ORIGINAL RESEARCH

Comparison of Changes in Intraoral Dynamic Space (Donders Space) with Myofunctional Therapy in Skeletal Class II Division 1 Malocclusion: An *In Vivo* Study

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Abstract

Aim: To evaluate the changes in the intraoral dynamic space with myofunctional therapy in skeletal class II division 1 malocclusion using three-dimensional digital volume tomography (3D-DVT).

Materials and methods: The study type is observational and the duration of intervention was 3 years. Dental casts obtained from 20 samples of 11–14 years age-group were collected and 3D-DVT scans were performed prior to and after the myofunctional therapy. The parameters depicting the arch perimeter, arch width, arch length, arch shape, and arch volume on dental cast were used in the study using several linear and volumetric measurements. All parameters were compared before and after myofunctional therapy using *t*-test.

Results: The Intraoral volume before myofunctional therapy (T0) was 5.59 mL and after myofunctional therapy (T1), it was 7.22 mL. Significant changes were seen in intraoral volume, arch perimeter, arch length, and intercanine and intermolar arch width and the arch shape. Linear and volumetric measurements were increased after myofunctional therapy.

Conclusion: Myofunctional appliances lead to an expansion in the anteroposterior and sagittal direction thus increasing the Donders space and leading to proper formation of dental arches and proper positioning of the teeth.

Clinical significance: Myofunctional therapy is an effective method of increasing arch width, length, and volume. This therapy can be used in routine practices in young children with constricted arch and improvement in facial esthetic.

Keywords: Dental arch, Donders space, Intercanine width, Intermolar width, Myofunctional appliance.

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Introduction

According to Balter, the shape of the oral cavity can be compared with that of an egg. In a normal subject, the shape of the anterior portion of the palate can be compared with that of the most rounded pole of an egg. Its maximum width is in the zone of the first molar, while the most pointed pole goes posteriorly to the isthmus of the fauces, tonsils, and uvula. The well-conformed dental arches follow the profile of the flattened pole in contrast; in the anomalous condition, the shape of the palate vault changes in such a way that it can be still compared with an egg but with the poles in positions opposite to the above-mentioned one. This hollow space is known as Donders space.[1]

Class II division 1 malocclusion is one of the most prevalent malocclusions in human population. The most prevalent aspect of class II division 1 malocclusion in developing youngsters is mandibular retrusion. The existence of an underlying skeletal difference between the mandible and maxillae complicates class II division 1 malocclusion. It may be due to retrusive mandible, protruding maxilla, or a combination of both. Treatment for class II division 1 relies on the patient's age, capacity for growth, degree of malocclusion, and level of treatment compliance.

Neutral zone consists of external perioral muscles, buccal muscles from the outside, and tongue from the inside. They both exert constant pressure on the teeth and dental arch.[2] Angle believed that the ideal occlusion necessitated a complete set of teeth and that the ideal occlusion provided "such efficient functioning will be adequate for ensuring a permanent outcome." As a result, arch expansion to accommodate the entire complement of teeth was believed to be the only means for ensuring the stability of treatment.[3]

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Lundstrom suggested the concept of apical base malocclusion. He disagreed with Angle's theory that the dental arch width determined the apical base size. When the tooth size exceeds the apical base limits, there are two options to resolve this. The first is a decrease in tooth mass caused by tooth extraction or a decrease in the mesiodistal size of specific teeth. The other option is to widen the arch (apical base) to allow the full dentition.[4]

Functional appliances improve soft tissue, muscular imbalance, and oronasopharyngeal function, thereby correcting the malocclusion. According to the functional requirements of the

