Comparison of Two Methods of Space Prediction in the Mixed Dentition

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Abstract

Purpose: This study compares the accuracy of space prediction for the unerupted permanent canines and premolars by a recognized method of mixed dentition space analysis (Moyers technique) vs estimation by simple visual observation (SVO).

Methods: Twenty clinicians with varying levels of dental experience and training blindly assessed study models of 4 intact arches (2 maxillary and 2 mandibular) from 3 patients in the mixed dentition using both Moyers and SVO space prediction methods. Corresponding full-mouth panoramic radiographs were available for each case. Follow-up records of the eventual outcome in the permanent dentition for each case available (ie, study models prior to any form of orthodontic intervention) served as the standard for further comparison of the space predictions made. Predictions by both methods were compared with each other as well as with the eventual space situation in the permanent dentition.

Results: The differences in overall mean space prediction between the Moyers technique (excluding molar shift) and SVO ranged between 3.67 mm to 6.9 mm (lower arches) and 4.3 mm to 4.8 mm (upper arches). Diagnostic consistency between both methods' predictions was highly variable, with correlation ranging from moderate (r=0.53, P=.01) to very weak (r=-0.1). Generally, more crowding was estimated with the SVO method's predictions. However, the inclusion of molar shift in the Moyers analysis resulted in the prediction of more crowding in the mandible compared to SVO and eventual outcome in the permanent dentition. The range and variability in predictions were always smaller with the Moyers technique compared to SVO. Neither technique's mean space prediction more closely resembled the eventual space situation in the permanent dentition.

Conclusions: This study demonstrated that although the Moyers technique demonstrated less variation and more reproducibility than SVO in its space predictions, neither of the techniques was any more accurate in predicting the final space outcome in the permanent dentition. (*Pediatr Dent.* 2003;25:350-356)

KEYWORDS: MOYERS ANALYSIS, VISUAL OBSERVATION, MIXED DENTITION ANALYSIS

Received May 21, 2002 Revision Accepted February 18, 2003

Prediction of the sizes of unerupted canines and premolars, plus the assessment of the space available to accommodate them, is fundamental to orthodontic diagnosis and treatment planning during the mixed dentition period.[1] Classically, mixed dentition space analysis (MDA) techniques rely on one of the following basic methods:

1. the estimation of unerupted tooth size by radiographic measurement (eg, Nance, 1947);
2. predictions based on the correlation between the sizes of different types of teeth within a dentition (eg, Tanaka and Johnson, 1974; Moyers, 1973 and 1988);
3. a combination of both methods (eg, Hixon and Oldfather, 1958; Staley and Kerber, 1980).

The accurate estimation of mesiodistal widths of the unerupted canines and premolars aids in predicting the space required (crowding/excess space) to accommodate them in the buccal segments of the mixed dentition arches of children. The dental literature is replete with investigations focusing on the comparative accuracy, reliability, and reproducibility of the various mixed dentition space analysis techniques.[1-4] To date, no technique has been shown to be significantly superior over others in its predictive ability.

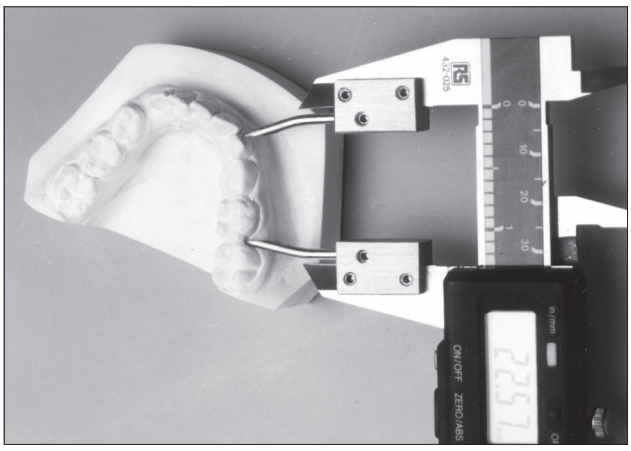

Figure 1. Modified electronic digital caliper used to measure tooth and arch dimensions on mixed dentition casts.

