity of Moyers Mixed Dentition Analysis and a New Proposed Regression Equation as a Predictor of Width of Unerupted Canine and Premolars in Children. J Clin Diagn Res. 2015;9(8):ZC01-6.

23. Mittal S, Pathak A, Mittal K, Pathania V. Predicting the mesiodistal width of unerupted canine and premolars by using width of the permanent mandibular incisors and first molar in the Himachal population. J Indian Soc Pedod Prev Dent 2016;34:204-9.

24. Shobha MB, Sai A, Manoj K, Srideevi E,Sridhar M, Pratap G. Applicability of two universally accepted mixed dentition analysis on a sample from Southeastern region of Andhra Pradesh, India. Ann Med Health Sci Res. 2016;6:176-80

25. Baheti K, Babaji P, Ali MJ, Surana A, Mishra S, Srivastava M. Evaluation of Moyer's mixed dentition space analysis in Indian children. J Int Soc Prevent Communit Dent 2016;6:453-458.

26. Kamatham R, Vanjari K, Nuvvula S. Applicability of Moyers' and Tanaka– Johnston's mixed dentition analyses for predicting canine and premolar widths in south Indian population – A cross sectional study. J Orofac Sci 2017;9:52-57.

27. Grover N, Saha S, Tripathi AM, Jaiswal J N, Palit M. Applicability of different mixed dentition analysis in Lucknow population. J Indian Soc Pedod Prev Dent 2017;35:68-74.

28. Thimmegowda U, Divyashree, Niwlikar KB, Khare V, Prabhakar AC. Applicability of Tanaka Jhonston Method and Prediction of Mesiodistal Width of Canines and Premolars in Children. J Clin Diagn Res. 2017;11(6): ZC16-ZC19.

29. Bhatnagar A, Chaudhary S, Sinha AA, Manuja N, Kaur H, Chaitra T R. Comparative evaluation and applicability of three different regression equation-based mixed dentition analysis in Northern Uttar Pradesh population. J Indian Soc Pedod Prev Dent 2018; 36:26-32.

30. Kakkar A, Verma KG, Jusuja P, Juneja S, Arora N, Singh S. Applicability of Tanaka– Johnston,

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

Moyers and Bernabéand Flores–Mir mixed dentition analyses in school-going children of Sri Ganganagar City, Rajasthan (India): A cross-sectional study. Contemp Clin Dent 2019;10:410-416.

