Applicability of Moyers analysis in mixed dentition: A systematic review

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Introduction: Moyers analysis is widely used for analyzing mixed dentition, however, the accuracy of its theoretical probability tables has been recently questioned. Taking into consideration the fact the mixed dentition analysis is of paramount importance to precisely determine the space needed for alignment of canines and premolars, this research aimed at objectively assessing in the literature such an important step for orthodontic diagnosis.

Methods: A computerized search involving articles published on PubMed and Lilacs between 1990 and September, 2011 was conducted in accordance with the method described in the Cochrane 5.1.0 handbook.

Results: The research resulted in a sample composed of 629 articles. The inclusion criteria were: Articles using the Moyers analysis with a sample greater or equal to 40 patients. Conversely, the exclusion criteria were: Dental casts of patients with syndromes or oral cleft, researches conducted with a literature review, only, or clinical case reports and researches conducted before 1990. For this systematic review, 19 articles were selected.

Conclusion: Based on the literature available, we can conclude that the Moyers mixed dentition analysis must be carefully used, since the majority of the articles analyzed showed that the probability of 75% was not as accurate as expected, leading to the need of adapting the probability levels depending on the study population.

Keywords: Mixed dentition. Malocclusion. Dental eruption.

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INTRODUCTION

A correct diagnosis is the first step towards a successful orthodontic treatment, and mixed dentition analysis[1] is considered a fundamental step to make a good diagnosis.[2,3]

The mixed dentition analysis enables the identification of a tooth size-arch length discrepancy and, according to the results obtained, proposes different treatment approaches such as: Eruption guidance, space regaining, serial extractions or not to intervene by keeping the development of the dentition under observation.[2,4]

The use of an accurate method for predicting the mesiodistal diameter of unerupted canines and premolars is essential when verifying the discrepancy between the size of the teeth and the size of dental arches in mixed dentition.[2] Several methods are used to assess the required space, i.e., to estimate the mesiodistal diameters of unerupted canines and premolars.[1,2,4]

Most methods use the mandibular permanent incisors to predict the sum of mesiodistal dimensions of the canine and premolars, since these incisors are the first to erupt in mixed dentition, have less variability in shape and size, can be easily and accurately measured and have a high correlation with other groups of teeth.[5,6,15]

The Moyers mixed dentition space analysis method is currently the most widely used.[3,4,5,7,8] It established a probability table to predict the mesiodistal diameter of unerupted canines and premolars, in both arches.[9] This table uses the sum of mesiodistal diameters of the four mandibular incisors and, for each value obtained in the sum of the four mandibular incisors, there is a corresponding value for unerupted canines and premolars of each quadrant. It was developed at the University of Michigan from a sample comprising northern European white subjects.[7,9]

The probabilities range from 5% to 95% and the author suggests the use of the table at a level of 75% in order to overestimate the value and avoid potential crowding. According to the author, this method has some advantages, such as: Minimum systematic error, it can be easily and safely used by beginners or specialists, it is fast and does not require the use of radiographies and also may be carried out directly in the mouth.[9]

The purpose of this study was to carry out a systematically review about the effectiveness of Moyers mixed dentition space analysis in predicting unerupted teeth.

MATERIAL AND METHODS

The systematic review was carried out in accordance with the Cochrane Handbook for Systematic Reviews of Interventions 5.1.0.

A computerized search was conducted by means of researching articles published from January 1990 to September 2011 on PubMed (http://www.ncbi.nlm.nih.gov/pubmed/) and Lilacs (http://regional.bvsalud.org/php). 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 were as follows: Sample greater than or equal to 40 dental casts and the use of Moyers mixed dentition space analysis to predict unerupted canines and premolars. Conversely, the exclusion criteria were: Dental casts of patients with some type of syndrome or cleft patients, literature reviews, clinical case reports and researches carried out prior to 1990.

Two reviewers independently assessed all the articles abstracts. All abstracts meeting the initial inclusion criteria were selected, those that did not provide enough information to determine their suitability to the inclusion criteria were selected too, so that the final decision would be made with the complete article.

RESULTS

The research resulted in a sample composed of 629 articles. After analyzing them according to the inclusion/exclusion criteria, 36 articles were selected for analysis, 30 from PubMed database and 6 from Lilacs. The final total number of selected articles was 19, since 17 articles were duplicated in the search results. The number of selected articles and methodological criteria of systematic review are shown in Table 2.