The Moyers analysis based on measurements of erupted teeth is one of the techniques that enjoys wide clinical acceptance due to its relative ease of application and interpretation. Research demonstrates a reasonably good correlation in the estimation of space discrepancies in the dental arches of children using this technique at the 75% level.[2] However, MDAs in general suffer from a number of potential errors, which can occur during measurement of dental records and calculation of dental arch space discrepancy. The impression that an answer is accurate because it results from a calculation or reading values off a table may be misleading. These criticisms have lead clinicians to question the value of such techniques. Based on this premise, it might be argued that mixed dentition analysis techniques, such as Moyers, would be no more likely to give an accurate result than a simple educated guess from visual observation of study models and radiographs. This hypothesis has never been tested. Therefore, it seemed appropriate to design a study to investigate and compare the accuracy of the MDA using the Moyers analysis with a simple visual observation (SVO) of study models and orthopantomographs of children in the mixed dentition. The study also investigated the effect that operator experience could have on the outcome of each approach.

Methods

Four sets of dental records of children with mixed and permanent dentition records (study models+orthopantomographs, or OPT), respectively, were selected. From these, 2 upper and 2 lower mixed dentition records were selected for assessment. These arches had all permanent incisors and first molars present. Primary canines and molars were also present, wherever possible on mixed dentition study models unless individual teeth underwent early exfoliation or were extracted many years ago. None of the mixed dentition arches had severe skeletal base discrepancy (as assessed from the dental records of patients), partially erupted permanent teeth and any history of interceptive orthodontic or space maintainer treatment. All OPTs had been taken at the same time or within a maximum of 6 months of the respective study models. In each case, permanent dentition study models were also available to provide the eventual space situation of the mixed dentition records. These patients did not undergo any form of space maintenance or orthodontic treatment in the intervening period between the timing of mixed and permanent dentition study model records.

A convenience sample of 20 dental practitioners equally stratified according to level of clinical experience (ie, 5 practitioners per skill level: senior undergraduate students, general dental practitioners, graduate students in orthodontics/pediatric dentistry, specialists in orthodontics/pediatric dentistry with several years of clinical experience) participated in this study. Prior to commencement of the study, all examiners received the same baseline information and instructions during a prestudy teaching session. An explanation and demonstration of the use of the measuring device, a modified electronic digital caliper (Figure 1); method of measuring mesiodistal tooth and arch dimensions; and use of the appropriate forms for each of the 2 techniques (previously devised, piloted, and redefined for ease of interpretation and clarity) were presented to them.

All examiners blindly evaluated each of the above mixed dentition records (study model+OPT) during a standardized time period on 2 separate occasions: (1) SVO; and (2) Moyers analysis. On a third occasion, examiners were asked to repeat either of the analyses. This allowed an assessment of technique reproducibility and intraexaminer reliability in arch space prediction by both methods. Recall bias was prevented by including other mixed dentition records at each occasion and by allowing a sufficiently long time lapse between repeat assessments. All measurements for the Moyers technique were made with the electronic digital caliper (Mitutoyo Digimatic Caliper, 0-150 mm/0-6, RS Components, RS 423-025, UK), calibrated to the nearest 0.01 mm (Figure 1). The tips of this caliper were modified to ensure better negotiation of the interproximal contact points of teeth and arch dimensions to be measured. The reproducibility of the new measuring tips was tested for accuracy prior to commencement of the study and at 2 further intervals throughout the study by blind measurements of standardized stainless steel blocks.

All the recorded data was entered into Excel 5 for Windows and statistically analyzed by means of diagnostic consistency testing,[5] Pearson's correlation coefficients, and ANOVA where appropriate.

Results

The standard error estimate (SE) of the baseline mean measurements of the standardised stainless steel blocks prior to commencing the study was 0.02 mm and 0.05 mm. The SE of the mean measurement values over the subsequent measuring occasions (T2, T3) did not exceed 0.05 mm for either block. ANOVA for repeated measures of each block failed to demonstrate any significant differences over time or between subjects.

Table 1. Intraexaminer Reliability of Arch Space Discrepancies With the Moyers Technique and With the Simple Visual Observation on Re-examination of Randomly Selected Dental Study Models (N=20 Examiners)

Arch	Technique	Overall space discrepancy X difference (mm)	±2 SD (mm)	±95% CI (mm)
Mandibular	Moyers	0.42	3.09	-0.07 to +0.92
	SVO	0.43	6.63	-0.63 to +1.48
Maxillary	Moyers	0.16	3.15	-0.90 to +0.58
	SVO	0.60	6.17	-0.84 to +2.04

SVO=simple visual observation.

