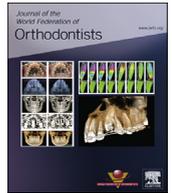


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Research Article

Changes in orthodontic occlusal indices after semi-rapid maxillary expansion

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ABSTRACT

Objectives: To quantify malocclusion complexity changes after semi-rapid maxillary expansion.**Materials and method:** The study sample consisted of pre- and postexpansion dental models and frontal intraoral photographs of 195 consecutive patients treated for maxillary expansion using a removable plate and a semi-rapid screw activation protocol. Differences between the pre- and posttreatment scores of the weighted Peer Assessment Rating Index (PAR), dental health component (DHC), aesthetic component (AC) of Index of Orthodontic Treatment Need (IOTN), and Discrepancy Index (DI) were analyzed.**Results:** The intraclass correlation coefficient test to assess the intraobserver error in PAR index and DI was performed and the value was found to be more than 0.80. The kappa score of 0.923 and 0.926 was observed in DHC and AC indices of IOTN, respectively, suggesting a good intraobserver agreement of scores. The pre- and postexpansion mean values in all the indices showed a significant reduction ($P < 0.001$). The IOTN-DHC, PAR, IOTN-AC, and DI scores showed improvements in 87.2%, 81.6%, 80.5%, and 72.8% of the subjects, respectively. The percentage change in the scores was maximum for IOTN-DHC (−27.8%) followed by PAR (−23.3%). IOTN-AC and DI showed approximately 20% improvement each. More than 25% improvement in scores was seen in 47% to 82% of the subjects.**Conclusion:** The study suggests that there is a significant decrease in orthodontic treatment need and treatment complexity after semi-rapid maxillary expansion treatment.

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1. Introduction

By definition, maxillary transverse deficiency (MTD) is a maxillary width that is narrower than the norm for a particular age group. Approximately 8% to 20% of healthy children exhibit maxillary arch constriction that may be expressed dentally as either a unilateral or bilateral posterior cross bite, or as a “V”-shaped arch with compensatory buccal tipping of the maxillary molars [1,2].

Early treatment of MTD aims to expand the maxilla and eliminate the functional shift, thereby restoring condylar and facial

symmetry and establishing normal craniofacial development and function [3]. Treatment of MTD is usually done with fixed or removable expansion appliances; however, the evaluation and clinical outcome of such treatment has been associated with a great degree of subjectivity and distorted perceptions of treatment need [4].

In orthodontics, it is important to objectively assess whether a worthwhile improvement has been achieved in terms of overall alignment and occlusion for an individual patient. The use of standardized indices which facilitates evaluation of malocclusion and esthetics, as well as treatment outcomes is often considered as subjective criteria and difficult to evaluate. Occlusal indices are also used to prioritize the need for treatment and minimize the subjectivity related to the diagnosis, outcome, and complexity assessment of orthodontic treatment [4]. Besides that, occlusal indices can be used for documentation of the prevalence and severity of malocclusion in population groups, for resource allocation and manpower planning, to predict estimated treatment time, for assessing the cost-effectiveness of orthodontic treatment, giving confidence to the orthodontic specialty, and to assess

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treatment effects of orthodontic appliances [5]. A manifold number of indices for orthodontic assessment have been described in the literature [6]. The Peer Assessment Rating (PAR) index is a quantitative, objective method for measuring malocclusion and the efficacy of orthodontic treatment [7]. It provides a single score, based on a series of measurements, that represents the degree to which a case deviates from normal alignment and occlusion [8]. This index is a valid and reliable tool for measuring malocclusion on plaster models and patients [9]. The Index of Orthodontic Treatment Need (IOTN) has two separate components: dental health component (DHC) and an aesthetic component (AC). The index defines specific, distinct categories of treatment need while including a measure of function [10]. The American Board of Orthodontics (ABO) developed objective measures of malocclusion complexity and treatment outcome called the ABO Discrepancy Index (ABO-DI). It measures pretreatment overjet, overbite, crowding, anterior open bite, lateral open bite, molar occlusion, lingual posterior crossbite, buccal posterior crossbite, ANB angle (angle formed by the intersection of lines from points A and B to point N), IMPA (incisor to mandibular plane angle), and SN-Go-Gn (sella nasion–gonion–gnathion) angle. The higher the DI score, the more severe is the malocclusion [11]. The DI is a reliable and relatively stable index for assessing the complexity of malocclusion [12].

