

Effect of Lingual Arch Space Maintainer on the Position of Mandibular Molars and Incisors in the Vertical Direction during the Resolution of Mandibular Incisors Crowding: A Systematic Review of Clinical Trials in Humans

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ABSTRACT

Introduction: This systematic review was designed to define and measure the changes in the position of mandibular molars and incisors in the vertical direction while using a lingual arch appliance as a space maintainer.

Materials and methods: The source of data collection used was PubMed, Medline, Cochrane Central, and Cochrane Database of Systematic Reviews for articles published until March 2021.

Inclusion criteria: Studies on human subjects in the English language using either prospective or retrospective methods considering the effect of the lingual arch used as a space maintainer in the mandibular arch.

Results: Four out of 465 studies acknowledged in the literature search met the final inclusion criteria.

Conclusion: A lingual arch is an effective appliance for controlling the position of mandibular molars and incisors in the vertical direction.

Keywords: Fixed lingual arch, Passive lingual arch, Space maintainer.

International Journal of Clinical Pediatric Dentistry (2021): 10.5005/jp-journals-10005-2039

INTRODUCTION

Pediatric orthodontics is an imperative segment of pediatric and preventive dentistry. The orthodontics in mixed dentition majorly spin around the preservation and maintenance of space in the dental arch.¹ Therefore, space management had been given a lot of emphasis in preventive and interceptive orthodontics procedures which include space maintainers and regainers. Early tooth loss of deciduous teeth especially second and first primary molars, before their affirmative shedding time can lead to varied consequences like dental crowding, arch length discrepancies, vertical and horizontal malpositioning of permanent molars, and anterior teeth.² A plethora of space maintainers have been documented in the literature to deal with these problems such as band and loop, lingual arch appliance, etc.¹⁻³

The mandibular fixed lingual appliance is frequently recognized in both passive and active forms used to prevent the mesial migration of posterior molars and tipping back of anterior teeth, and hence maintaining the arch length and perimeter.² This mechanism results in the uprighting of molars and protrusion of incisor teeth.⁴⁻⁷ This systematic review aimed to appraise the effects of the lingual arch as a space maintainer on the vertical growth of the mandible.

MATERIALS AND METHODS

Rationale

This systematic review assesses a literature-based search to define the effects of the lingual arch appliance on the vertical growth of incisors and first permanent molars in the resolution of incisors crowding in the mandible when compared with the control group without the lingual arch in the mandible.

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How to cite this article: Ahuja V, Thosar NR, Shrivastav S, *et al.* Effect of Lingual Arch Space Maintainer on the Position of Mandibular Molars and Incisors in the Vertical Direction during the Resolution of Mandibular Incisors Crowding: A Systematic Review of Clinical Trials in Humans. *Int J Clin Pediatr Dent* 2021;14(S-1):S76-S81.

Source of support: Datta Meghe Institute of Medical Sciences (Deemed to be University), Wardha, Maharashtra, India

Conflict of interest: None

Focused Question

The focused question: "In patients with mandibular incisor crowding, what is the effect of the fixed lingual arch as a space maintainer on the position of mandibular first permanent molar and incisors in the vertical direction before the placement and after the placement of lingual arch and when compared with mandibular arch without a lingual arch, on clinical and radiological parameters."

Search Protocol

Data Sources

The source of data collection used was PubMed, Medline, Cochrane Central, and Cochrane Database of Systematic Reviews for articles published until March 2021.

Search Strategies

The systematic review and all concomitant explorations were restricted to studies published in the English language. The literature was searched from 1950 till March 2021. The medical subject headings (MeSH) used in MEDLINE and Cochrane Library database were: lingual arch, lingual arch space maintainer, lingual arch space maintainer in mandibular crowding, lingual arch, and vertical eruption of incisors and molars. An additional search was performed in each database, respectively, succeeding the previous pursuit to take account of all systemic reviews on fixed lingual arches and vertical assessment of the mandibular first molars and incisors, to reassure reliability with the study protocol.

Four hundred and sixty-five studies in total (Fig. 1) addressing the use of "Lingual arch in mandible" and "Vertical growth of mandibular first molar and incisors" systemically in mandibular incisors crowding were identified. Two autonomous reviewers (VA, AA) were selected to evaluate all the studies and select those studies pertinent to the focused question postured in this review. Based on the study protocol, study titles, and abstracts, four studies were finally included which satisfied the inclusion criteria. The process of evaluating articles for inclusion was based on PRISMA guidelines.

