Volumetric changes in inter-arch space following malocclusion treatment: a pilot study

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Abstract. This study aimed to evaluate whether inter-arch space, expressed as oral cavity volume, increases following malocclusion treatment. A retrospective analysis was conducted on 10 patients (aged 6-28 years) with mixed and permanent dentitions presenting different types of malocclusion. All patients underwent treatment involving transverse and/or sagittal expansion, mandibular posture modification, and occlusal harmonization using Jaw Functional Orthopedics appliances. Inter-arch volume was assessed using dental casts obtained before and after treatment. A standardized acrylic resin filling technique was applied to delimit the intraoral space, and volume measurements were obtained using the fluid displacement method based on Archimedes' principle. All patients showed an increase in inter-arch volume after treatment, with a mean increase of 30.4 % (range: 14.28 %-4.54 %). The mean volume increased from 16.8 mL pre-treatment to 21.9 mL post-treatment, corresponding to an average gain of 5.1 mL. These findings suggest that malocclusion treatment using Jaw Functional Orthopedics may increase intraoral space, potentially improving conditions for dental alignment and tongue posture. Further studies with larger samples and controlled designs are required to confirm these results.

Keywords: jaw functional orthopedics, orthodontics, malocclusion, mouth breathing.

1. Introduction

The volume of the oral cavity corresponds to the space between the maxillary and mandibular arches, where the tongue is positioned and performs its functions. Previous studies have demonstrated a relationship between jaw development and changes in stomatognathic system functions, which may impact overall health and quality of life [1-5].

Understanding craniofacial growth and development is essential for accurate diagnosis, treatment planning, and post-treatment evaluation in orthodontic and orthopedic cases [6]. It is also important to consider the synchronism and synergy among breathing, sucking, and swallowing functions. Disruption of any of these three coordinated and interdependent processes may adversely affect the others [1].

When dental arches are reduced in size and/or poorly related, the available space for proper tongue posture may be compromised. This can result in posterior tongue displacement, reducing the airway space and potentially affecting mastication due to occlusal issues [7, 8], as well as impairing breathing [9].

Jaw Functional Orthopedics (JFO) appliances can promote maxillary expansion and induce changes in mandibular position, acting in three dimensions – sagittal, vertical, and transverse – with the aim of achieving harmony between the jaws. This therapeutic approach creates space for proper tooth alignment and tongue positioning, contributing to improved upper airway conditions and restoration of stomatognathic system functions [1, 9-11].

2. Objective

To evaluate whether the inter-arch space increases after malocclusion treatment involving transverse and/or sagittal expansion, changes in mandibular posture, and occlusal harmonization.

3. Methodology

Ten clinical cases (7 females and 3 males) with mixed and permanent dentitions were analyzed. Two cases presented mixed dentition (ages 7 years 6 months and 10 years 10 months; mean age: 8 years 8 months), while eight cases had permanent dentition (ages 14-28 years; mean age: 18 years 2 months). All patients presented malocclusions requiring transverse and/or sagittal dental arch expansion, mandibular posture adjustment, and occlusal harmonization as part of the treatment plan.

3.1. Volume measurement protocol

For each patient, pre-treatment and post-treatment dental casts were prepared (Fig. 1). The models were obtained from alginate impressions (Hidrogum, Zhermack) and poured with orthodontic plaster. All procedures were performed by the same operator to ensure standardization.

The internal volume between the dental arches was quantified using an acrylic resin filling technique developed by the author.

a) Before treatment b) After treatment

Fig. 1. Working models of one of the patients who were involved in the study

The limits for volume measurement were defined as follows:

1) Posterior limit: distal surface of the upper first molars (Figs. 1(a) and 1(b)).

2) Superior limit: palatal vault.

3) Inferior limit: floor of the mouth, defined as 3 mm below the free gingival margin (Fig. 2).

The floor of the mouth region was filled with plaster up to 3 mm below the lingual gingival margin. The space was then sealed with utility wax and internally insulated (Fig. 3(a)).

Acrylic resin was subsequently introduced into the internal space, filling it up to the distal limit of the upper first molars (illustrated in Figs. 2-3). After polymerization, the resin block was removed from the model (Fig. 4).

Volume was measured based on Archimedes' principle, in which the volume of displaced water corresponds to the volume of the object [12]. Measurements were performed using Becker-type volumetric containers (flat-bottom, wide opening) and a measuring syringe (Fig. 5). All readings were recorded in milliliters using a standardized technique.