Using the method of determining diagnostic consistency suggested by Bland and Altman,[5] the overall intraexaminer reliability scores for both arch space discrepancies demonstrated the lowest overall mean difference with the Moyers prediction (mean difference=0.16 mm±3.15 mm, ±95% confidence interval: -0.90, +0.58) and the highest overall mean difference with SVO prediction (mean difference=0.6 mm±6.17 mm, ±95% confidence interval: -0.84, +2.04) in repeat assessments (Table 1). The Moyers technique was, therefore, more reproducible in its predictions when compared with SVO. Although perfect agreement between repeat SVO predictions occurred in 15% of examiners compared with 5% for the Moyers analysis, in greater than half of the examiners the difference between repeat Moyers prediction failed to exceed 1 mm. In contrast, only one third of the SVO repeat predictions were within 1 mm of each other.

The difference in arch space prediction between Moyers and SVO was calculated for each study model for the overall group of examiners (Table 2). In all 4 arches, the overall mean predictions from the SVO method predicted more crowding than its Moyers counterpart (excluding molar shift). The largest and smallest spread of the ±2 standard deviations of the mean difference between the 2 methods of prediction was 16.26 mm for the minimally crowded lower arch and 10.93 mm for the severely crowded upper arch, respectively. Clinicians varied widely in their space prediction between the 2 techniques, ranging from a negligible difference to a clinically significant disparity (>2 mm). These differences were independent of the examiner's level of clinical experience, arch examined (upper vs lower) or the arch characteristics (crowded/spaced). A moderate correlation (Pearson's correlation: $r>0.5$, $P<.05$) between the predictions produced by the 2 techniques was demonstrated for the severely crowded upper arch and the uncrowded lower arch (Table 3).

A comparison of arch space prediction of the overall group of examiners and the eventual space situation determined from the permanent dentition study models can be seen in Table 4 and Figure 2. Neither of the techniques were more accurate in maxillary space predictions. For the uncrowded maxilla, the Moyers space prediction more closely resembled that of the eventual outcome in the permanent dentition, while an estimation of minimal crowding was made by the SVO predictions. In the crowded maxilla, examiners were able to detect a deficiency of space by both methods, but the mean SVO prediction was more realistic in its estimate of 1.1 mm more crowding than the eventual outcome. However, the crowding problem was underestimated by the mean Moyers prediction with 2.3 mm less crowding than the eventual outcome. In both mandibular assessments, the overall mean predictions by the SVO method more closely resembled the eventual space situation than did the Moyers prediction (±molar shift). However, the spread of SVO predictions was over a larger range when compared to those of the

Table 2. Overall Diagnostic Consistencies of Mean Space Prediction Between Moyers and SVO Techniques According to Study Model

Arch	Overall mean difference* (mm)	±2 SD limits of the mean difference (mm)
Mandible		
Uncrowded	-3.67	-9.94, +2.06
Minimally crowded	-6.90	-15.03, +1.23
Maxilla		
Uncrowded	-4.80	-13.17, +3.58
Severely crowded	-3.78	-9.24, +1.69

*Sum of examiner mean difference between Moyers and visual techniques for each study model divided by the total number of examiners (20).

Table 3. Overall Correlation of Arch Space Discrepancies Between Moyers Analysis (Excluding/Including Molar Shift) and Simple Visual Observation (SVO)

Arch	Correlation (*r*)	Fishers exact value	*P* value
Maxilla			
Uncrowded	0.13	0.13	NS
Crowded	0.50*	0.55*	0.02*
Mandible			
Uncrowded			
Molar shift excluded	0.53*	0.59*	0.01*
Molar shift included	0.52*	0.57*	0.01*
Minimally crowded			
Molar shift excluded	-0.10	-0.10	NS
Molar shift included	-0.15	-0.15	0.50

*Moderate correlation, significant association between the mean Moyers and SVO predictions.