Inclusion Criteria

- Studies included were randomized, experimental clinical trials.
- Studies on human beings published in peer-reviewed international journals.
- Studies published in English.
- Studies with clearly specified objectives of the research and/or hypothesis to be tested.
- Studies where prerequisite therapeutic interventions were (1) lingual arch (2) treatment of mandibular incisor crowding.

Exclusion Criteria

- Studies that do not meet the inclusion criteria were excluded.
- Studies with split-mouth designs, case reports, and series were also excluded.

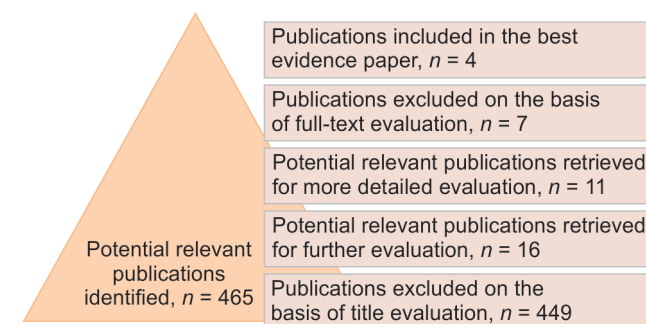


Fig. 1: Search strategy

Clinical Primary Outcome

The clinical primary outcome investigated included changes in mandibular first molar and incisors position in vertical direction after the placement of fixed lingual arch in the mandible.

Data Analysis

Primarily, two autonomous reviewers (VA and AA) identified all titles and abstracts of the studies as per previously designated search strategies and were independently screened by two of them to decide if they could be incorporated in the systematic review. Selected studies were individualistically studied by both the reviewers using the criteria defined before. The criteria for study selection were also applicable to a subgroup of associated studies to standardize the reviewers and to offer practical application of the selection criteria.

RESULTS OF FOUR INCLUDED STUDIES

Methodical Selection and Explanation of Studies

Four hundred and sixty-five hits ensued in the MEDLINE and CENTRAL literature searches (Fig. 1). Sixteen articles were included for further analysis based on the title of the collected studies after the first selection step. Eleven studies were further sub-finalized based on the abstract screening at the second step. At the last step, seven studies were excluded, and the reason for the same is presented in Table 1. Four studies ($n = 4$) that remained after the third selection step are presented in Table 2. These studies met the inclusion criteria entirely and were finally selected from the study pool.

Out of the studies selected, one article¹⁵ assessed the vertical and sagittal control longitudinally in the lower arch by the mandibular fixed lingual arch appliance. The study design was a longitudinal cohort study with a time duration of 18.3 months. The study group included 23 patients of 10.4 years as a mean age. The only appliance received by this group was the mandibular lingual arch as a treatment intervention. The records of 24 patients without receiving mandibular lingual arch were longitudinally studied for 12 months and 24 months and were used as controls. Positional changes were examined and compared using pre-treatment and post-treatment cephalograms. The methodology used to quantify the dimensional changes in the vertical direction was to draw a reference line through the long axis of the tooth. The reference line was recorded in its pretreatment position. A perpendicular line was drawn to this reference line at the incisal edge of the mandibular incisor for anterior teeth and at the mesiobuccal cusp tip of the mandibular first molar for the posterior teeth in post-treatment position. The positive values were given if the tooth had moved towards occlusal or incisive direction at vertical axis and negative values were given if the tooth had moved towards apical direction at the vertical axis. Measurements for the experimental group with fixed lingual arch reflect an insignificant extrusion of 0.29 ± 0.48 mm. Measurements for the control group without fixed lingual arch reflect an extrusion of 1.28 ± 0.73 mm with the mandibular molars for the 12-month observation period, which inferred statistically significant differences ($p < 0.0001$). Vertically, the mandibular incisors extrusion observed was 0.56 ± 0.44 mm in the experimental group with fixed lingual arch, whereas extrusion observed in the control group without fixed lingual arch was 0.95 ± 0.46 mm; which inferred statistically insignificant differences. In the second article,¹⁶ the sample size selected was 30 patients.