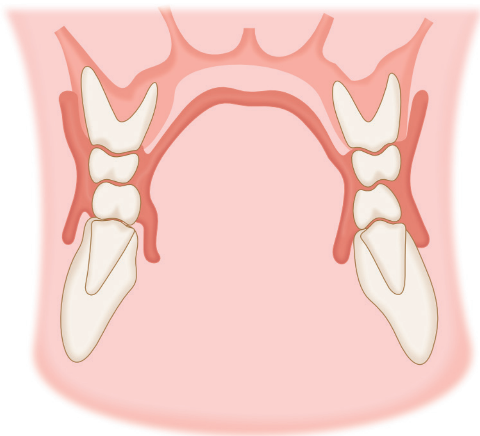

Fig. 1: Evaluation of intraoral volume

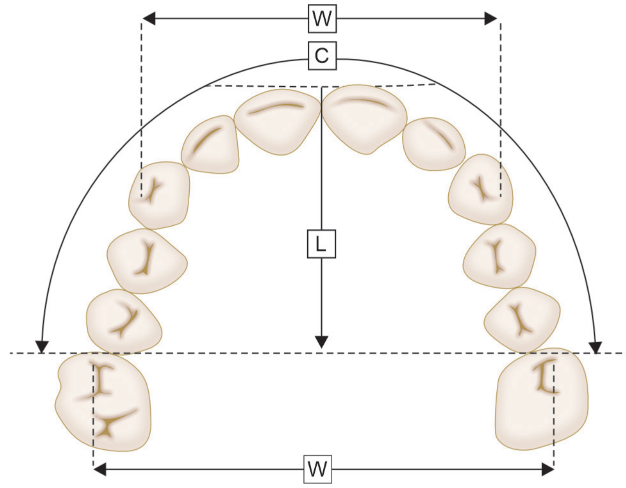

Fig. 2: Maxillary arch width (W), arch length (L), and arch perimeter (circumference, C)

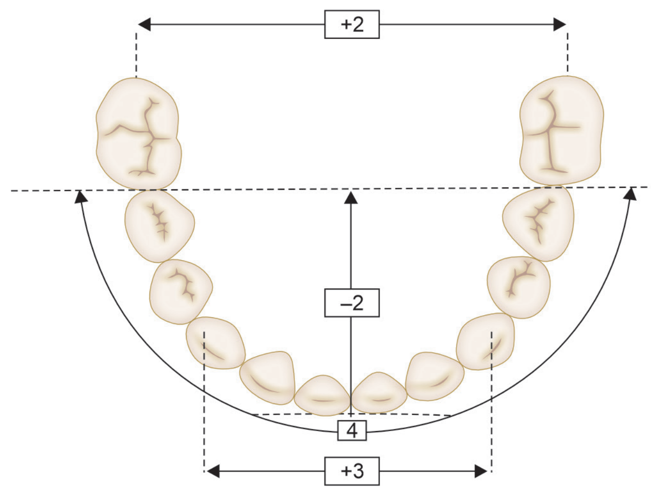

Fig. 3: Mandibular arch width, arch length, and arch perimeter (circumference)

oral cavity, the space also changes its volume and shape due to alterations in the neuromuscular environment which can be evaluated.

There are limited evidences in the evaluation of three-dimensional Donders space. Therefore, the purpose of the present study was to evaluate changes in the intraoral dynamic space (Donders space) with myofunctional therapy in skeletal class II division 1 malocclusion using three-dimensional digital volume tomography (3D-DVT) to provide data on the changes in shape and volume in the oral cavity in three dimensions.

Materials and Methods

The study design is an observational *in vivo* study conducted in the Department of Orthodontics, Sharad Pawar Dental College, Wardha, Maharashtra, India. The study duration was 3 years from September 25, 2014 to March 20, 2017 (ethical clearance no. DMIMS (DU)/IEC/2014-15/880). The sample comprised 20 patients (12 males, 8 females) of 11–14 years age-group were selected from the patients reported to the OPD of the Department of Orthodontics, Sharad Pawar Dental College of DMIMS (DU), Sawangi (M), Wardha, Maharashtra, India. A total of 20 skeletal class II division 1 malocclusion cases were selected. Inclusion criteria include mixed dentition or permanent dentition and positive visual treatment objective (VTO). Exclusion criteria include crowding of upper or lower arch. Patient consent was obtained from their parents. Three-dimensional digital volume tomography scans of all the cases were done and intraoral volume was measured at two stages, the first measurement was done before starting the myofunctional therapy (T0) and second one was done after completion of myofunctional therapy (T1) (approx. 14–18 months). The duration was same for all 20 patients. The parameters depicting the arch perimeter, arch width, length, and volume were quantified using several linear and volumetric measurements on the dental cast of each patient. After 14–18 months of myofunctional therapy, DVT was done again to measure the changes in measurements.

- Intraoral volume: (Fig. 1)
  - The intraoral volume was evaluated by overlapping a best-fitting oval on the palate to the body of the mandible.
- Arch perimeter:[5] (Figs 2 and 3)
  The arch perimeter was measured using five linear measurements
  - From the mesial aspect of the first molar to the tip of the canine on one side.
  - From the tip of canine to the middle of lateral incisors.
  - From the middle of lateral incisor on one side to the middle of lateral incisor on the opposite side.
  - Measurements in the same way on the contralateral side.
  - A summation of all five linear measurements was done to get the arch perimeter.
- Arch length:[5] (Figs 2 and 3)
  - A line was drawn connecting the mesial side of the first molar, and the perpendicular distance from the contact area of central incisors to the line was measured.
- Arch width:[5] (Figs 2 and 3)
  - Intercanine width: It was measured from the cusp tip of the canine on one side to the opposite side.
  - Intermolar width: It was measured from the mesial pit on the occlusal surface of the molar on one side to the opposite side.
- Arch shape:[4] (Figs 4 and 5)

The arch form was evaluated by overlapping a best-fitting oval on the maxillary and mandibular arches.