Table 4. Comparison of the Overall Mean Arch Space Prediction by the Moyers Analysis, SVO, and Eventual Space Situation in the Permanent Dentition Using Dental Study Models

Arch	Technique	X (mm)	SD (mm)	±95% CI (mm)
Maxilla				
Uncrowded	Moyers	+1.0	1.49	-1.92 to +3.91
	SVO	-3.8	2.10	-11.8 to +4.21
	Eventual	+0.3		
Severely crowded	Moyers	-6.7	2.34	-11.26 to -2.11
	SVO	-11.0	3.06	-16.99 to -5.0
	Eventual	-9.9		
Mandible				
Uncrowded	Moyers (-ms)*	+4.6	1.38	+1.90 to +7.29
	Moyers (+ms)*	-3.3	2.61	-4.45 to -2.15
	SVO	+1.0	3.14	-5.19 to +7.10
	Eventual	+1.3		
Minimally crowded	Moyers (-ms)*	+3.3	1.62	+0.12 to +6.48
	Moyers (+ms)*	-9.5	3.54	-11.02 to -7.92
	SVO	-3.6	3.42	-10.31 to +3.11
	Eventual	-2.6		

*±ms=inclusion/exclusion of molar shift in the Moyers analysis.

Moyers prediction. When an estimate of molar shift was entered into the Moyers analysis, the overall mean space prediction by this method estimated crowding which exceeded the eventual space outcome by 4.6 mm in the well spaced and 6.9 mm in the crowded mandibles, respectively. Hence, the Moyers and SVO predictions varied in their ability to accurately predict the amount of mandibular crowding.

One-way ANOVA for mean space predictions between skill groups using the Moyers technique (excluding molar shift) failed to reach any level of significance for all study models examined. However, with SVO the group of general dental practitioners' mean space prediction differed significantly (*P*=.018) from that of the specialists and graduate students in orthodontics/pediatric dentistry (Table 5). Specialists in orthodontics and pediatric dentistry were most consistent in predictions with the Moyers technique but varied as widely as the other groups with their SVO predictions. All skill groups predicted more crowding when molar shift was included compared to when molar shift was not included in the Moyers analysis. The specialist group predicted the most crowding for both lower arches when molar shift was included in the analysis, exceeding the eventual space outcome by 8.1 mm for the minimally crowded mandible (2.6 mm actual crowding).

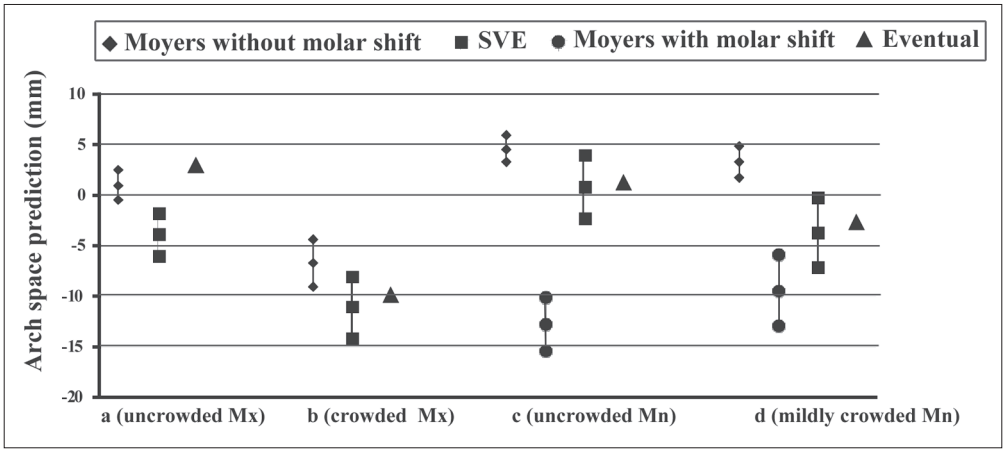

Figure 2. Comparison of mean space prediction for each method of space analysis on each of the 4 arches (mean±SD) across all clinicians.

Discussion

Traditionally, correlation coefficients have been used for the comparison of MDA techniques. The use of correlation to compare such measurements may be misleading.[5] A correlation coefficient (*r*) measures the strength of a relation between 2 variables, not the agreement between them. Perfect agreement only occurs if the points, when plotted graphically, lie along the line of equality (passing through 0 with a slope of 1), but perfect correlation occurs if the points lie along any straight line (not necessarily passing through zero). Therefore, data in poor agreement can produce quite high correlations.