The change in volume was defined as the difference between post-treatment and pre-treatment measurements.

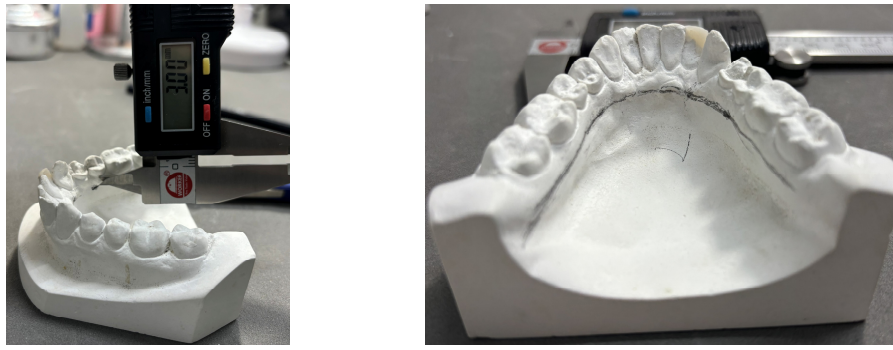
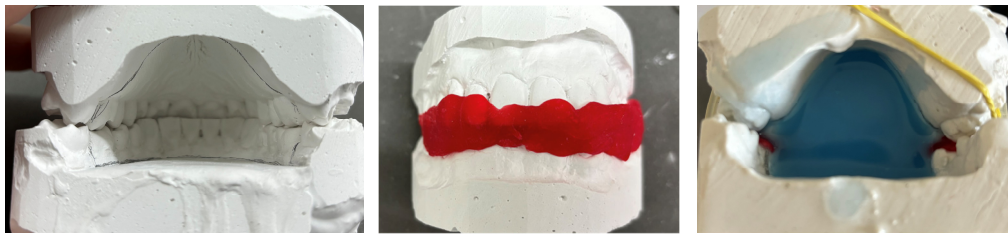


Fig. 2. Measuring and limiting the lower part: 3 mm below the free marginal gingiva of the premolars



a) b) c)

Fig. 3. a) Articulated models; b) wax used to seal the resin exit;
c) resin inserted into the previously isolated and hydrated model

Fig. 4. Polymerized resins, in blue before treatment and in lilac, after treatment

3.2. Study design and treatment

3.2.1. Study design and treatment

This pilot study consisted of a retrospective and descriptive analysis of measurements obtained before and after treatment. No control group was included, and there was no standardization regarding patient age or treatment protocol.

The two patients with Class I malocclusion were treated with a Mauricio expander for 6 months, followed by Indirect Planas Tracks for 1.5 years.

Among the two patients with Class III malocclusion, one patient used a Mauricio-designed appliance with posteroanterior action for the anterior maxilla for 4 months. Both patients were additionally treated with a Mauricio expander for 6 months and the SN3 appliance for 1 year.

The six patients with Class II malocclusion were treated with a Mauricio expander for an average of 7 months. Subsequently, two patients used a Klammt appliance for 1 year, while four patients were treated with Simões Network 1 (SN1) for 1.5 years.

One patient also used a Mauricio distalizer for 4 months to achieve dental arch symmetry and create space for the upper right canine.

Fig. 5. Becker and syringe used to measure the resin volume

3.2.2. Ethical aspects

Number of the substantiated opinion of the Research Ethics Committee: 4.390.918.
Number of CAAE: 36113820.7.0000.5102.

4. Results

All cases demonstrated an increase in volume after treatment, with gains ranging from 14.28 % to 54.54 %. Variations in treatment approaches—such as transverse expansion alone, mandibular advancement, and/or increases in vertical dimension—contributed to differences in the magnitude of volume increase.

Table 1 presents the pre- and post-treatment volumes, along with the corresponding percentage increases for all 10 patients.