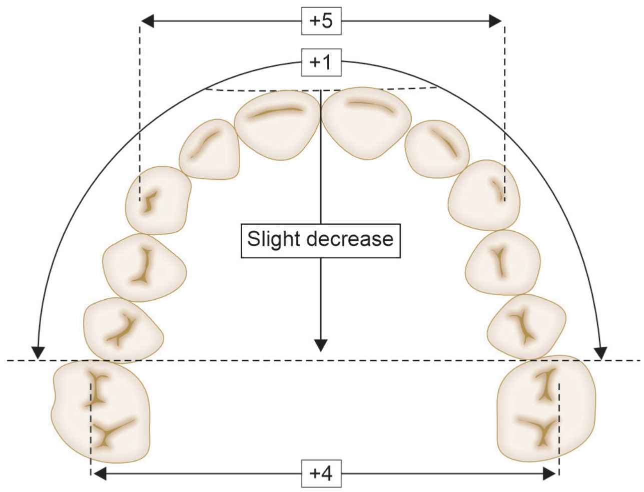

Fig. 4: Evaluation of maxillary arch perimeter by overlapping a best-fitting oval on the maxillary arch

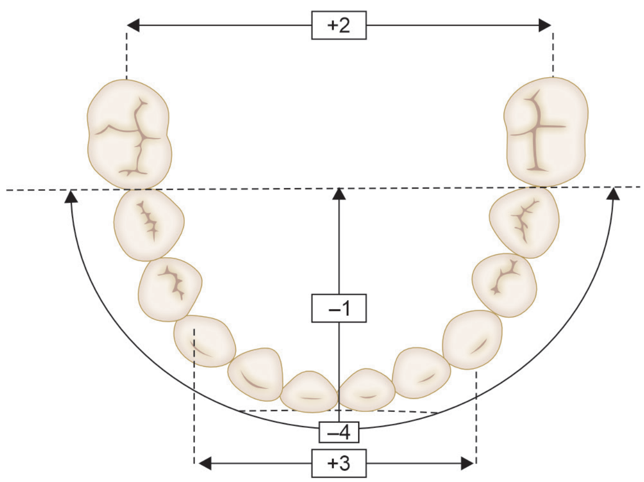

Fig. 5: Evaluation of maxillary arch perimeter by overlapping a best-fitting oval on the mandibular arch

And *t*-test was performed to compare the intraoral volume, arch perimeter, arch length, and arch width, before and after myofunctional therapy. All the statistical analysis was done using IBM SPSS software.

Results

The present study involves a sample of 20 cases (12 males, 8 females) with skeletal class II division 1 malocclusion. The age-group of patients was 11–14 years with the mean age of 12.5 years.

The intraoral volume (Donders space) before myofunctional therapy (T0) was 5.59 mL (SD ± 1.87) and after myofunctional therapy (T1), it was 7.22 mL (SD ± 1.80). A significant difference was found between T0 and T1 (Table 1).

Significant changes were found in the mean maxillary and mandibular arch perimeter which were 81.98 mm (SD ± 4.97) and 71.47 mm (SD ± 3.76) before myofunctional therapy (T0), and after myofunctional therapy (T1), they were 82.87 mm (SD ± 5.07) and 72.52 mm (SD ± 3.79), respectively (Tables 2 and 3).

Maxillary and mandibular arch lengths also showed marked difference, before myofunctional therapy (T0), they were 27.12 mm

Table 1: Comparison of intraoral volume before myofunctional therapy (T0) and after myofunctional therapy (T1) of maxillary and mandibular arch

	Mean	*N*	*Std. deviation*	*Std. error mean*	*Mean difference*	*t-value*	*p-value*
T0	5.59	20	1.87	0.42	1.62 ± 0.61	11.77	0.0001, S
T1	7.22	20	1.80	0.40			

Table 2: Comparison of arch perimeter before myofunctional therapy (T0) and after myofunctional therapy (T1) of maxillary arch