Table 1: Abstracts excluded after text screening for not fulfilling inclusion criteria, $n = 7$

Reference	Patient group	Study type level of evidence	Methods	Key results	Comments
1. Chen et al. in 2019 ⁸	-	Systematic review and meta-analysis	Searched PubMed, Web of Science, and Cochrane database of systematic reviews for both randomized and nonrandomized studies from 1940 to March 2018.	The average resolution of mandibular incisor crowding was 5.10 mm and arch perimeter and arch length changes were not statistically significant between the lower lingual arch group and the untreated control group.	The lower lingual arch was effective in resolving mandibular incisor crowding without any significant arch perimeter or arch length changes of >1 mm.
2. Brennan and Gianelly in 2000 ⁹	N = 107	Observational retrospective cohort	Passive lingual arches were given in 107 patients with mixed dentition with incisor crowding to preserve arch length and make leeway space available for resolution of crowding.	Passive lingual arch resolves crowding to a significant level. It also produces changes in arch length and arch width of up to 1 mm.	The study was inconclusive about arch length. The arch length was decreased in 59 patients and increased in 42 and unchanged in 6 out of 107. The average arch length decreased was -0.44 mm.
3. Gianelly in 1995 ¹⁰	N = 100	Observational study	100 mandibular models in the mixed dentition stage were evaluated.	Average crowding of 4.5 mm was present in 85 of 100 subjects. 85% of subjects can be relieved of crowding if the leeway space of Nance is preserved with an appliance-like lingual arch.	4-5 mm of crowding in the region of the incisor of the mandible can be easily resolved with non-extraction procedures whose goals include maintaining E-space like a lingual arch.
4. Owais et al. ¹¹	N = 67	Experimental RCT	44 subjects were randomly divided into two treatment groups and 23 subjects were taken as control. Group I: 20 subjects with a lingual arch made of 0.9 mm stainless steel wire. Group II: 24 subjects with a lingual arch made of 1.25 mm stainless steel wire. Group III: No lingual arch was given and served as a control group. Study models, lateral cephalograms, and dental pantomograms were compared.	Lingual arch made of 0.9 mm was superior in arch preservation when compared with lingual arch made of 1.25 mm.	A lingual arch leads to proclination of lower incisors and space loss of lower second primary molar was observed even after the placement of lingual arch.
5. Fichera et al. ¹²		Observational retrospective cohort		Passive lingual arch influences the mandibular growth.	Mesial migration of molars is not completely blocked especially in subjects with mandibular posterior rotation.
6. Eslambolchi et al. in 2008 ¹³	N = 33	Observational cohort study	In this study, longitudinal dental changes in untreated children who had been recorded at 3 times and in the untreated adult group who had records for 2 times were compared.	Late mandibular incisor crowding can occur whether a person receives orthodontic treatment.	Inter-canine width, inter-first premolar width, mandibular arch length, anterior space, and total space decreased in mixed to permanent dentition even after placement of lingual arch. The little irregularity index increased at a statistically significant rate.
7. De Baets and Chairini et al. in 1995 ¹⁴		Observational retrospective cohort		Lower lingual arch was effective in resolving mandibular incisor crowding	Mandibular arch length decreases in mixed to permanent dentition even after placement of lingual arch. Arch length was decreased by -0.5 mm after the insertion of lingual arches. Arch perimeter was decreased due to lingual tipping of lower incisors.

Table 2: Abstracts included after text screening which fulfilled inclusion criteria of randomized clinical trials