31. Bhatnagar A, Jindal MK, Khan SY. Comparison of two different nonradiographic mixed dentition analysis. Pesquisa Brasileira em Odontopediatria e Clínica Integrada. 2019;19:e4374.
32. Ravinthar K, Gurunathan D. Applicability of different mixed dentition analyses among children aged 11–13 years in Chennai population. Int J Clin Pediatr Dent. 2020;13(2): 163-166.
33. Kumar T, Sardana D, Doda A. Evaluation and applicability of Tanaka–Johnston and Moyers' mixed dentition analysis for north Indian population. World J Dent. 2021;12(1):57–63.
34. Gaur S, Singh N, Singh R, Phukan AH, Mittal M, Kohli A. Mixed Dentition Analysis in and around Kanpur City: An Existential and Illustrative Study. Int J Clin Pediatr Dent. 2022;15(5):603-609.
35. Bangi S, Kondody R, Sana S, Fatima A & Hussain A. Evaluation of Accuracy of Tanaka-Johnston Mixed Dentition Analysis in North Karnataka Population: A Cross-Sectional Study. Journal of Indian Orthodontic Society. 2022; 56(4): 328-333.
36. Bugaighis I, Karanth D, Elmouadeb H. Mixed dentition analysis in Libyan schoolchildren. J Orthodont Sci 2013; 2:115-9.
37. Toodehzaeim MH, Aghili H, Shariatifar E, Dehghani M. New regression equations for mixed dentition space analysis in an Iranian population. J Contemp Dent Pract. 2013;14(6):1156-60
38. Burhan AS, Nawaya FR. Prediction of unerupted canines and premolars in a Syrian sample. Prog Orthod. 2014; 15:4.
39. Tayyab M, Hussain U, Ayesha, Sumayya, Ayub A. Applicability of Tanaka and Johnston Mixed Dentition Analysis in a Peshawar Sample. Pakistan Oral & Dental Journal. 2014;34(2):322-325.
40. Brito FC, Nacif VC, Melgaço CA. Mandibular permanent first molars and incisors as predictors of mandibular permanent canine and premolar widths: applicability and consistency of the method. Am J Orthod Dentofacial Orthop. 2014;145(3):393-8.
41. Asiry MA, Albarakati SF, Al-Maflehi NS, Sunqurah AA, Almohrij MI. Is Tanaka-Johnston mixed dentition analysis an applicable method for a Saudi population? Saudi Med J. 2014 ;35(9):988-92.
42. Al-Kabab FA, Ghoname NA, Banabilh SM. Proposed regression equations for prediction of the size of unerupted permanent canines and premolars in Yemeni sample. J Orthodont Sci 2014;3:68-73
43. Cruz B S, Rothier E K C, Vilell, B S, Vilella O V, Nascimento R R. Evaluation of two methods for mixed dentition analysis using the method error. Braz J Oral Sci. 2014;13(3):163-167
44. Sherpa J, Sah G, Rong Z, Wu L. Applicability of the Tanaka-Johnston and Moyers mixed dentition analyses in Northeast Han Chinese. J Orthod. 2015;42(2):95-102.
45. Paredes V, Tarazona B, Zamora N, Cibrian R, Gandia JL. New regression equations for predicting human teeth sizes. Head Face Med. 2015; 11:8.
46. Al-Dlaigan YH, Alqahtani ND, Almoammar K, Al-Jewair T, Salamah FB, Alswilem M, et al. Validity of moyers mixed dentition analysis for Saudi population. Pak J Med Sci 2015;31(6):1399-1404.
47. Abdelbagi A. Alzubir, Shaza Abass & Mohamed A. E. Ali. Mixed dentition space analysis in a Sudanese population, Journal of Orthodontics. 2016;43 (1):33-38.
48. Gyawali R, Shrestha BK, Yadav R. Mixed dentition space analysis among Nepalese Brahmins/Chhetris. BMC Oral Health. 2016;17(1):36.
49. Giri J, Pokharel PR, Gyawali R, Timsina J, Pokhrel K. New regression equations for mixed dentition space analysis in Nepalese mongoloids. BMC Oral Health. 2018;18(1):214
50. Kareem FA. Permanent Maxillary and Mandibular Central Incisor Width as Predictor of Permanent Maxillary Canine Width in a Kurdish Population: A Pilot Study. Children (Basel). 2020;7(8):92

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1857-1873 | ISSN:2251-6727

51. Chong SY, Aung LM, Pan YH, Chang WJ, Tsai CY. Equation for Tooth Size Prediction from Mixed Dentition Analysis for Taiwanese Population: A Pilot Study. Int J Environ Res Public Health. 2021;18(12):6356.

52. Mahida H, Memon S, Khan M & Naz F. Applicability of Two Non-Radiographic Mixed Dentition Analysis Methods in Orthodontic Patients. Pakistan Journal of Medicine and Dentistry. 2021;10(01):58-63

53. Dahaq WAM, Al-Kholani AIM, Al-Kibsi TAM, Al-Deen HS, Al-Shamahy HA, AL-Haddad KA, et al. Tanaka and Johnston's mixed dentition validity: an analysis among Yemeni adults in Sana'a city. Universal Journal of Pharmaceutical Research 2021;6(6):1-5

54. Kerre N, Ngesa JL, Ng'ang'a P, Kemoli AM, Bermudez J, Seminario AL. Comparison of measured and predicted mesiodistal tooth-widths of 13-17 years old Kenyans: a descriptive cross-sectional study to develop a new prediction equation for use in the mixed dentition in a Kenyan population. BMC Oral Health. 2022;22(1):338.

55. Rehan SA, Imtiaz R, Mustafa S, Saleh A. Application of Moyer's mixed dentition analysis and establishing probability tables in a sample of Pakistani population. Pak J Med Sci. 2023;39(5):1312-1316.

56. Ghada A. Salem, Mohammed Abou Elyazied, Ehab Radwan, Omnia A. Elhiny. New Equations for Egyptian Children Based on Tanaka and Johnston Mixed Dentition Analysis. Egypt J Hosp Med. 2023;92(1):6807- 6811.

57. Altherr ER, Koroluk LD, Phillips C. Influence of sex and ethnic tooth-size differences on mixed-dentition space analysis. Am J Orthod Dentofacial Orthop. 2007;132(3):332-9.

58. Schwartz GT, Dean MC. Sexual dimorphism in modern human permanent teeth. Am J Phys Anthropol. 2005;128(2):312-7.

59. Foneseca C. Predicting of mesiodistal crown width of the canine premolars segment in maxillary dental arches. Memphis, Tenn: University of Tennessee School of Dentistry; 1961.