Occlusal indices, in spite of a few limitations, are simple, easy to use, and give us an objective assessment of the malocclusion as well as assessment of the efficacy of the treatment given. Knowledge of changes in the complexity of the malocclusion during any given orthodontic treatment is important to justify its delivery among different stakeholders. The impact of MTD treatment as the only initial orthodontic treatment provided on orthodontic treatment need and complexity has not been reported yet. Hence, the objective of this study was to quantify malocclusion complexity changes after semi-rapid maxillary expansion (SRME).

2. Materials and methods

A total of 195 patients visiting the orthodontic center of the main author and whose treatment plan included maxillary expansion were included in the study. No other treatment or braces were given to the study subjects other than the upper expansion appliance as a phase I approach.

2.1. Treatment details

All patients were treated by the same operator using a similar type of expansion appliance (i.e., a removable screw plate with a semi-rapid expansion protocol) (Fig. 1). Expansion is considered to be semi-rapid when the frequency of activation and consequently the force generated is lower than in rapid maxillary protocols but higher than in slow expansion protocols. Typically, an expansion protocol of more than 1 mm and less than 3 mm per week is considered semi-rapid expansion [13]. The appliance used was a modified Schwarz plate with six Adam's clasps on the first molar, first premolar (or first primary molar), and lateral incisors on both sides, and a screw activation protocol of one-quarter turn six times a week (0.2-mm expansion per turn). The appliance was worn by the patients for 3.5 ± 0.5 months. Patients were advised to wear the appliance at all times including meal times, except during brushing. The study subjects were aged between 10 and 15 years at the start of treatment. Subjects with mixed dentition or permanent dentition were included in the study sample. The maxillary and mandibular impressions were taken in alginate (Tropicalgin, Zhermack, Italy) and the study models were prepared using dental stone plaster (Neelkanth, Rajasthan India). The

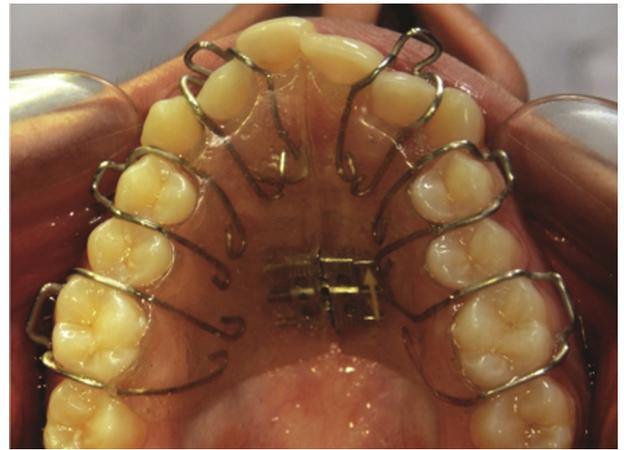


Fig. 1. The removable expansion appliance with six Adam's clasps.

facial photographs of the subjects were taken using a digital single-lens reflex camera with a 105-mm lens (Nikon AF-S VR Micro, Tokyo, Japan). All the photographs were taken 4.5 feet from the subject by the principal investigator. The dental models and the facial photographs of each patient were taken pretreatment (T_0) and at the completion of expansion (T_1), after 3.5 ± 0.5 months.

2.2. Outcome variable measurements

The differences between the T_0 and T_1 scores of the weighted PAR, DHC, and AC of the IOTN, and DI were analyzed. The 11 components of PAR index were measured for each model and weighted according to criteria of Richmond et al [8]. The IOTN was measured as per the guidelines of Shaw et al [6] in their series of studies. The DHC of the IOTN was recorded using the community periodontal index probe, and a digital vernier caliper (DIGI-0150; Libral Traders, New Delhi, India). Assessment of the DHC was recorded by examining following the occlusal traits of MOCDO: missing teeth, overjet, crossbite, displacement, and overbite. The five grades for DHC were as follows:

- Grade 1: No need for orthodontic treatment.
- Grade 2: Little need for orthodontic treatment.
- Grade 3: Moderate need for orthodontic treatment.
- Grade 4: Great need for orthodontic treatment.
- Grade 5: Very great need for orthodontic treatment.