Table 1. Initial and final volumes (mL) and percentage increases by patient

Patient	Age (years)	Sex	Class	Volume Pre (ml)	Volume post (ml)	Increase (%)
1	14	F	II	16.0	21.5	28.00 %
2	16	F	II	18.0	22.5	25.00 %
3	20,5	F	III	19.0	23.5	23.68 %
4	7,5	F	III	11.0	17.0	54.54 %
5	15	F	II	17.0	23.5	38.23 %
6	10	M	II	14.0	16.0	14.28 %
7	18	F	II	17.0	21.0	23.52 %
8	14	F	II	16.0	21.0	31.25 %
9	28	M	I	20.0	23.5	17.50 %
10	22	M	II	20.0	29.0	45.00 %

Fig. 6 shows a mean increase of 30.4 % in oral cavity volume after treatment, with a 95 % confidence interval. The mean pre-treatment volume was 16.8 mL, while the mean post-treatment volume was 21.9 mL, resulting in an average absolute increase of 5.1 mL.

Fig. 7 illustrates the individual variation in volume changes across patients.

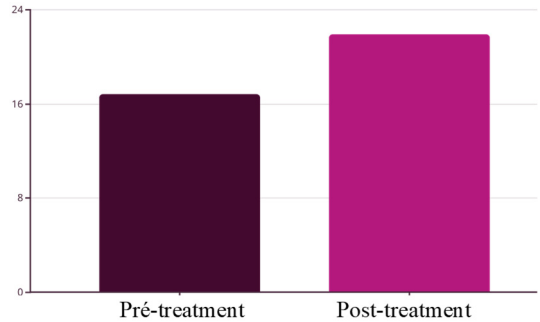


Fig. 6. Statistical analysis reveals a mean increase of 30.4 % in oral volume after treatment, with a 95 % confidence interval

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Statistical insights:
1) Mean pre-treatment volume: 16.8 ml.
2) Mean post-treatment volume: 21.9 ml.
3) Absolute difference: 5.1 ml.
4) Clinical significance confirmed.

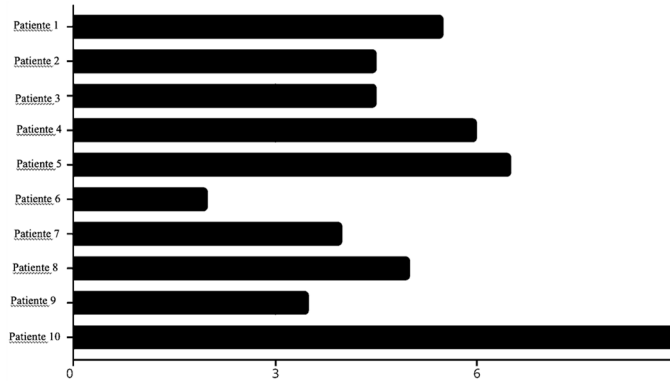

Fig. 7. Analysis of individual variation by patient: Patient 10 presented the greatest absolute volumetric gain, Patient 6 had the smallest increment observed in the study, average variation among all patients evaluated

5. Discussion

This retrospective exploratory case series analyzed a heterogeneous sample of children, adolescents, and adults undergoing treatment involving transverse and/or sagittal arch expansion, mandibular posture modification, and occlusal harmonization. All cases demonstrated an increase in dental arch space and in the inter-arch oral cavity volume following treatment.

The observed improvements in spatial dimensions and arch morphology are consistent with the clinical objectives of Jaw Functional Orthopedics and with the concept that occlusal balance contributes to the proper functioning of the stomatognathic system and overall quality of life [1, 7-11].

The increase in arch dimensions and volume suggests the potential for space gain through bone remodeling not only in growing patients but also in adults. However, this interpretation should be approached with caution due to the study's limitations. These include the small sample size ($n = 10$), the heterogeneity of malocclusion types and treatment protocols, and the absence of a control group.

The literature reviewed predominantly reports linear measurements of dental arch changes [13]. To the best of our knowledge, no previous studies have evaluated volumetric changes in the space between dental arches using a comparable methodology.

Future studies should include larger samples and, ideally, randomized controlled trial designs to better isolate the effects of specific interventions on inter-arch volume and tongue space.

6. Conclusions

The findings of this study suggest that treatment guided by the principles of Jaw Functional Orthopedics may increase intraoral space, thereby facilitating proper tooth positioning in both growing patients and adults.

However, randomized controlled clinical trials with improved and standardized measurement protocols are necessary to confirm these findings and strengthen the evidence base.

Acknowledgements

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors declare that they have no conflict of interest.

Ethics statement

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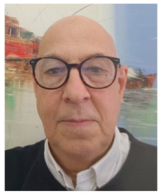

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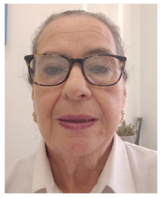

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