For continuous variables, the measure of agreement between 2 methods of measuring involves the assessment of 2 aspects: bias (Do the 2 methods agree on average?) and variation (How well do these readings agree?). The mean of the differences between the 2 readings gives an estimate of the average bias. If this difference is negligible, the methods must agree exactly on average or the repeatability of a method must be excellent. The interpretation of these parameters depends upon the clinical circumstances, as it is not possible to use statistics to define acceptable agreement. It is for

Table 5. Comparison of Arch Space Prediction by the Moyers Analysis (Excluding Molar Shift), SVO, and Eventual Space Situation in the Permanent Dentition According to the Clinicians' Level of Skill (N=20)*

Arch and level of skill Mean (SD)	Moyers technique Mean (SD)	SVO
Uncrowded maxilla (+0.3)†		
Undergraduate students	+0.5 (2.09)	-3.6 (3.65)
General dental practitioners	+2.1 (0.90)	-2.6 (4.51)
Ortho/pedo graduate students	+1.4 (1.02)	-2.6 (2.88)
Ortho/pedo specialists	0.0 (0.88)	-6.4 (5.02)
Severely crowded maxilla (-9.9)†		
Undergraduate students	-7.1 (2.12)	-10.6 (3.21)
General dental practitioners	-6.2 (1.52)	-9.2 (1.64)
Ortho/pedo graduate students	-5.4 (3.56)	-10.6 (3.97)
Ortho/pedo specialists	-8.0 (1.32)	-13.6 (1.67)
Uncrowded mandible (+1.3)†		
Undergraduate students	+4.7 (0.69)	+0.6 (2.07)
General dental practitioners	+5.7 (1.51)	+4.4 (2.70)
Ortho/pedo graduate students	+4.7 (1.33)	-1.0 (2.12)
Ortho/pedo specialists	+3.4 (1.03)	-0.2 (3.03)
Minimally crowded mandible (-2.6)†		
Undergraduate students	+2.4 (1.54)	-5.2 (1.79)
General dental practitioners	+4.6 (1.30)	-3.8 (2.28)
Ortho/pedo graduate students	+3.1 (1.40)	-3.8 (4.97)
Ortho/pedo specialists	+3.1 (1.80)	-1.6 (3.78)

*All values are in millimeter measurements.
† Indicates the eventual space outcome in the permanent dentition.

these reasons diagnostic consistency testing,[5] which assesses both the bias and variation between measurement techniques, was used for statistical analysis of results in the present investigation.

Sliding calipers have been shown to be more accurate, giving consistently repeatable measurements than other methods (eg, dividers) with a 0.15 mm standard error estimate of the mean measurement.[6] The more recent use of digital calipers[7] and electronic digital calipers[8,9] have shown to be even more accurate methods of measuring mesiodistal tooth dimensions on dental study models with a standard error of <0.01 mm–hence its choice for this study. Our examiners found the device easy to use, and the excellent measurement accuracy reduced the possibility of introducing systematic and random errors in measurements irrespective of the varying number of people using the instrument.

Although slightly more examiners demonstrated perfect agreement with the SVO predictions, this does not imply consistency, as the range of intraexaminer variability in most repeat SVO predictions was quite high when compared to the very small range of intraexaminer variability between repeat Moyers predictions. In general, examiners were more consistent in repeat assessments with the Moyers technique, which proved to be more reproducible than the SVO technique for all examiners. With the Moyers technique, the user is guided step by step with clear instructions on the various measurement procedures involved in finally arriving at a prediction of arch space, which may be more easily conceptualised at different levels of operator experience.[4] The only subjectivity resulting from this method is the manner of carrying out the measurement procedures on the study models. The simple visual observation method, however, is an entirely subjective assessment and the current results show that a single clinician may vary substantially from one occasion to another in the prediction of space discrepancy by this method. Furthermore, it is unlikely that measurements within 1/10 mm will be easily perceived with the naked eye. However, this difference in reproducibility does not imply that the Moyers analysis is any more accurate than the SVO method.

A significant correlation (association not agreement) between the 2 techniques was demonstrated for 1 lower and 1 upper study model examined. As previously mentioned, good correlation does not give any indication at all of the diagnostic agreement (ie, equality) between values–it simply indicates an association. The ±95% CI of the overall mean Moyers prediction was generally smaller when compared with that of the overall mean SVO prediction for all mixed dentition arches examined irrespective of the dentition's space situation. This only proves that the Moyers technique was more consistent than the SVO in its prediction. It must be remembered that a more precise mean prediction does not at all imply a more accurate prediction (ie, closer to the real situation). The mean prediction and its corresponding ±95% CI may not at all replicate the real/actual space situation. It is widely accepted that the Moyers space analysis technique (at the 75% level) tends to overpredict the size of the unerupted canine and premolar teeth when compared with other techniques, resulting in a prediction of more crowding than is actually the case.[1,3] However, examiners in the present study underpredicted crowding by as much as 2.3 mm in the crowded upper arch and 5.9 mm in the minimally crowded lower arch (excluding molar shift) with the Moyers technique. This situation was reversed for the mandible when molar shift was included in the Moyers analysis.