The Kappa index of agreement between reviewers was 1.00.

A total of 610 articles were excluded: 593 by the established criteria and 17 articles because they were the same articles published in different databases. The reasons for exclusion and the number of excluded articles are listed in Table 3. In the Lilacs database, 57 articles

Table 1 - Strategy for literature research.

Number	Keyword	PUBMED	LILACS
1	Mixed dentition AND Moyers analysis	17	7
2	Prediction of unerupted teeth	59	1
3	Mixed dentition analysis	490	55

Table 2 - Studies included and excluded after reviewers' analyses.

Keyword / PubMed Database	Studies included	Studies excluded	Total
Mixed dentition AND Moyers analysis	9	8	17
Prediction of unerupted teeth	12	47	59
Mixed dentition analysis	9	481	490
Keyword / Lilacs Database	**Studies included**	**Studies excluded**	**Total**
Mixed dentition AND Moyers analysis	3	4	7
Prediction of unerupted teeth	0	1	1
Mixed dentition analysis	3	52	55

Table 3 - Reasons for articles exclusion.

Reasons for exclusion	LILACS	PubMed	Total
Sample with less than 40 subjects	5	3	8
Patients with some type of syndrome or cleft patients	0	4	4
Moyers analysis was not used	4	37	41
Research was not about predicting space	43	392	435
Literature review/case reports	3	4	7
Research conducted prior to 1990	2	96	98
Total of excluded studies	57	536	593

were excluded, while in the PubMed database 536 articles were excluded.

Most articles were excluded because they were not related to prediction of unerupted canines and premolars, followed by articles published out of the stipulated period and by studies that did not use the Moyers analysis.

All 19 articles were entirely read, except for one article written in Chinese which had to be evaluated by the title and abstract in English.

Among 19 articles, only two[14] enabled the use of a probability level of 75% in both arches and for both genders.

In 10 articles,[2-5,7,16-20] the probability table had to be adapted in order to make the Moyers analysis appropri-

ate to their population and, in 7 articles,[8,10-13,15,21] the Moyers mixed dentition space analysis was not suitable for prediction of canines and premolars. Summarized data of the articles are shown in Table 4.

DISCUSSION

A systematic review is a literature review focused on a research question that tries to identify, appraise, select and synthesize all high quality research evidences relevant to that question in order to help our clinical approach.

Inclusion and exclusion criteria for this systematic review were determined with the aim of selecting the most relevant papers on the subject in question, only.

The mixed dentition analysis is a fundamental step that should always be performed in orthodontic diagnosis and planning of patients with mixed dentition.[2,3] The use of an inappropriate method may hinder the entire treatment plan because both overestimation and underestimation of crown diameters of unerupted canines and premolars can influence treatment planning, especially decisions regarding extractions.

Moyers mixed dentition space analysis method is currently the most widely used (1963),[3,4,5,7,8] but recently, its accuracy has been questioned, mainly because its probability table was developed on the basis of a population with a Northern European ancestry.

In recent years, studies have shown that the prediction tables formulated by Moyers is neither accurate nor applicable when applied to a population of different ethnic origin, due to the fact that the values obtained at 75% (as recommended by the author) do not correspond to the real values.[2,3,5,7,12,13,15,19]

The biggest clinical problem exists when, at 75%, the predicted values underestimate the real values, in which case there will not be enough space to properly align the teeth. When the values overestimate the real values, it means that there will be more space to accommodate the posterior teeth, which is not considered a real clinical problem.

Table 4 shows that in several studies, Moyers probability tables underestimated[2,3,4,8,10,15] the real values at 75%. In other studies,[5,7,12,13] the predicted values overestimated the real ones. This means that Moyers mixed dentition space analysis was not appropriate for most populations evaluated.