	Mean	*N*	*Std. deviation*	*Std. error mean*	*Mean difference*	*t-value*	*p-value*
T0	81.98	20	4.97	1.11	0.88 ± 0.44	8.88	0.0001, S
T1	82.87	20	5.07	1.13			

Table 3: Comparison of arch perimeter before myofunctional therapy (T0) and after myofunctional therapy (T1) of mandibular arch

	Mean	*N*	*Std. deviation*	*Std. error mean*	*Mean difference*	*t-value*	*p-value*
T0	71.47	20	3.76	0.84	1.05 ± 0.43	10.92	0.0001, S
T1	72.52	20	3.79	0.84			

Table 4: Comparison of arch length before myofunctional therapy (T0) and after myofunctional therapy (T1) of maxillary arch

	Mean	*N*	*Std. deviation*	*Std. error mean*	*Mean difference*	*t-value*	*p-value*
T0	27.12	20	2.68	0.59	1.68 ± 0.67	11.18	0.0001, S
T1	28.81	20	2.70	0.60			

Table 5: Comparison of arch length before myofunctional therapy (T0) and after myofunctional therapy (T1) of mandibular arch

	Mean	*N*	*Std. deviation*	*Std. error mean*	*Mean difference*	*t-value*	*p-value*
T0	22.01	20	1.81	0.40	1.83 ± 0.76	10.71	0.0001, S
T1	23.84	20	1.79	0.40			

(SD ± 2.68) and 22.01 mm (SD ± 1.81), and after myofunctional therapy (T1), they were found to be 28.81 mm (SD ± 2.70) and 23.84 mm (SD ± 1.79), respectively (Tables 4 and 5).

The mean maxillary intercanine and intermolar arch widths before myofunctional therapy (T0) were 34.54 mm (SD ± 3.01) and 46.80 mm (SD ± 1.57), and after myofunctional therapy (T1), they were 35.64 mm (SD ± 2.98) and 47.99 mm (SD ± 1.66), respectively (Table 6).

The mean mandibular intercanine and intermolar arch widths before myofunctional therapy (T0) were 27.95 mm (SD ± 2.11) and 42.16 mm (SD ± 2.11), and after myofunctional therapy (T1), they were 28.27 mm (SD ± 2.22) and 42.55 mm (SD ± 5.15), respectively. (Table 7)

Significant differences were found between the intraoral volume, maxillary and mandibular arch perimeters, maxillary and mandibular arch lengths, maxillary and mandibular intercanine and intermolar widths, and also the shape of the arch.

After evaluating the intraoral volume, arch perimeter, arch length, intercanine and intermolar arch widths, and arch shape

Table 6: Comparison of arch width before myofunctional therapy (T0) and after myofunctional therapy (T1) of maxillary arch

		Mean	*N*	*Std. deviation*	*Std. error mean*	*Mean difference*	*t-value*	*p-value*
Intercanine	T0	34.54	20	3.01	0.67	1.09 ± 0.41	11.78	0.0001,S
	T1	35.64	20	2.98	0.66			
Intermolar	T0	46.80	20	1.57	0.35	1.18 ± 0.59	8.92	0.0001,S
	T1	47.99	20	1.66	0.37			

Table 7: Comparison of arch width before myofunctional therapy (T0) and after myofunctional therapy (T1) of mandibular arch

		Mean	*N*	*Std. deviation*	*Std. error mean*	*Mean difference*	*t-value*	*p-value*
Intercanine	T0	27.95	20	2.11	0.47	0.31 ± 0.88	1.60	0.125,NS
	T1	28.27	20	2.22	0.49			
Intermolar	T0	42.16	20	5.14	1.15	0.38 ± 0.48	3.59	0.002,S
	T1	42.55	20	5.15	1.15			

on 20 samples before and after myofunctional therapy in growing patients, it was observed that all parameters were increased after myofunctional therapy.

Discussion

Correction of class II with functional appliances is based on changes in both the skeleton and the dentoalveolar system. Several clinical investigations on skeletal and dental modifications related to myofunctional appliance therapy in class II malocclusions have been conducted, but scientific results remain controversial.

The correction of skeletal class II malocclusion by growth modification is one of the most common and important treatment modalities in the field of orthodontics and dentofacial orthopedics. The recommended therapeutic approach in growing patients with skeletal class II division 1 malocclusion is the use of functional jaw orthopedics as a prime mechanism of mandibular growth stimulator or advancement. Oronasopharyngeal complex's muscular imbalance, soft tissue tone, and function are corrected by functional appliance, thereby correcting the malocclusion. Patient contribution and involvement plays an important role in achieving the objectives. The patients were selected according to age with no gender predilection. Patient contribution is also a major factor. The patients should wear myofunctional appliances as indicated without fail. In the current study, patient cooperation was satisfactory.