In the uncrowded upper dentition, the Moyers assessment more realistically mirrored the eventual situation, while the visual method was more variable in its prediction. This pattern was not observed in the lower arch predictions. It is apparent that all examiners were able to distinguish those study models with a greater potential for crowding from those without such problems using both methods. This is similar to the observation made by Runey et al.[4]

On the basis of comparing mean predictions alone for the maxillary dentition if it is well aligned, the Moyers analysis produced a fairly reliable prediction of the actual space discrepancy. In cases where the maxilla is crowded, it appears to be less accurate, with the SVO method producing a more realistic assessment of space discrepancy (closer to the eventual outcome). The latter, however, is more susceptible to a greater degree of variation in mean space prediction. For the mandibular arches, although the overall mean SVO predictions more closely resembled the eventual space situation, examiners varied widely in their ability to accurately predict the final outcome, as reflected in the large span of ±95% confidence intervals (uncrowded arch=12.3 mm; minimally crowded arch=13.4 mm). While examiners predicted the space requirements within a smaller range of values with the Moyers technique, a clinically significant underprediction (excluding molar shift) and overprediction (including molar shift) was made of the eventual space situation. Therefore, both techniques failed to reliably determine the actual amount of crowding in the permanent mandibular arches.

Other plausible reasons for why the Moyers technique was no better than SVO in its predictions include:

1. the possibility of individual variation in dentoalveolar development, resulting from whether molar shift occurs or not;
2. variations in buccal eruption of the permanent posterior teeth;
3. variations in the sequence of eruption;
4. variations in eruption pattern;
5. the influence of second molar eruption, among others.

Therefore, the value of MDSAs such as Moyers, needs to be considered within this dynamic framework.

The level of operator skill made no difference to the accuracy of arch space prediction by either technique. The present results suggest that highly skilled clinicians are more likely to anticipate space problems in the future permanent dentition of children irrespective of technique (Moyers vs SVO). However, the conservative variation within this group of clinicians with the Moyers technique reflects a more consistent approach in space prediction among skilled clinicians using MDA techniques. Conversely, clinical judgement (SVO) alone, even among highly skilled clinicians, does not appear to improve one's ability to more accurately predict space discrepancies in the dental arches of children. In fact, there is a tendency to overpredict crowding with clinical judgement (SVO) across all levels of skill.

Effect of including molar shift in the Moyers prediction

None of the previous studies has evaluated the role of molar shift in the determination of space discrepancy. Unless mesial drift of the lower first permanent molars has been deemed to have already occurred, an estimate of "molar shift" (to allow for the anticipated mesial shift of lower permanent molars following the loss of primary molars) is traditionally considered during mixed dentition analysis.[10] A longitudinal survey on arch circumferences changes found that only 50% of first permanent molars shifted during transition from the primary to the permanent dentition.[11] In the present study, the inclusion of molar shift in the Moyers predictions always resulted in an estimation of a significant amount of crowding much greater than the actual situation in the permanent dentition. In all cases, this exceeded more than half the width of a premolar tooth (>4 mm). It appears that examiners were unable to reliably predict when molar shift was really necessary and the exact amount of molar shift that actually occurred. It appears that the first permanent molar shifted much less than anticipated.

Interestingly, the most skilled clinicians (specialists in orthodontics and pediatric dentistry) made the worst space predictions with the Moyers technique when they included molar shift in the computation. A possible explanation may be that highly skilled clinicians generally rely on their vast experience and knowledge of malocclusions rather than on the predictive value of MDA techniques in potentially crowded cases. While every effort was made to ensure that all examiners received sufficient training on the concept of molar shift and its application (as described in the materials/methods), either inadequate understanding of this principal, its application, or factors outside of clinical control might have affected the results. The utilization of arch perimeter, adaptive changes in occlusion, and jaw growth changes during the transitional dentition play integral interdependent roles in the occlusal relationship of the permanent dentition.[10,12] These factors cannot be reliably accounted for at the time MDA techniques are usually carried out, bearing in mind that only 50% of molars are likely to shift during the transition period. However, appropriate case selection for application of molar shift corrections warrants further study.