The AC of the IOTN was recorded to assess the change in the patient's dental attractiveness after the treatment, requiring the examiner to compare the patient's frontal intraoral photographs with 10 standardized photographs that ranged from 1 for the most attractive, to 10 for the least attractive dental arrangement. DI was calculated directly on the casts using a digital vernier caliper. During scoring, care was taken to place the base of the models on a flat surface after they had been placed together in occlusion. Cephalometric parameters were not used in this evaluation. The total score was calculated and recorded on a data sheet. All the readings were measured by the same operator twice on two different occasions spanning a week. The operator, who was the treating orthodontist as well as the principal investigator, was trained to do the calibration before the calculations. The data obtained were tabulated in an Excel sheet for further statistical analysis. The percentage change was calculated using the formula $([x_2 - x_1]/x_1) \times 100$, where x_1 is the pretreatment score and x_2 is the posttreatment score.

2.3. Statistical analysis

The Statistical Package for Social Sciences (SPSS) software version 16 (SPSS Inc., IBM Corp, Chicago, IL) was used for performing the statistical analysis with a significance level set at less than 0.05. The intraclass correlation coefficient test was performed to analyze the intraobserver error of the measured data in the PAR index and DI. The intrarater agreement for categorical data for IOTN was measured using kappa coefficient. The normality of the data distribution was checked using Kolmogorov-Smirnov test and the difference in the pretreatment and posttreatment scores was tested using the Wilcoxon signed rank test for IOTN-DHC and IOTN-AC indices, as they had ordinal data. For the measured variables in PAR and DI indices, the Student's *t* test was applied.

2.4. Reliability values

The intraclass correlation coefficient for the PAR index and the DI was found to be above 0.80. The kappa coefficient for the ordinal data in the IOTN index was 0.926 and 0.923 for the IOTN-AC and IOTN-DHC, respectively, and the correlation was highly significant ($P < 0.001$).

2.5. Treatment changes

There was significant increase in the transverse width with significant changes in the intercanine and intermolar distance posttreatment using the removable expansion appliance and SRME protocol (Table 1).

There was an overall reduction in the percentage changes in the scores in all the four indices. The IOTN-DHC index showed the maximum reduction of 27.8% in scores followed by the PAR index (23.3%). The IOTN-AC and the DI showed approximately 20% reduction in the score values. The descriptive statistics and the results of the Wilcoxon signed rank test for significance in the pre- and posttreatment mean values in DI and PAR index are summarized in Table 2. The Wilcoxon signed rank test for significance in the ordinal scored data in IOTN-DHC and IOTN-AC indices also showed significant differences ($P < 0.001$). A decrease in the postexpansion values in all the four indices was observed in 80.5% of the subjects. Only 8.8% of the subjects did not show any change in the pre- and posttreatment score values (Table 3). Improvement in IOTN-DHC was observed in 87.2% of the subjects. PAR index, IOTN-AC, and DI showed improvements in 81.6%, 80.5%, and 72.8% of patients, respectively. More than 25% of improvement was observed in 82.0% of subjects in the IOTN-DHC index, 52.8% in IOTN-AC, 51% in the PAR index, and 47.2% in the DI. The distribution of the categorical data in IOTN index was analyzed using Microsoft Excel pivot table. In IOTN-DHC, 95 of 195 patients had a score of 4, and 76 had a score of 3 in the preexpansion data. In the postexpansion data, 87 and 82 patients had score of 3 and 2, respectively. With regard to IOTN-AC, 43 and 42 patients had score of 7 and 6, respectively, in the preexpansion data and 48 and 62 patients had score of 5 and 4,

respectively, in the postexpansion category. Thus, there was a reduction of one score in IOTN-DHC and a reduction of two scores in IOTN-AC.