Article	Sample and Gender	Population	Outcomes
Boboc and Dibbets[1]	320 (158 ♂ and 162 ♀)	German	Moyers 75% ↑♀ and ♂
Philip et al[2]	600 (300 ♂ and 300 ♀)	Indian	Moyers ↑ 85% and 95% ♂
			Moyers ↑ 85% and 95% ♀ L
			Moyers ↑ 95% ♀ U
Schirmer and Wiltshire[3]	100 (50 ♂ and 50 ♀)	American	Moyers ↓ 5% to 95% underestimated ♂
			Moyers ↑ 85% and 95% ♀
Pereira Neto et al[4]	40 (20 ♂ and 20 ♀)	Brazilian	Moyers ↑ 75% L ♀ and ♂
			Moyers ↑ 95% U ♀ and ♂
Farret et al[5]	100 (55 ♂ and 45 ♀)	Brazilian	Moyers ↑ 65% L ♀ and ♂
			Moyers ↑ 65% and 75% U ♀ and ♂
nik Tahere et al[7]	50 (25 ♂ and 25 ♀)	Iranian	Moyers ↑ 65% U and L ♂
			Moyers ↑ 75% and 85% U ♀
			Moyers ↑50% and 65% L ♀
Cabral and Pessôa[8]	60 (30 ♂ and 30 ♀)	Brazilian	Moyers ↓ underestimated 50% ♀ and ♂
Wang et al.[10]	140	Chinese	Moyers ↓ underestimated
Jaiswal et al.[11]	200 (100 ♂ and 100 ♀)	Nepalese	Moyers ↓ underestimated 50% ♂
			Moyers ↓ overestimated 50% ♀
Durgekar and Naik[12]	150 (75 ♂ and 7 5 ♀)	Indian	Moyers ↓ 75% ♀ and ♂ overestimated
			Moyers ↓ 50% ♂ overestimated L
			Moyers ↓ 50% ♂ underestimated U
			Moyers ↓ 50% ♀ underestimated L
			Moyers ↓ 35% ♀ and ♂ underestimated
Verzi et al[13]	150 (68 ♂ and 82 ♀)	Italian	Moyers ↓ overestimated 75% ♀ and ♂
de Paula et al[14]	40 (20 ♂ and 20 ♀)	Brazilian	Moyers 75% ↑ ♀ and ♂
van der Merwe et al[15]	200 (73 ♂ and 127 ♀)	African	Moyers ↓ 5% to 95% underestimated
Memon and Fida[16]	121 (45 ♂ and 76 ♀)	Pakistani	Moyers ↑ 50% ♂
			Moyers ↑ 75% ♀
Abu Alhaija and Qudeimat [17]	226 (130 ♂ and 96 ♀)	Jordanian	Moyers ↑ 75% U ♂
			Moyers ↑ 65% L ♂
			Moyers ↑ 85% U and L ♀
Hashim and Al-Shalan [18]	65 (37 ♂ and 28 ♀)	Arab	Moyers ↑ 50% ♀ and ♂
Flores-Mir et al[19]	248 (131 ♂ and 117♀)	Peruvian	Moyers ↓ 5% to 95% L ♂
			Moyers ↑ 65% U ♂
			Moyers ↑ 95% L ♀
			Moyers ↑ 65% L ♀
al-Khadra[20]	34 (not informed ♀ and ♂)	Arab	Moyers 35% ↑ ♀ and ♂
Diagne and Diop-Ba[21]	50 (25 ♂ and 25 ♀)	Selegalese	Moyers 50% ↓ Underestimated ♀ and ♂

Table 4 - Summarized data of the 19 articles included in this review.

↑ = High correlation of real values with the values found after Moyers analysis.

↓= Low correlation of real values with the values found after Moyers analysis.

♀ = Female.

♂ = Male.
U = Upper arch.
L = Lower arch.

For the Brazilian population, at 75%, the Moyers analysis overestimated the real values in one article (Farret et al[5]), underestimated the real values in another article (Cabral and Pessôa[8]), and was appropriate in two articles (De Paula et al[14])and for the lower arch, only, in one article (Pereira Neto et al[4]).

Due to the wide variability of results found for the Brazilian population, perhaps the use of a different method is necessary to evaluate mixed dentition space in Brazilian subjects.

CONCLUSIONS

Based on our systematic review, it seems that the use of Moyers mixed dentition analysis should be used carefully, because, in the majority of the articles examined, its accuracy regarding probability level at 75% was poor. Therefore, we suggest that the probability tables be adapted according to each population, or that another method be used to predict unerupted permanent canines and premolars.

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