The limited number of records used in the present study precludes any definite conclusions regarding improvement of space evaluation methods. Prospective longitudinal studies are needed to evaluate:

1. the true value of molar shift for MDA;
2. the influence of differential jaw growth pattern on eventual permanent first molar relationship.

Finally, it must be remembered that mixed dentition analyses indicate how much spacing or crowding would exist for the patient if all primary teeth were replaced by their permanent successors on the same day, but not 2 to 3 years later.

Conclusions

1. The Moyers technique produces more consistent space predictions when compared to simple visual observation.
2. The diagnostic agreement between the 2 methods' space predictions tested was highly variable.
3. Neither of the tested techniques' space predictions were superior in predicting the eventual space situation in the permanent dentition.
4. The clinicians' level of experience made no difference in the accuracy of space predictions by either of the techniques.

Acknowledgements

The authors wish to acknowledge Dr. C.F.G. Fairpo for assisting with the statistical analysis of this manuscript and all the clinicians that participated in this study.

References

1. Irwin RD, Herold JS, Richardson A. Mixed dentition analysis: a review of methods and their accuracy. *Int J Paediatr Dent.* 1995;5:137-142.
2. Kaplan RE, Smith CS, Kanarek PH. An analysis of three mixed-dentition analysis. *J Dent. Res*. 1977;56: 1337-1343.
3. Gardner RB. A comparison of four methods of predicting arch length. *Am J Orthod.* 1979;75:387-339.
4. Runey M, Johnsen D, Merow W. Reproducibility of three mixed dentition space analyses by practitioners and students. *J Dent Child*. 1978;45:68-72.
5. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*. 1986;1:307-310.
6. Howe RP, McNamara JP, O'Connor KA. An examination of dental crowding and its relationship to tooth size and arch dimension. *Am J Orthod*. 1983;83:363-373.
7. Crosby DR, Alexander CG. The occurrence of tooth size discrepancies among different malocclusion groups. *Am J Orthod Dentofacial Orthop*. 1989; 95:457-461.
8. Little RM. The irregularity index: a quantitative scale of mandibular alignment. *Am J Orthod*. 1975;68:554-563.
9. Al Dashti AA. *The prediction of tooth size in Arabian Gulf children* [dissertation]. Leeds, UK: School of Dentistry, University of Leeds; 1995.
10. Moyers RE. *Handbook of Orthodontics*. 4th ed. New York, NY: Year Book Medical Publishers, Inc; 1988:233-237.
11. Bishara SE, et al. Changes in molar relationships between the deciduous and permanent dentitions: a longitudinal study. *Am J Orthod Dentofacial Orthop.* 1988;93:19-28.
12. Proffit WR. *Contemporary Orthodontics*. 2nd ed. St. Louis, Mo: Mosby Year Book Publishers; 1993:69-85.

ABSTRACT OF THE SCIENTIFIC LITERATURE

CARIES DECLINE AND INCIDENCE, 1985-2000

Because of the importance of planning for future preventive programs to improve or maintain low caries activity, identifying various factors contributing to the caries decline is important. Annual data reported from the Public Dental Services in Norway allowed for statistical analysis of factors associated with the caries decline. Therefore, the purpose of this study was to assess the possible impact of certain factors believed to be associated with the caries decline among Norwegian adolescents after 1985. This study reports DMFT data for 12 and 18 year olds from 1985 to 2000 (children born between 1967-1988). The authors give background information on variables they have focused on in this analysis. The average caries-free proportions of 18 year olds increased from 2% to 15%, while the DMFT scores declined by 49% between 1985 and 2000. The variables of migration and children per dentist were significantly associated with the caries decline in multivariate analyses. The caries decline at age 18 was significantly steeper before than after 1990, and this steep decline may be attributed to the use of fluoride as well as restrictive criteria for fillings in teenagers. The slower decline in the 1990s seems to be primarily attributable to fewer teeth being filled before the age of 12, since the DMFT increments from age 12 to 18 were not significantly different. **DARB**

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Birkeland JM, Haugejorden O, von der Fehr FR. Analysis of the caries decline and incidence among Norwegian adolescents 1985-2000. *Acta Odontol Scand*. 2002;60:281-289.

54 references