In the current study, the intraoral volume of the arches was increased post-myofunctional therapy. Myofunctional therapy helps in the expansion of the arches by balancing the intraoral and extraoral pressures which is a major reason for this increase in the volume, which thus normalizes the Donders space for these patients with class II malocclusion. There were no relevant studies done in the past regarding this Donders space.

In the present study, an increase in the arch perimeter after myofunctional therapy (T1) in both the maxilla and mandible were seen. The mean value of the maxilla and mandible obtained after myofunctional therapy (T1) was greater comparatively.

Grossen et al.[6] found similar results in studying the effects of a lip bumper on the lower arch dimensions and also on the angulation of the anterior and molars in young age of the same group of patients in class II division 1 malocclusion. The lip bumper increased the widths of the dental arch between the canines, premolars, and molars. The length of the dental arch increased due to incisor proclination and the first molar uprighting.

Ronald A McWade et al.[7,8] found contrasting results when they evaluated Frankel II treatment effects on the width and perimeter of the dental arch in young adolescents of similar age-group in class II division 1 malocclusion. The perimeter of the dental arch decreased in the maxilla by 2 mm lesser than the control group, while it decreased by 2.63 mm in the lower arch.

In the present study, an increase in the arch length after myofunctional therapy (T1) in both the maxilla and mandible was seen. The mean value of the maxilla and mandible obtained after myofunctional therapy (T1) was greater. This was seen due to the expansion effect of the jaws which also alters the position of the teeth. Also, the proclination of teeth is marked with functional appliances.

Nevant CT et al.[9] in their study evaluated lip bumper treatment for arch lengthening in class II division 1 malocclusion. Canines, first premolars, and first molars showed significant expansion in a transverse direction in young patients of the same age-group. They observed that the rate total length of the arch increased by 7.45 mm/year.

David L Hime et al.[10] reported contrasting results when they assessed the expansion stability effects of the functional regulator in adolescents of the same age-group in class II division 1 malocclusion. They reported that the arch length decreases with treatment and kept on decreasing throughout the period of post-retention, but to a smaller extent than previously reported in the research, supporting Frankel's statements about the stability of this arch expansion.

The width of the intercanine arch increased after myofunctional therapy (T1) in both the upper and lower arches. However, no significant difference was found in the lower arch. The mean value obtained after myofunctional therapy (T1) was greater in the upper arch when compared with the lower arch.

Intermolar arch width is significantly increased after myofunctional therapy (T1) in both the upper and lower arches.

Albert H Owen et al.[11–13] in their study of more than 100 class II division 1 patients who were treated with the Frankel appliance showed that after one phase of treatment with a functional regulator, dental arch was rounded out, and the mandibular crowding was eliminated in young adolescent patients. There was a more significant change in the transverse dimension.

On the contrary, Scott D Hamilton et al.[14] reported that 77% of the adolescent patients of the same age-group in class II division 1 malocclusion treated with the Frankel appliance showed that the mandibular intercanine width increased during treatment, but concluded that there was no increase in the upper intercanine width despite 60% of the sample showed some increase in dimension during therapy.

A change in the arch shape after myofunctional therapy (T1) in both the maxilla and mandible was found. Before myofunctional therapy (T0), tapered arch was seen, whereas an ovoid arch was seen after myofunctional therapy (T1). This change was again due to the expansion in all three dimensions.

Vargervik K[15] reported similar results while studying the changes during correction of distocclusion in class II division 1 malocclusion with the activator appliance and stated "Changes in dental arch form and size can result from changes in the muscle stimuli acting on them" in young patients. This study did not include the muscle influence on malocclusion. Muscle orientation and activity is also an important factor for the evaluation of arch volume. This study includes same arch form. This result may vary in different arch perimeter, arch length, intercanine and intermolar arch widths, and arch shapes. The result may also vary according to race and region. This study can be further extended by including muscle orientation and activities in different race and region.

Conclusion

Functional appliance leads to expansion in all three planes. This expansion in turn increases the intraoral volume which corrects the shape of the arch and positioning of the teeth. Thus, malocclusions like class II where the jaws are narrow and intraoral and extraoral pressures are abnormal can be treated with these appliances thus correcting the Donders space which in turn helps in determining the proper shape of the arch and position of the teeth and reducing the further need of any surgical intervention.

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