3. Discussion

Malocclusions in the transverse plane are often difficult to evaluate in an objective manner. Whether the patient needs treatment and whether the treatment given and the appliance used have any favorable outcome on the end result is often arbitrarily decided. According to Hass, palatal expansion is the most encouraging treatment option to answer some of the severe challenges of orthodontics. Cases that would be considered difficult become routine after expansion. For example, marked cross-bites are corrected in days after the expansion procedure rather than months or years by other procedures [14]. Increase in arch perimeter and consequent decrease in crowding are also said to be the benefits of expansion. More recently, it has been suggested that early transverse treatment may be beneficial, in the absence of posterior crossbite, to improve arch length deficiency, and to facilitate correction of skeletal class II malocclusions [15]. Deep bite cases also seem to benefit from expansion of the palate.

In spite of so many benefits of expansion, there are very few studies that have objectively evaluated the end results after expansion using a removable palatal expansion appliance. Indices have been used in this study to determine whether the appliance given has been able to decrease the complexity of the malocclusion and benefit the patient in an objective and quantifiable manner. Different indices have been used in this study because each index has a different purpose. The PAR index determines the amount of improvement due to treatment, the IOTN categorizes the malocclusion based on treatment need, and the DI determines the severity of the malocclusion [9]. The mean PAR score in this study was 26.8 ± 10.3 at T_0 , which reduced to 20.2 ± 10.2 at T_1 . The reduction in PAR scores between pre- and posttreatment cases reflects the degree of improvement and therefore the efficiency of the appliance used. Of the 195 patients treated with SRME using a removable plate, 159 patients (81.5%) showed some reduction in score and approximately 51% of the cases showed a reduction in score by more than 25%, putting them in the "greatly improved" or "improved" category. There are a few cases in the "worse/no different" category, because expansion causes spacing and posterior buccal cross bite. The DHC of IOTN is a measure of dental irregularities in which the worst feature of the occlusion is scored. A decrease in score shows the decrease in need and therefore amount of improvement in the malocclusion. The pre-expansion score in DHC was in the IOTN grade 3 category of "greater irregularities." This was statistically significantly reduced to IOTN grade 2 category of the "minor irregularities" group. In the IOTN-AC index, there was reduction of two scores from pre-expansion category to postexpansion one. The ABO has devised the DI to provide an objective evaluation of complexity that might lead to a better understanding of the clinical effort required to achieve optimal treatment. The greater the number of target

Table 1
Changes in the intercanine and intermolar distance after maxillary expansion

Parameter	Pretreatment		Posttreatment		Change		Significance ^a
	Mean	SD	Mean	SD	Mean	SD	
ICW	32.57	3.28	37.49	3.56	4.92	3.02	0.000
IMW	44.46	3.05	49.20	3.53	4.73	2.92	

ICW, intercanine width; IMW, intermolar width.

^a $P \leq 0.05$.

Table 2
Descriptive statistics of the PAR and DI indices

Occlusal indices	Preexpansion, mean, T ₀	SD	Postexpansion, mean, T ₁	SD	Change, mean	SD	P
PAR	26.8	10.3	20.2	10.2	−6.5	7.2	0.000 ^a
DI	10.8	5.2	8.1	5.5	−2.6	4.8	0.001 ^a

DI, Discrepancy Index; PAR, Peer Assessment Rating.

^a Significant at $P < 0.05$.