Reference	Patient group	Study type level of evidence	Methods	Key results	Comments
Villalobos et al. ¹⁵	Study group (N = 23) Control group (N = 24)	Longitudinal cohort study for 18.3 months	Twenty-three patients with a mean age of 10.4 years were selected to receive lingual arch treatment as the only appliance in the mandibular arch. Longitudinal records for 12 and 24 months of 24 individuals were used as controls. Pre-treatment and post-treatment cephalograms were used to determine the positional changes.	The results of this investigation indicated that statistically significant differences were found between the study and control group regarding vertical changes in the position of molars and incisors. The mandibular fixed lingual arch is a useful tool to control the vertical extrusion of mandibular molars.	Long-faced patients in mixed dentition can be benefited by placing lingual arch to control the vertical eruption of mandibular molars and to prevent the opening of the bite which may further complicate the treatment.
Rebellato et al. ¹⁶	N = 30 Study group (n = 14) Control group (n = 16)	Experimental randomized controlled trial	Thirty patients were randomly assigned to either the treatment or control group. Study models, cephalograms, and tomograms of the patients were taken at the beginning of the study and at the end of the study and were examined and compared. Changes in tooth position were measured at the center of resistance of incisors and molars, at the incisal edge of the incisors, and at the mesiobuccal cusp tip of the mandibular first permanent molar. Mesial or extrusive movements were recorded as positive values and distal or intrusive movements were recorded as negative values.	There are no significant differences in the level of vertical extrusion of first mandibular molars and incisors in both study and control groups.	The fixed lingual arch is a useful space maintainer which maintains the arch perimeter in the transition period between mixed to permanent dentition.
Singer ¹⁷	N = 53 Study group (n = 36) Control group (n = 17)	Experimental clinical trial	The study involved two groups of individuals. Group I consisted of 17 patients with untreated lower arches. This group could be further subdivided into two subgroups: (a) untreated lower, untreated upper. (b) Untreated lower and treated upper with headgear. Group II consisted of 36 individuals who wore passive lingual arches and two subgroups were made as done for the control group. Lateral cephalograms, X-rays, and study casts were made at the time of placement and removal of lingual arches and compared for the positional changes of mandibular first molar and incisors.	The mandibular fixed lingual arch is an effective appliance to control the vertical extrusion of mandibular molars and incisors.	Lingual arch is an effective space maintainer which prevents mesial migration of molars.
Foster and Wylie ¹⁸	N = 72 at the beginning of the study and the subjects left were 34 at the end of the study.	Experimental randomized controlled trial	Three groups were assigned: Group I: Lower deciduous canines were removed with no lingual arch and no permanent teeth extracted during the study. Group II: Lingual arches were given and no permanent teeth were extracted. Group III: Lingual arches were given and permanent first premolars were extracted. Study casts and cephalograms were taken at the beginning and at the end of the study and were compared and analyzed.	Vertical eruption is seen with mandibular molars and incisors in all the study groups with lingual arches and control groups without lingual group. Mandibular incisors extrude more than mandibular molars.	Lingual arch is not effective in preventing the vertical extrusion of molars and incisors.

They were randomly divided into treatment or control groups. The diagnostic records taken at pre-treatment and post-treatment stages were study models, lateral cephalograms, and tomograms of the patients and were studied and compared. The reference points taken for anterior teeth were the incisal edge of the incisors and for posterior teeth were the mesiobuccal cusp tip of the mandibular first permanent molar, and the vertical changes in tooth position were measured at the center of resistance of incisors and molars teeth. The positive values were given if the tooth had shown extrusive or mesial movements and negative values were given if the tooth had shown distal or intrusive movements. The results of the study showed no significant differences in the values for vertical changes in tooth position for the incisors and molars between the groups. It was an experimental randomized controlled trial. In the third article,¹⁷ the study involved two groups of individuals. Group I consisted of 17 patients with untreated lower arches. This group could be further subdivided into two subgroups: (a) untreated lower, untreated upper, (b) untreated lower and treated upper with headgear. Group II consisted of 36 individuals who wore passive lingual arches and two subgroups were made as done for the control group. Lateral cephalograms, X-rays, and study casts were made at the time of placement and removal of lingual arches and compared for the positional changes of mandibular first molar and incisors. The results showed significant changes in the vertical extrusion of incisors and molars.

And, in the fourth study¹⁸ included in this systematic review, three groups were assigned: group I: lower deciduous canines were removed, lingual arches were not given and permanent teeth were not extracted during the study; group II: lingual arches were given and permanent teeth were not extracted; group III: lingual arches were given and permanent first premolars were extracted. Study casts and cephalograms were taken at the pre-treatment and at the post-treatment stages were compared and analyzed. The results indicate that the vertical eruption is seen with mandibular molars and incisors in all the study groups with lingual arches and control groups without a lingual group and mandibular incisors extrude more than mandibular molars. The I group (lingual arches were not given and permanent teeth were not extracted) displayed the most, unpredictable results. Out of 10 cases, 4 cases presented with molars eruption more than incisors with a maximum difference of 2.7 mm, whereas 6 cases presented with incisors eruption more than molars with a maximum difference of 5.1 mm. The II group (Lingual arches were given and permanent teeth were not extracted) displayed stable results. Out of nine cases, eight cases presented with incisors eruption more than molars with a maximum difference of 2.8 mm and an average of 1.2 mm, whereas one case presented with molars eruption more than incisors with a maximum difference of only 0.3 mm. In the III group (Lingual arches were given and permanent first premolars were extracted). Out of 10 cases, six cases presented with incisors eruption more than molars with a maximum difference of 3.0 mm, whereas three cases presented with molars eruption more than incisors with a maximum difference of only 0.5 mm.