disorders, the greater the complexity of the case and the more time needed for treatment. According to some authors, the average increase in treatment duration is approximately 11 days for each point increase in total DI score, so a 10-point increase in DI score will increase treatment duration by 110 days on average [16]. When the DI score decreases, the complexity is said to be reduced, which may in turn reduce the treatment time. In this study, in 142 of 195 patients, the DI reduced, meaning 72.8% of cases reduced in complexity after treatment with SRME, thus making further treatment with fixed appliances easier. The mean initial DI score of 10.8 ± 5.2 was reduced to 8.1 ± 5.5 post-expansion. Thus, there was a mean reduction of nearly 20% in scores. All the indices showed an improvement in the severity of malocclusion after treatment with SRME. More than 25% improvement was seen in 47% to 82% of the subjects who showed improvement. Whenever the complexity of a malocclusion decreases, time and effort needed to achieve optimal results also decreases. Other studies have reported significant associations between duration of orthodontic treatment and severity levels of malocclusion [17]. Unlike malocclusions in sagittal and vertical planes, those in the transverse planes are difficult to identify and often go unnoticed. However, treatment in the transverse plane not only corrects cross bite but also increases the arch perimeter and solves many other problems like crowding, rotations, deep bite, and class II or end-to-end occlusion. This current protocol of using a removable expansion appliance with a semi-rapid activation protocol showed more than 25% improvement in 47% to 82% of the subjects, suggesting a decrease in the complexity of the malocclusion as well as need for further complex treatment mechanisms. Nearly 90% of patients who showed improvements in PAR index also showed improvements in DHC index. The improvement in DHC index was observed in 90.1% of those who showed improvement in DI index. Similarly, the DHC index was improved in 85.5% of those subjects who also showed improvement in aesthetic index (AI). Sixty-two percent of the patients showed improvements in all three indices, namely PAR, DHC, and AI. Improvement in all the indices was observed in 47.2% of subjects. Overall, it was observed that when there was an improvement in the score of one index, approximately 71% to 90% of the patients showed improvement in other indices also.

The appliance used in this study was a removable appliance with a modified design and activation protocol. Using this appliance for expansion gave efficient expansion along with its associated benefits, as seen by the reduction in the scores. This appliance was also

easy to construct, removing need for laborious laboratory steps, it was easy to insert and remove, and oral hygiene was easier to maintain. Although there are different methods of expansion, such as rapid maxillary, semi-rapid, and slow expansion, and many different types of appliances, we found this an efficient, simple, and cost-effective method to achieve expansion. The clinician uses an appliance based on personal preferences, and this could be one more appliance to add to the clinician's armamentarium. In summary, the present study quantifies the degree of occlusal improvement during treatment of MTD with a single orthodontic device. This information is important for orthodontic clinicians to support the need of such treatment approach to our stakeholders. In an era of accountability, it is important to have quality data to support our clinical procedures.

4. Limitations

The main limitation in the study was that a control group was not included. The study could have benefited if a long-term post-retention analysis of the occlusal indices also could be included. Although these indices have proven to be an objective, valid, and reproducible method for scoring occlusal change for the entire mouth, they have few other limitations. Factors such as root resorption, functional occlusion, periodontal health, decalcification of enamel, patient compliance, and the likely stability of the result are not addressed. Changes in facial profile, psychosocial attitudes, and cephalometric measures that reflect skeletal aspects are also not considered. Similarly, in the IOTN index, sometimes there is a discrepancy between the DHC and AC grades. It has been suggested that there is only a moderate agreement between AC and DHC scores [13].

5. Conclusions

There was a reduction of 23.3%, 27.8%, 20.6%, and 20.1% in the scores of PAR, IOTN (DHC), IOTN (AC), and DI indices, respectively, and more than 25% improvement was seen in 47% to 82% of the subjects. The overall result in this study showed an improvement in scores in all the indices, suggesting a decrease in orthodontic treatment need and a reduction in the complexity of the malocclusion postexpansion with the SRME protocol using removable expansion appliances in cases that would fulfill the inclusion criteria.

Table 3
Frequency distribution of the effects of score in all the indices following treatment

Occlusal indices	Decrease in score		Increase in score		No change in score		Total
	Count	%	Count	%	Count	%	
PAR	159	81.54	27	13.85	9	4.62	195
IOTN-DHC	170	87.18	2	1.03	23	11.79	195
IOTN-AC	157	80.51	16	8.21	22	11.28	195
DI	142	72.82	38	19.49	15	7.69	195
Total	628	80.51	83	10.64	69	8.85	780

AC, aesthetic component; DHC, dental health component; DI, Discrepancy Index; IOTN, Index of Orthodontic Treatment Need; PAR, Peer Assessment Rating.

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