LIMITATIONS

A handful of studies, heterogeneity and the lack of double-blind randomized clinical trials were the limitations recorded for this systematic review; hence, no study could be assembled for a statistical process to quantify the extrusion of molars and incisors in the vertical direction in the human mandible.

DISCUSSION

This systematic review endeavored to evaluate any existing randomized, clinically controlled human trials published till March 2021, to study the effects of the lingual arch appliance as a space maintainer on the vertical changes in the position of mandibular molars and incisors while resolving the mandibular incisor crowding. The emphasis was to garner sufficient evidences from existing clinical studies to explore the effect of the lingual arch on the position of incisors and molars in the mandible in the vertical direction. The four finally included studies are experimental clinical trials in human beings carried out for a duration of >6 months. These four studies harmonized each other when measured in duration parameter, but they presented with heterogeneity in study design, outcome measured, sample size; and compared the vertical position of mandibular incisors and molars with or without lingual arch appliance intervention as a space maintainer. The critical question in this systematic review was—In patients with mandibular incisor crowding, what is the effect of the fixed lingual arch appliance as a space maintainer on the position of mandibular first permanent molar and incisors in the vertical direction before the placement and after the placement of lingual arch and when compared with mandibular arch without a lingual arch, on clinical and radiological parameters? Four studies qualified for the review (Table 1), but due to their heterogeneity, they were not subjected to statistical analysis for concluding, whether lingual arch intervention alone is effective in controlling the vertical extrusion of incisors and molars or not; and if yes, what is the quantification of the extrusion with or without lingual arch intervention as a space maintainer. All studies qualified for this systematic review were with sample size small in number, and crowding of mandibular incisors, background differences, and patient exclusion with previous orthodontic treatment is not documented. In this systematic review, because of heterogeneity of studies, statistical analysis was though not possible, it was inferred that the resolution of crowding in mandibular incisors thorough lingual arch intervention proved beneficial along with its effect on vertical control of mandibular incisors and molars in the arch. There is no dearth of literature to prove that a fixed lingual arch appliance in the mandible is a beneficial space maintainer appliance as far as the arch length and perimeter preservation and maintenance are concerned. However, there is a definite scarcity in the literature to correlate lingual arch appliance with the vertical changes of the molar and incisor position in growing children. And, the vertical control of molars and incisors is an imperative parameter to consider for pediatric orthodontics in some ubiquitous conditions like cases with high mandibular plane angle and open bite, etc.

According to the findings of the study by Villalobos et al.,¹⁵ the fixed lingual arch is truly an effective appliance to control the extrusion of mandibular molars in the vertical direction. This judgment is in line with the observation of Singer, who concluded 0.6 mm extrusion of molars with lingual arches when compared with 1 mm extrusion of molars in the control group without lingual arches, which is a statistically significant value ($p < 0.05$). This inference is in chide with Rebellato et al.,¹⁶ who concluded no statistically significant differences in extrusion of the mandibular molars between experimental groups using fixed lingual arch and control groups without fixed lingual arch. However, Villalobos et al.¹⁵ reported in the group with lingual arch, the amount of extrusion with the incisors was approximately four times that of the molars. This is in agreement with the outcomes of studies by Foster and Wylie¹⁸ and Rebellato et al.¹⁶ but in disagreement with Singer's¹⁷

observations where it was found that extrusion was greater in molars than that of the incisors.

CONCLUSION

The lingual arch appliance as a space maintainer proved effective in controlling the vertical eruption of incisors and mandibular first molars as and when compared to the control groups without lingual arch intervention. However, because of heterogeneity in analyzed studies, this systematic review could not assess the statistical analysis of the included studies; and, the studies are still sparse to draw a strong statement regarding the effectiveness of lingual arch in controlling the vertical extrusion of mandibular molars and incisors in a significant manner.

Included studies ($n = 4$): Characteristics

Table 2 displays the included studies. Reason for inclusion: Included studies $n = 4$ which were divided into (1) longitudinal cohort, (2) experimental randomized controlled trials, and (3) experimental clinical trial.

Excluded studies ($n = 7$): Characteristics

Table 1 displays the excluded studies. Reason for exclusion: They emphasized the effectiveness of the lingual arch on the resolution of mandibular incisors crowding but not on the vertical growth of mandibular incisors and molars.

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